GOVT CO-ED POLYTECHNIC

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LAB MANUAL

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2024562(024) – Power Electronics (Lab)

CONTENTS

EXPERIMENT-01

AIM: To plot the V-I characteristics of SCR, MOSFET and IGBT.

APPARATUS:

S.NO.	COMPONENTS	RANGE
1	SCR, MOSFET & IGBT characteristic kit module	
2	CRO with probes	20MHz
3	Multi Meter	
4	Ammeter	(0-1A, MC)
5	RPS , Dual Channel	0-30 V

THEORY:

SCR:

The full form of SCR is "Silicon Controlled Rectifier". It is a three terminal semi conducting device. The three terminals are anode (A), cathode (K) and gate (G). SCR is used as static switches in relay control, motor control, phase control, heater control, battery chargers, inverter, and regulated power supplies. SCR characteristic is drawn between anode to cathode voltage (V_{AK}) vs. anode current (I_A) for different values of gate current (I_G).

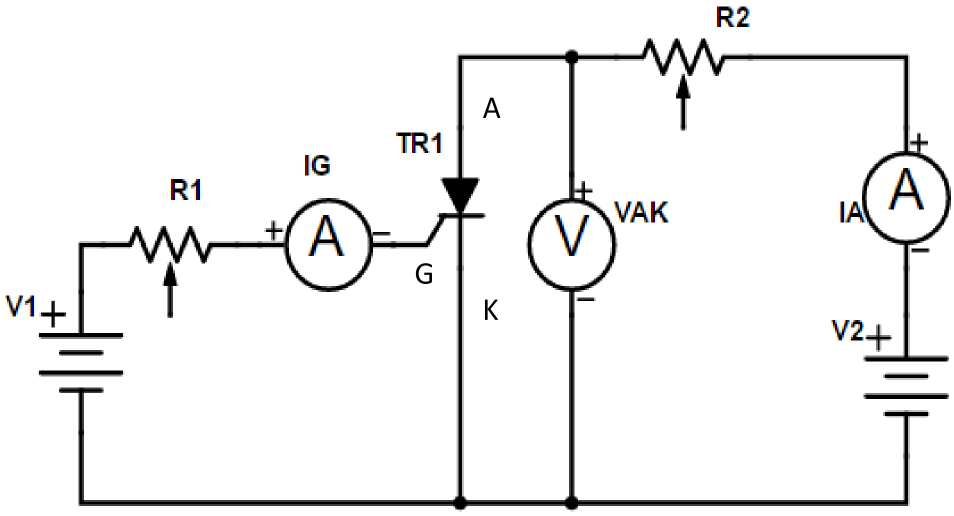
MOSFET:

MOSFET is a three terminal semi conducting device. Its conductivity can be controlled by gate signal. The three terminals are gate (G), source (S) and drain (D). It can be operated as an amplifier or as a switch. Static output characteristic curve is drawn between drain current (I_D) and drain to source voltage (V_{DS}) for the given value of gate to source voltage (V_{GS}). Transfer characteristic is drawn between drain current (I_D) vs. gate to source voltage (V_{GS}).

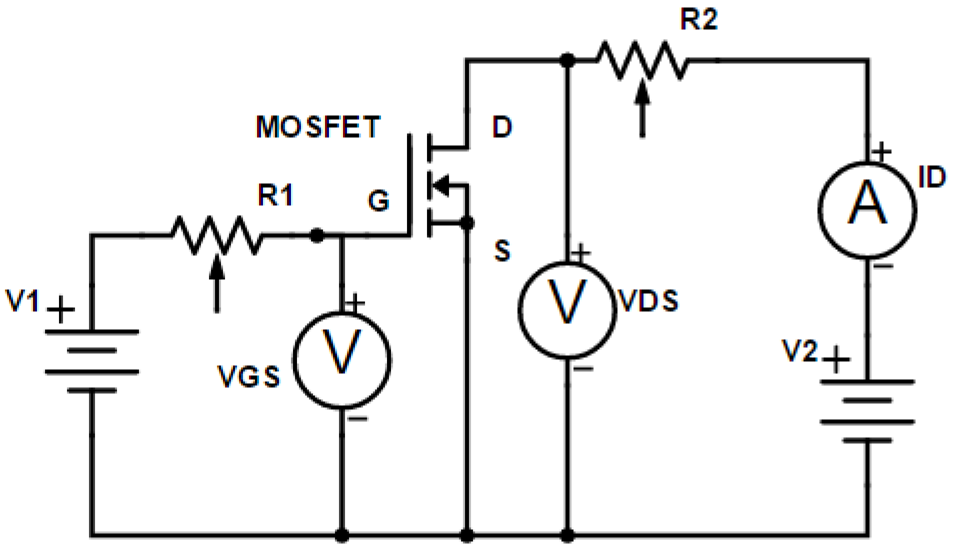
IGBT:

IGBT is a three terminal semi-conductor device. The device is turned ON by applying positive voltage greater than threshold between gate and emitter. The three terminals are base (B) or gate (G), collector (C) & emitter (E). It can be operated as an amplifier or as a switch. Static output characteristic curve is drawn between collector current (I_C) and collector to emitter voltage (V_{CE}) for a given value of base/gate to emitter voltage (V_{GE}).

CONNECTION DIAGRAM



(a)



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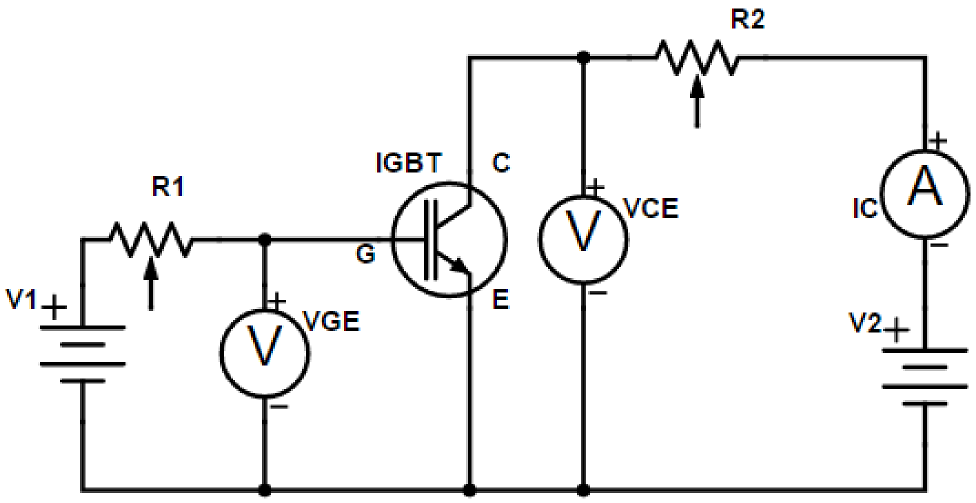


(c)

Fig.1.1. Connection diagram to plot V-I characteristics of (a) SCR, (b) MOSFET and (c) IGBT

PROCEDURE:

For plotting SCR characteristic curves:

1. Connections are made as per the circuit diagram given in Fig. 1.1 (a).
2. Set R_1 and R_2 to mid positions and V_1 and V_2 to minimum.
3. Set a finite gate current (I_{G1}) by varying R_1 and V_1.
4. Slowly vary V_2 (or R_2) and note down V_{AK} and $I_{A.}$
5. Repeat the steps 3 and 4 for second gate current (I_{G2})
6. Reverse the anode voltage polarity to find the reverse characteristics.

For finding holding current of SCR:

1. Ensure SCR is at ON state
2. Remove the gate voltage and start reducing V_{AK} ; simultaneously verify the state ofSCR. If SCR is turned off, note the current (I_A) just before it comes to zero.

For finding latching current of SCR:

1. Ensure that the SCR is in the state of conduction.
2. Start reducing anode voltage (V_{AK}) slowly; simultaneously check the state of SCR by switching off gate supply. If SCR switches off just by removing gate terminal, and switches on by connecting gate supply, then the corresponding anode current (I_A) is the latching current for the SCR.

For plotting MOSFET static (Drain) characteristic curves:

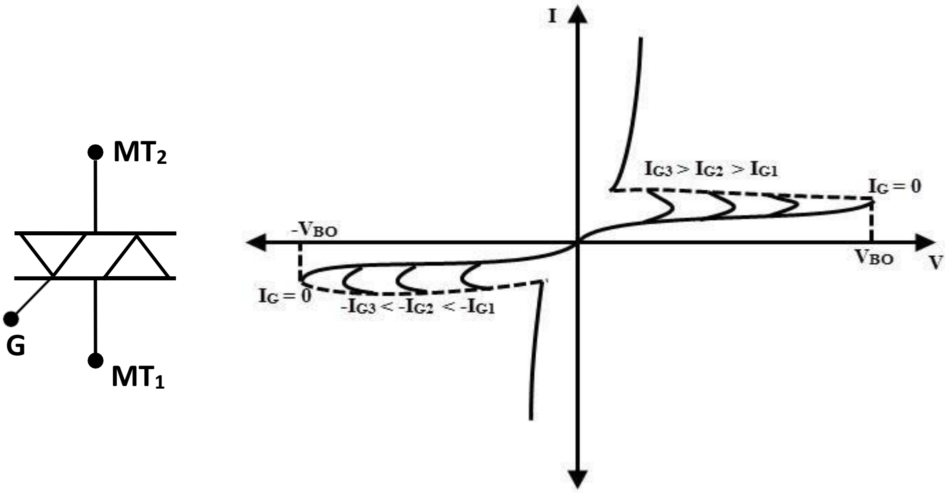
1. Connect the circuit as given in Fig. 1.1 (b).
2. Set a finite gate source voltage (V_{GS1}) by varying R_1 and V_1.
3. By varying V_2 (or R_2), note down V_{DS} and $I_{D.}$
4. Repeat the steps 3 and 4 for second gate source voltage (V_{GS2})

For plotting IGBT static (Collector) characteristic curves:

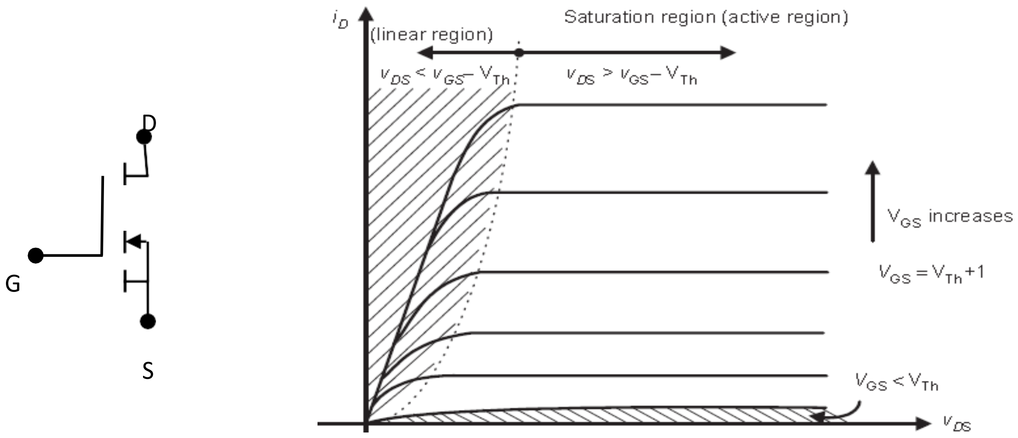
1. Connect the circuit as given in Fig. 1.1 (c).
2. Set a finite gate source voltage (V_{GE1}) by varying R_1 and V_1.
3. By varying V_2 (or R_2), note down V_{CE} and $I_{C.}$
4. Repeat the steps 3 and 4 for second gate source voltage (V_{GE2})

MODEL GRAPHS

Characteristics of SCR



(a)



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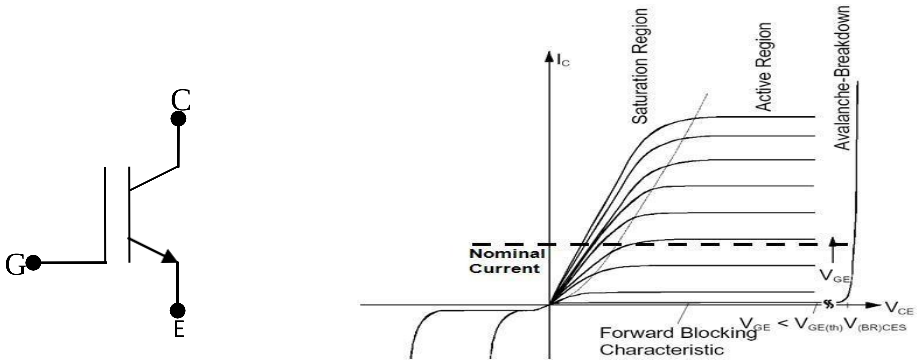


(c)

Fig.1.2. V-I characteristics of (a) SCR (b) MOSFET (c) IGBT

TABULAR FORM:

Observations of SCR

I_{G1}		I_{G1}	
V_{AK}	I_A	V_{AK}	I_A

Observations of MOSFET

V_{GS1}		V_{GS2}	
V_{DS}	I_D	V_{DS}	I_D

Observations of IGBT

V_{GE1}		V_{GE2}	
V_{CE}	I_C	V_{CE}	I_C

RESULTS:

Viva questions:

1. What is semi controlled device?
2. What is fully controlled device?
3. What is uncontrolled device?
4. What are the devices used for high frequency applications?
5. What are the different methods of turning on an SCR?
6. Why is dv/dt technique not used in SCR?
7. What are applications of SCR, MOSFET and IGBT?
8. Which parameter defines the transfer characteristics in MOSFET and IGBT?
9. Write the procedure to plot the transfer characteristics of MOSFET and IGBT using the experimental setup?
10. What are the merits and demerits of SCR, MOSFET and IGBT?
11. What is rating of SCR, MOSFET and IGBT?

EXPERIMENT-02

AIM: To plot and observe the output waveform of single phase half controlled bridge rectifier with R and RL Loads.

APPARATUS:

S.NO.	COMPONENTS	RANGE
1	Half Controlled Converter Module	
2	CRO with probes	20MHz
3	Resistive load	500Ω, 1KΩ
4	Inductive load	100mH
5	RPS , Dual Channel	0-30 V
6	Transformer	230/0-30V

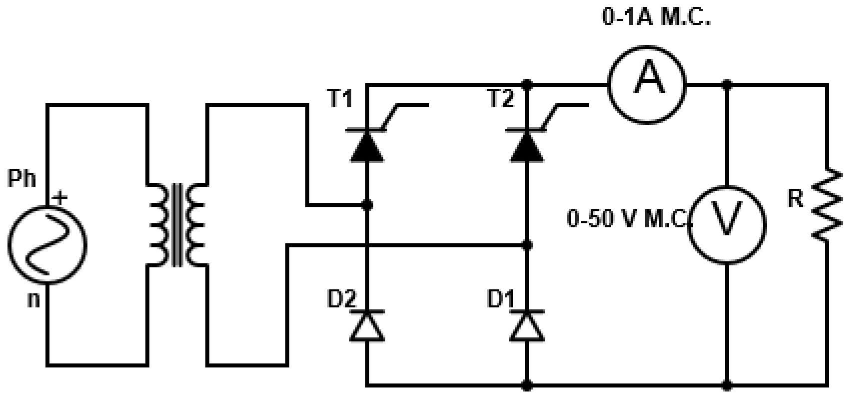
THEORY:

Rectification is a process of converting an alternating current or voltage into a direct current or voltage. Rectifier circuits are classified into three classes:

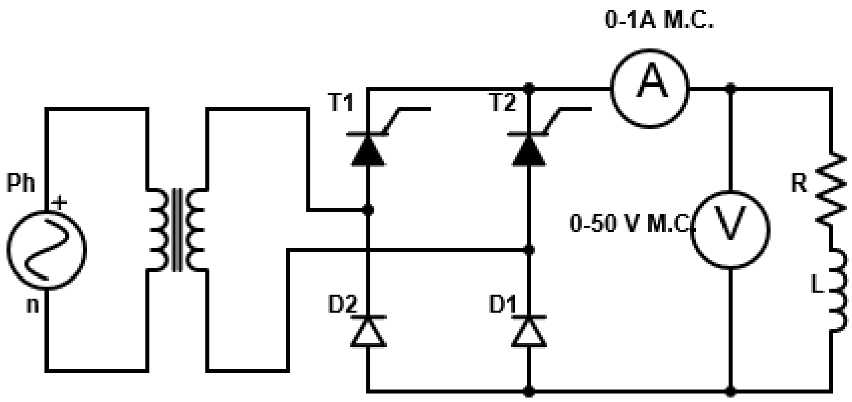
1. Uncontrolled
2. Fully Controlled
3. Half Controlled.

A half/semi controlled converter is given in Fig.3.1. It has two thyristors and two diodes. Thyristors need to be triggered by firing circuits; diodes conduct depends on the polarity of the input supply. Due to presence of diodes, freewheeling operation takes place without allowing the bridge output voltage to become negative. In a semi-controlled rectifier, control is affected only for positive output voltage, and no control is possible when its output voltage tends to become negative. When source, V_{in} is positive, SCR T_1 can be triggered at a firing angle called α and then current flows out of the source through SCR T_1 first, then through the load and returns via diode D_1. SCR T_1 and diode D_1 conduct during $\alpha<\omega t<\pi$. When $\pi<\omega t< 2\pi$, V_{in} is negative and SCR T_2 is normally triggered at $\omega t = \pi + \alpha$. During $\pi<\omega t< (\pi + \alpha)$, diode D_2 tends to get forward-biased and it starts conducting along with SCR T_1 and hence the bridge output voltage is clamped at zero. During $(\pi + \alpha)<\omega t< 2\pi$, the devices in conduction are SCR T_2 and diode D_2. SCR T_2 and diode D_1 would conduct during $0 <\omega t<\alpha$.

CIRCUIT DIAGRAM:



(a)



(b)

Fig. 3.1 Single phase half controlled rectifier with (a) R-load and (b) RL load

PROCEDURE:

With R-load:

1. Connect the circuit with R-load as shown in the circuit diagram.
2. Switch on the main supply.
3. Vary the firing angle, observe the load voltage waveform on CRO and note downthe firing angle and sketch the output voltage.

With RL-load:

1. Connect the circuit with R-L load as per the circuit diagram.
2. Switch on the main supply.
3. Vary the firing angle, observe the load voltage waveform on CRO and note downthe firing angle and sketch the output voltage.

TABULAR FORM:

R-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A

RL-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A

MODEL GRAPH:

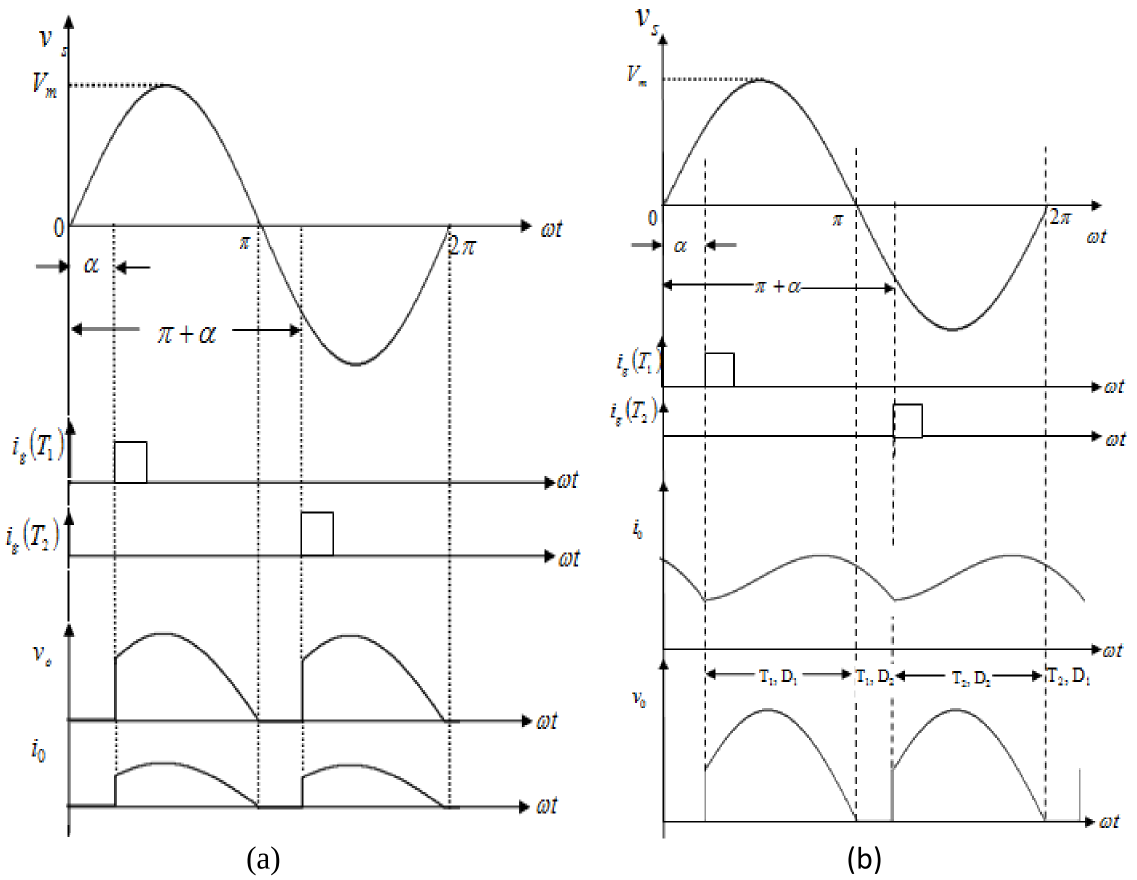


Fig. 3.2 Waveforms of semiconverter with (a) R-load and (b) RL load.

RESULT:

Viva questions:

1. Differentiate RMS and DC value of output voltage?
2. What is rectifier?
3. What is semi controlled rectifier?
4. Draw the waveforms of semiconverter with RL-load operated under discontinuousmode.
5. What is the function of zero crossing detector (ZCD) circuit?
6. Realize ZCD circuit using OP-AMP?

EXPERIMENT-03

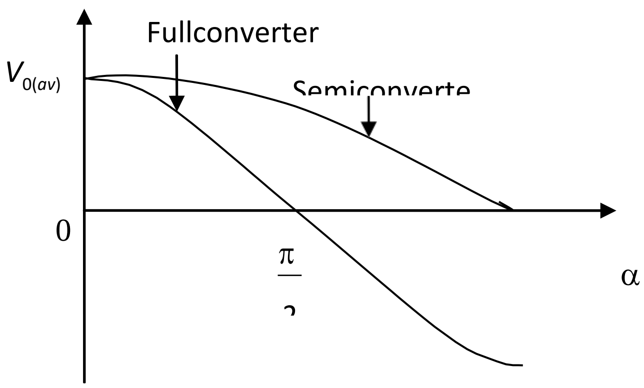
AIM: To obtain controlled output waveforms of a single phase fully controlled bridge rectifier with R and RL Loads.

APPARATUS:

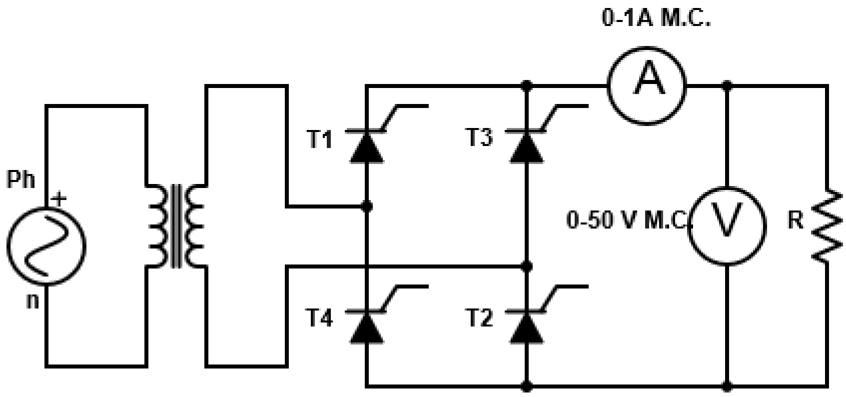
S.NO.	COMPONENTS	RANGE
1	Single Phase Fully Controlled Bridge Rectifier module	
2	CRO with probes	20MHz
3	Resistive load	500Ω, 1KΩ
4	Inductive load	100mH
5	Multi Meter	
6	Ammeter	(0-1A, MC)
7	RPS , Dual Channel	0-30 V
8	Transformer	230/0-30V

THEORY:

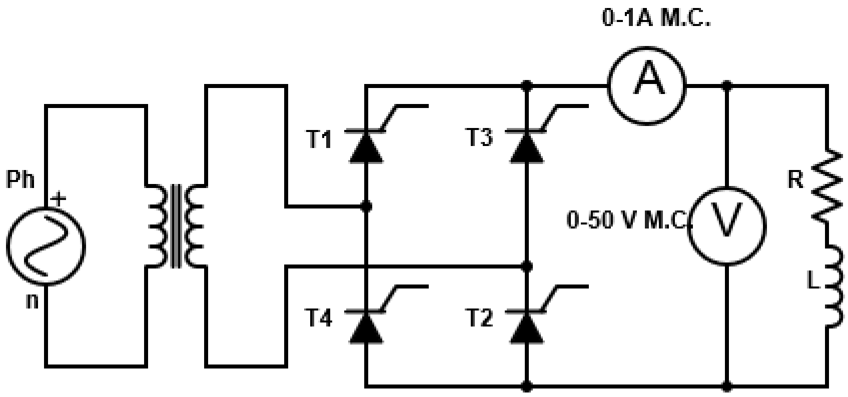
The full controlled rectifier has four thyristors; two thyristors, one from top and the other from bottom will conduct at any point of time. During positive half cycles of input voltage, thyristors T_1 and T_3 are triggered at $\omega t=\alpha$; similarly, T_2 and T_4 are triggered at $\omega t = \pi + \alpha$. Unlike semiconverters, the output voltage contain negative portion too; thus average output voltage can be either positive or negative which depends on firing angle show in below figure. Hence, full converter can be employed for motoring as well as for regenerative braking applications.



CIRCUIT CONNECTIONS:



(a)



(b)

Fig. 4.1. Power circuit of full converter with (a) R load and (b) R-L load.

PROCEDURE:

WITH R-LOAD:

1. Connect the circuit with R-load as shown in the circuit diagram.
2. Connect the firing circuit to the semiconductor devices appropriately.
2. Check the pulses from the firing circuit and switch on the power supply.
3. Vary the firing angle; observe the output and SCR waveforms on CRO and plot observed waveforms on graph.
4. Tabulate output voltage and output current and compare theoretical and practicalvalues.

WITH RL-LOAD:

1. Connect the circuit with R-L load as per the circuit diagram.
2. Repeat the steps 1 to 4 for R-L load.

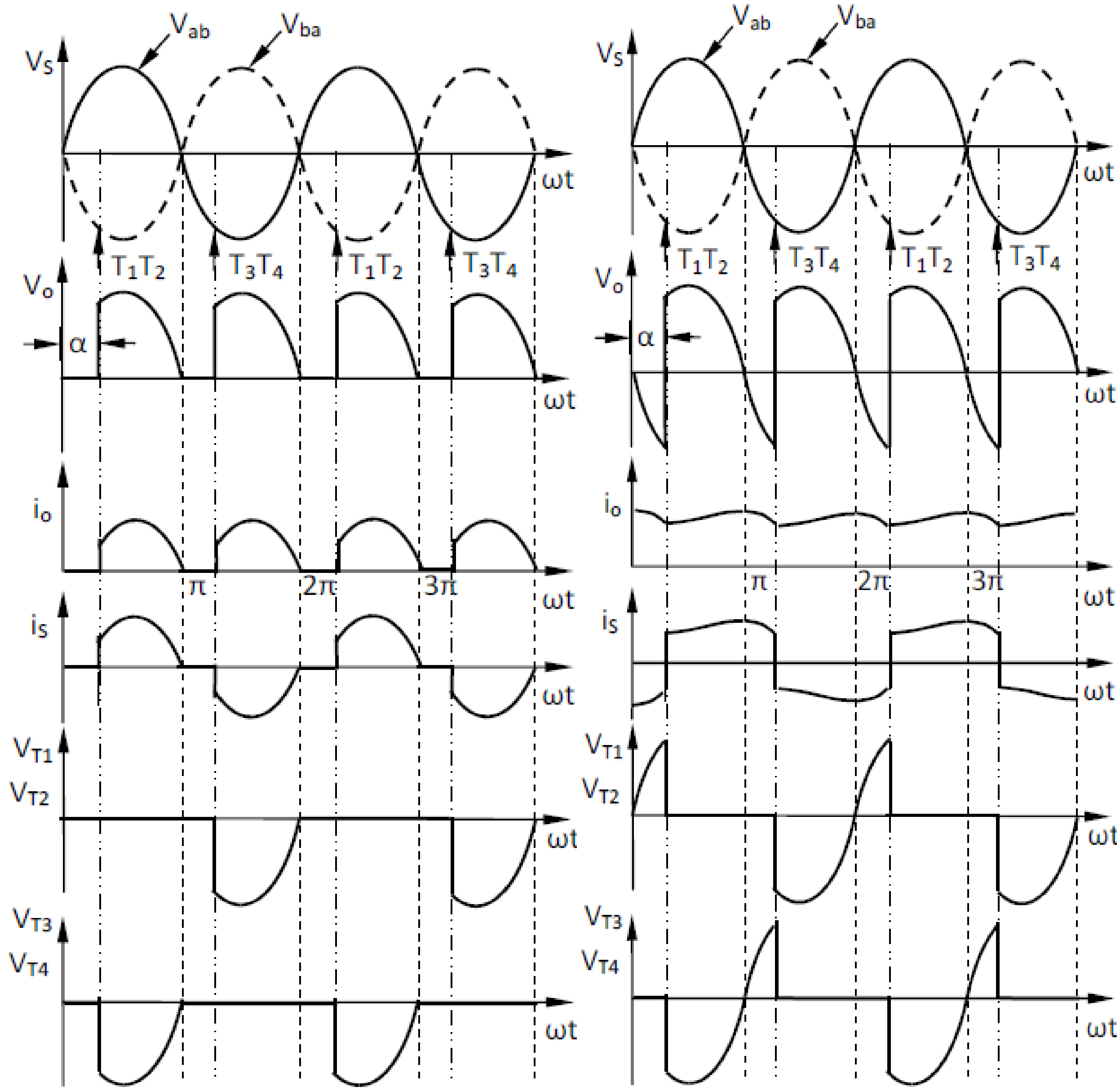
TABULAR FORM:

R-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A

RL-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A



MODEL GRAPH:

(a) (b)

Fig. 4.2 Output and SCR voltage wave forms of full bridge converter for (a) R and (b) RL loads.

RESULTS:

Viva questions:

1. Explain the operation of full bridge converter operation in discontinuous andcontinuous mode?
2. Compare half controlled converter and full controlled rectifier?
3. Derive the relations for load current (assuming R-L load) and output voltageequations for (a) half controlled and (b) full controlled rectifiers.
4. Collect the components list to fabricate half and full controlled rectifiers.

EXPERIMENT-04

AIM: To plot and observe various voltage & current wave forms AC Voltage Controller with R & R-L loads.

APPARATUS:

S.NO.	COMPONENTS	RANGE
1	AC voltage controller module	
2	CRO with probes	20MHz
3	Resistive load	500Ω, 1KΩ
4	Inductive load	100mH
5	Multi Meter	
6	Ammeter	(0-1A, MC)
7	RPS , Dual Channel	0-30 V
8	Transformer	230/0-30V

THEORY:

AC voltage controllers are thyristor-based devices, which convert fixed alternating voltage directly to variable alternating voltage without change in the frequency. In AC voltage controllers, two SCR's are connected in anti parallel. Applications of AC voltage controllers are domestic and industrial heating, transformer tap changing, lightening controls, speed control of single phase and three phase AC drives.

R-load

AC voltage controller or phase angle controller for R load is given in Fig. 5.1 (a). During positive half cycle, T_1 is triggered at α, making v_o same as v_s. At $\omega t=\pi$, both v_o and i_o go to zero and T_1 is turned OFF. Similarly, T_2 is fired at $\pi+\alpha$ and is naturally commutated at 2π. The output r.m.s. voltage which is a function of input voltage and firing angle can be derived from the output voltage wave shape and is given below:

$$V_{0rms} = \frac{V_m}{\sqrt{2\pi}}\left[\pi-\alpha+\frac{\sin 2\alpha}{2}\right]^{\frac{1}{2}}$$

R-L load

If the load is in inductive in nature, the load current has both transient and steady state components.

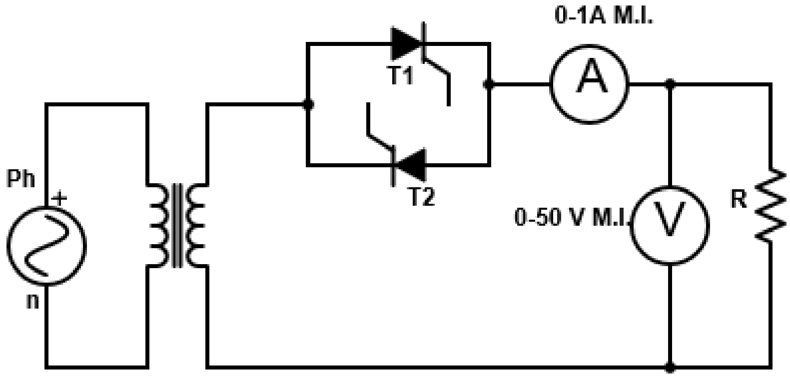
$$i = -\frac{V_m}{2}\sin(\alpha-\phi)e^{-\frac{R}{L}\left(t-\frac{\alpha}{\omega}\right)} + \frac{V_m}{2}\sin(\alpha-\phi)$$

Where

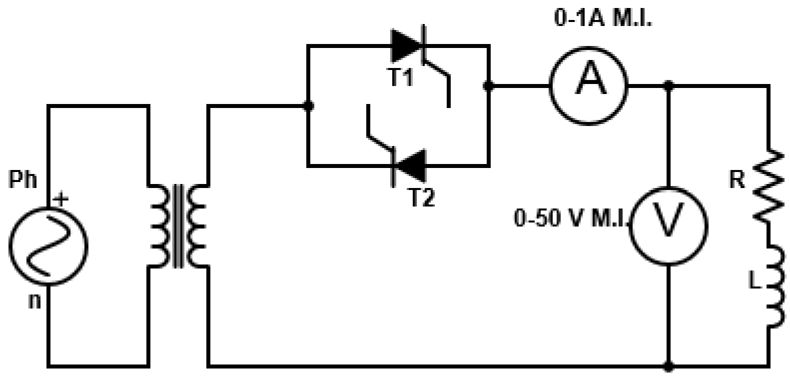
ϕ is the load power factor angle and is given by $\tan^{-1}(\omega L/R)$

β is the angle at which $i_0(t)$ falls to zero.

CIRCUIT DIAGRAM:



(a)



(b)

Fig. 5.1 Circuit diagram of AC voltage controller with (a) R and (b) R-L load.

PROCEDURE:

With R load:

1. All connections are to be made as per the circuit diagram given in Fig. 5.1 (a)
2. Keep all resistances in max position.
3. Connect the oscilloscope across the load.
4. Turn on power supply to the module.
5. Vary the firing angle and observe the output and SCR waveforms on the CRO
6. Draw the corresponding waveforms for different values of firing angle.
7. Measure the load current and voltage and compare with the theoretical values.

With R-L load:

1. Repeat above procedure for R-L load.

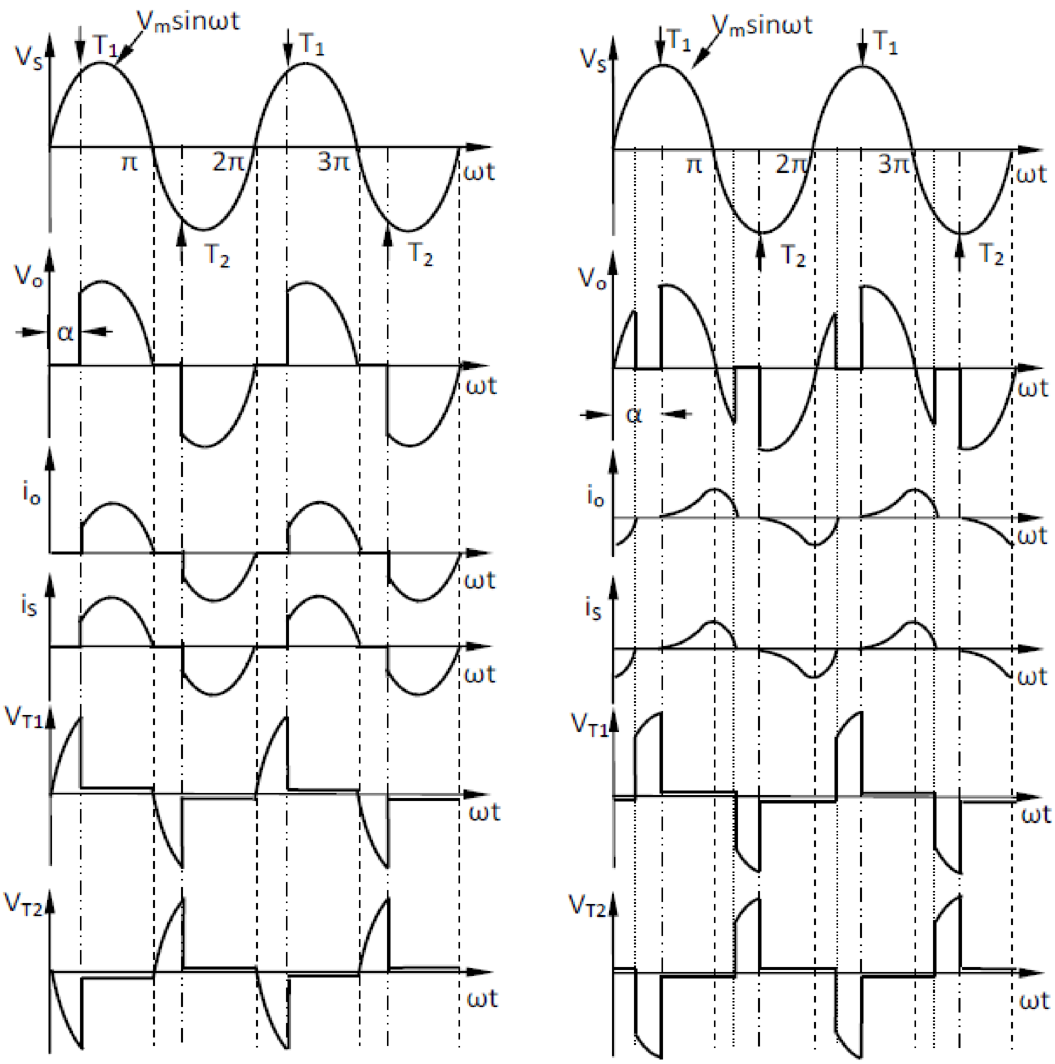
TABULAR FORM:

R-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A

RL-Load:

S. No.	α, Firing Angle	Theoretical V	Practical V	I_L in A



MODEL GRAPH:

(a) (b)

Fig. 5.2 Output and SCR voltage wave forms of ac-ac converter for (a) R and (b) RL loads

RESULTS:

Viva questions:

1. Explain the procedure to evaluate extinction angle, β for the given R-L load for ac-ac converter?
2. List out various applications of AC voltage controllers?

EXPERIMENT- 05

AIM: To obtain the output waveforms of a single-phase cyclo-converter.

APPARATUS:

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S.NO.	COMPONENTS	RANGE
1	Single phase Cycloconverter module	
2	CRO with probes	20MHz
3	Resistive load	500Ω, 1KΩ
4	Inductive load	100mH
5	Multi Meter	
6	Ammeter	(0-1A, MC)
7	Transformer	230/0-30V

THEORY:

A device that converts input power at one frequency to the output power at another frequency with one stage is known as cyclo-converter; basically there are two types:

1. Step- down
2. Step up cyclo-converter

In step down cyclo-converter, the output frequency f_0 is lower than the supply frequency f_s. i.e. $f_o<f_s$. In step up $f_o>f_s$. A cyclo-converter is controlled through the timing of its firing pulse so that it produces an alternating output voltage at lowest frequency. The majority of cyclo-converters are naturally commutated and the maximum output frequency is limited to a value that is only a fraction of the source frequency ($f_s/2$).

The applications of cyclo-converters are given below:

1. Speed control of high-power ac drives
2. Induction heating
3. Static VAR. generation
4. For converting variable speed alternator voltage convert into constant frequencyoutput voltage for use as power supply in aircraft or shipboards.

CIRCUIT DIAGRAM:

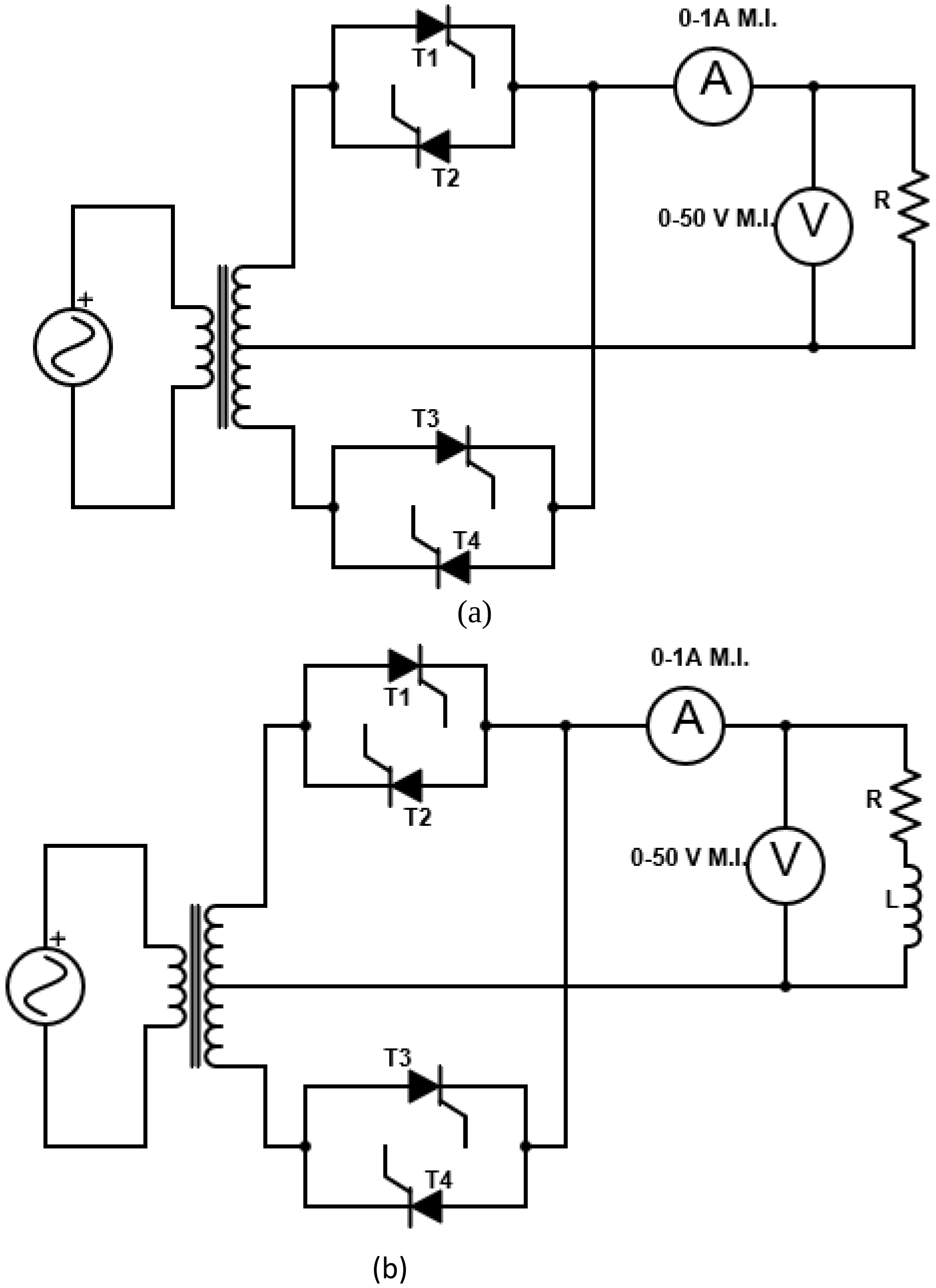


Fig. 6.1 Cycloconverter circuit with (a) R laod and (b) R-L load.

PROCEDURE:

1. All connections are made as per the circuit diagram given in Fig. 6.1.
2. Check all firing circuit triggering outputs and its relative phase sequence.
3. Switch on the power supply to the kit and release firing pulses to the corresponding SCR switches.
4. If the output is zero after all proper connections, switch OFF the MCB, switch OFF the AC supply to the isolation transformer and just inter change the AC input connections in the power circuit. This is to make the firing circuit and power circuitto synchronize.
5. Change the frequency division only when the trigger output pulse switch at off position
6. Observe and plot output voltages across load at different frequencies.
7. Repeat for R-L load

TABULAR FORM:

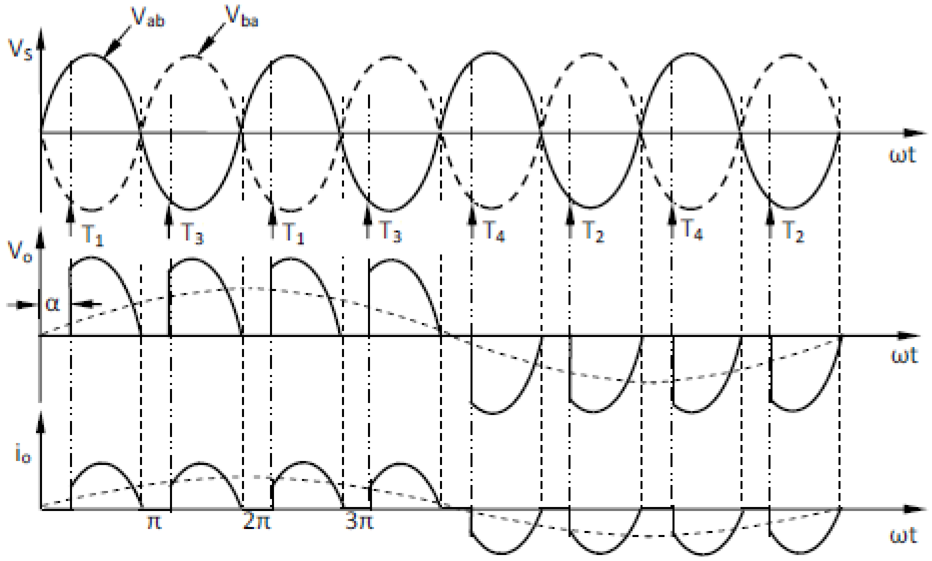
R load

S.No.	$f_s/2$			$f_s/3$			$f_s/4$		
	Firing angle, α	Output voltage, V_o	Output current, I_o	Firing angle, α	Output voltage, V_o	Output current, I_o	Firing angle, α	Output voltage, V_o	Output current, I_o

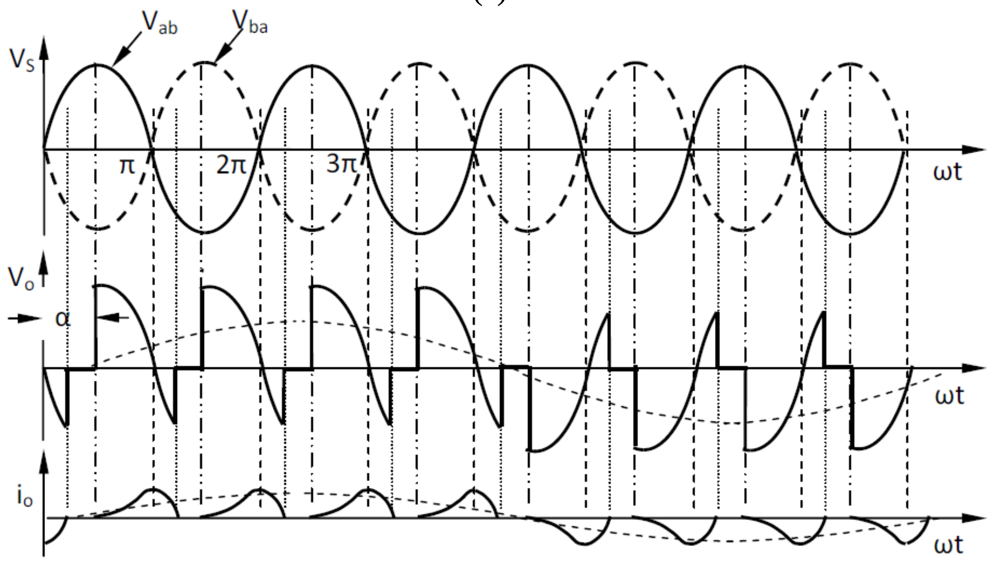
R-L load

S.No.	$f_s/2$			$f_s/3$			$f_s/4$		
	Firing angle, α	Output voltage, V_o	Output current, I_o	Firing angle, α	Output voltage, V_o	Output current, I_o	Firing angle, α	Output voltage, V_o	Output current, I_o

MODEL GRAPH:



(a)



(b)

Fig. Cycloconverter waveforms for (a) R and (b) R-L loads

RESULTS:

Dos & Don’ts in Power Electronics Lab

Dos	Don’ts
• Enter/exit lab quietly. • Raise your hand before asking any doubt. • Always have a clean & dry hand. • Operate Kit/module gently. • Keep your work space clean. • Search only approved websites • Identify leads of IC before connection. • Find out the current and voltage rating before experiment.	• No food or drinks in the lab. • Do not mark on any part of kit. • Do not change any key settings of computer. • No magnets allowed in lab • Do not pull any cable/cord of any system. • Ask teacher before taking any printout. • Do not pull any cable/cord of jack.