Experiment 5: Single Phase Fully Controlled Converter using R and R-L load

Introduction to the Experiment

This experiment is aimed to study the operation of single phase fully controlled converter using R and R-L load by observing the output waveforms. The circuit is implemented in simulation as well as hardware and the performance is studied.

Learning outcomes:

Circuit Diagram:

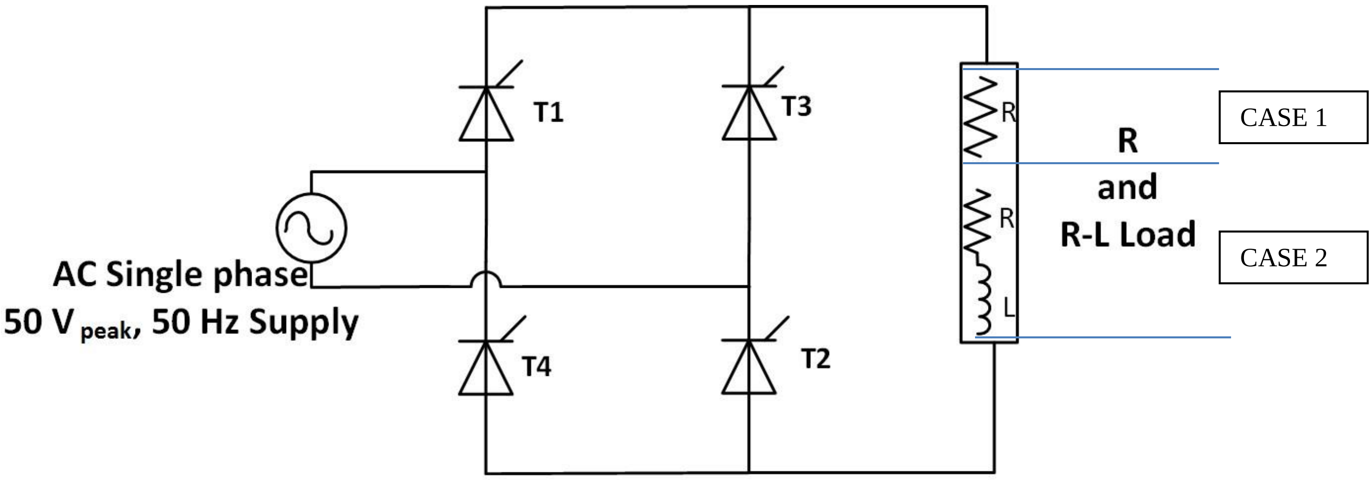


Figure 1 Circuit diagram

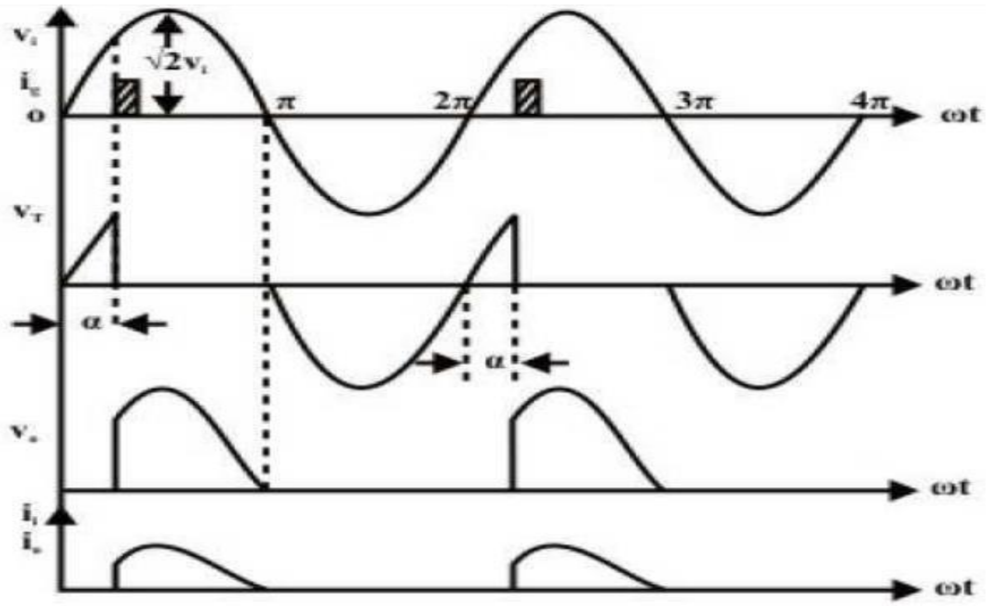


Figure 2 model waveform

Theory:

A fully controlled converter or full converter uses thyristors only and there is a wider control over the level of dc output voltage. With pure resistive load, it is single quadrant converter. Here, both the output voltage and output current are positive. With RL- load it becomes a two-quadrant converter. Here, output voltage is either positive or negative but output current is always positive. Figure shows the quadrant operation of fully controlled bridge rectifier with R-load. Fig shows single phase fully controlled rectifier with resistive load. This type of full wave rectifier circuit consists of four SCRs. During the positive half cycle, SCRs T1 and T2 are forward biased. At $\omega t = \alpha$, SCRs T1 and T3 are triggered, then the current flows through the L – T1- R load – T3 – N. At $\omega t = \pi$, supply voltage falls to zero and the current also goes to zero. Hence SCRs T1 and T3 turned off. During negative half cycle (π to 2π).

SCRs T3 and T4 forward biased. At $\omega t = \pi + \alpha$, SCRs T2 and T4 are triggered, then current flows through the path N – T2 – R load- T4 – L. At $\omega t = 2\pi$, supply voltage and current goes to zero, SCRs T2 and T4 are turned off. The Fig-2, shows the current and voltage waveforms for this circuit. For large power dc loads, 3-phase ac to dc converters are commonly used. The various types of three-phase phase-controlled converters are 3 phase half-wave converter, 3-phase semi converter, 3-phase full controlled and 3-phase dual converter. Three-phase half-wave converter is rarely used in industry because it introduces dc component in the supply current. Semi converters and full converters are quite common in industrial applications. A dual is used only when reversible dc drives with power ratings of several MW are required. The advantages of three phase converters over single-phase converters are as under: In 3-phase converters, the ripple frequency of the converter output voltage is higher than in single-phase converter. Consequently, the filtering requirements for smoothing out the load current are less. The load current is mostly continuous in 3-phase converters. The load performance, when 3- phase converters are used, is therefore superior as compared to when single-phase converters are used.

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

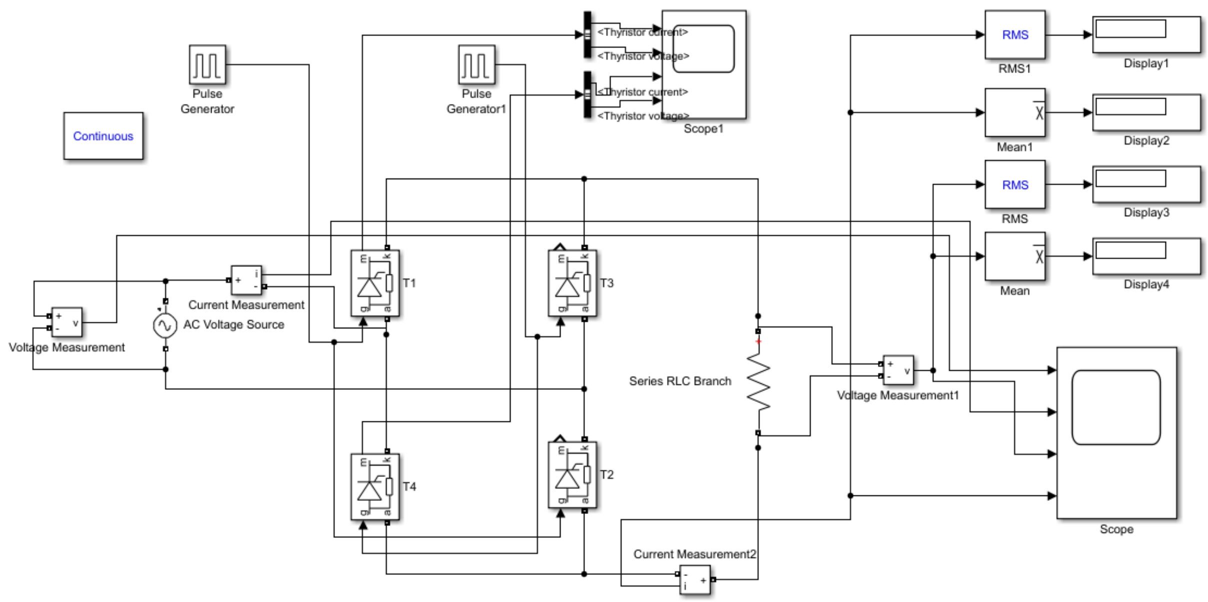
$I_{avg}=V_{avg}/R$

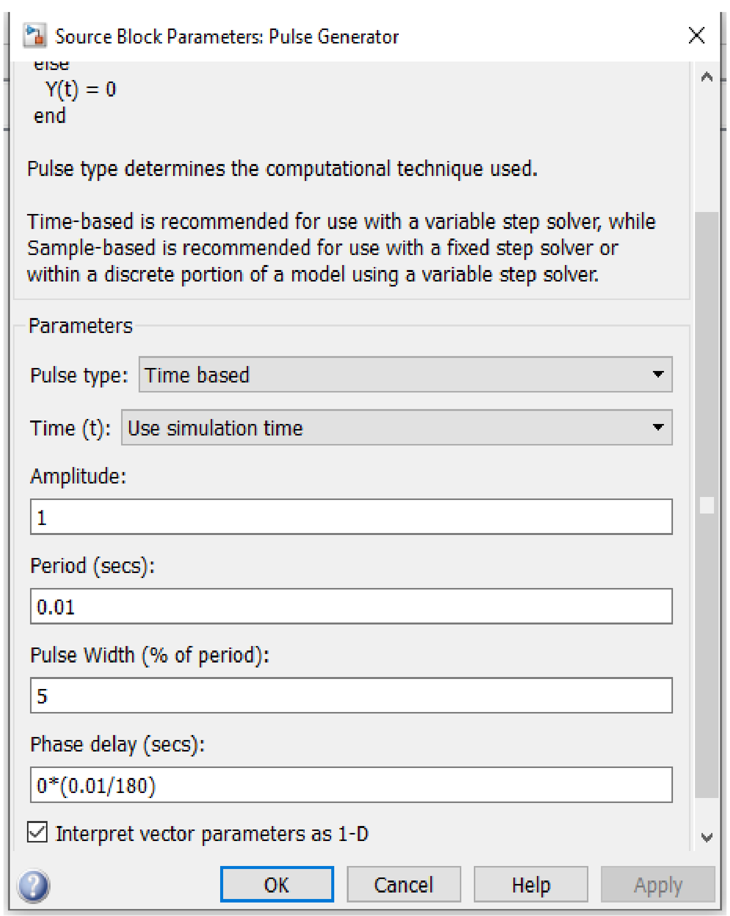
1 a). Simulation of single phase fully controlled converter with R Load.

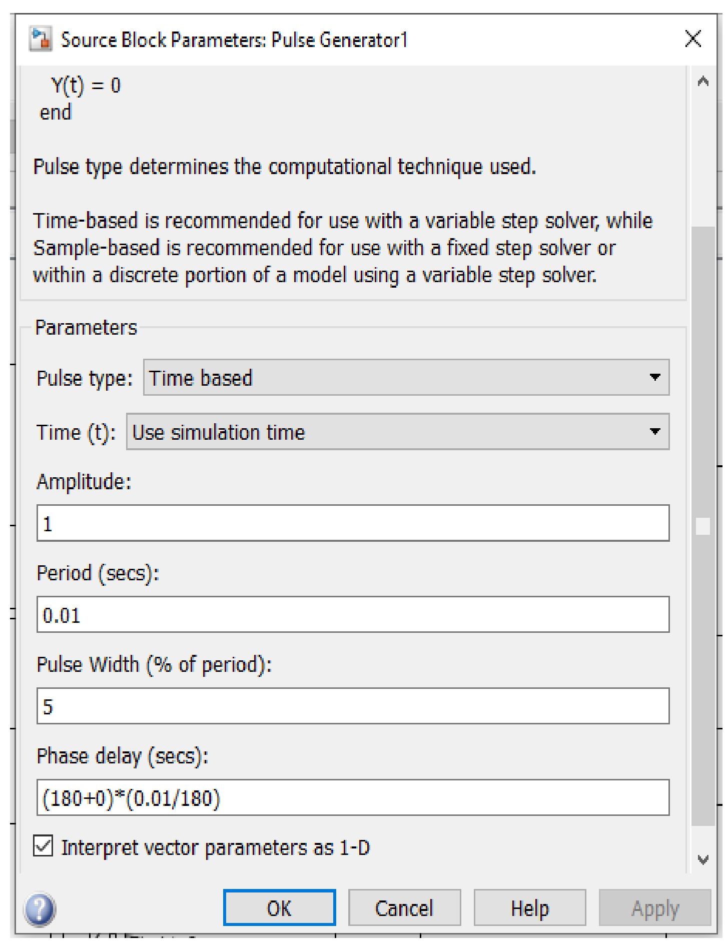
Aim: To simulate Single phase fully controlled converter with R load in MATLAB Simulink

PROBLEM 1:

a. Implement the 1-phase *fully controlled* full wave rectifier with the R load of **12.5 Ω** and observe the changes in the output voltage waveform at different firing angles. (Input voltage: 50V Peak = **35.35V (RMS) and 50Hz**)


Continuous
Pulse Generator
Pulse Generator1
<Thyristor current>
<Thyristor voltage>
<Thyristor current>
<Thyristor voltage>
Scope1
RMS
RMS1
Display1
Mean1
Display2
RMS
RMS
Display3
Mean
Display4
T1
T3
T4
T2
Current Measurement
AC Voltage Source
Voltage Measurement
Series RLC Branch
Voltage Measurement1
Scope
Current Measurement2


Source Block Parameters: Pulse Generator
else
Y(t) = 0
end
Pulse type determines the computational technique used.
Time-based is recommended for use with a variable step solver, while Sample-based is recommended for use with a fixed step solver or within a discrete portion of a model using a variable step solver.
Parameters
Pulse type: Time based
Time (t): Use simulation time
Amplitude:
1
Period (secs):
0.01
Pulse Width (% of period):
5
Phase delay (secs):
0*(0.01/180)
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

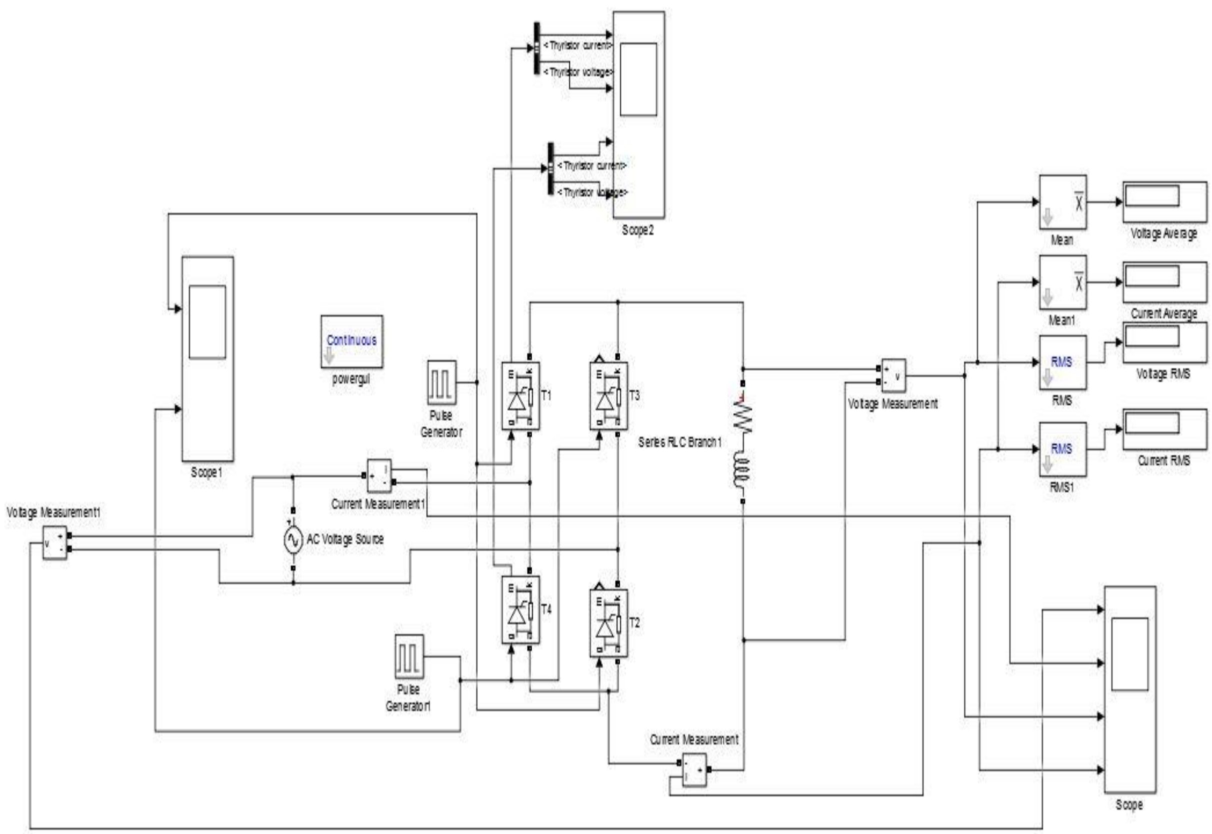

Source Block Parameters: Pulse Generator1
Y(t) = 0
end
Pulse type determines the computational technique used.
Time-based is recommended for use with a variable step solver, while Sample-based is recommended for use with a fixed step solver or within a discrete portion of a model using a variable step solver.
Parameters
Pulse type: Time based
Time (t): Use simulation time
Amplitude:
1
Period (secs):
0.01
Pulse Width (% of period):
5
Phase delay (secs):
(180+0)*(0.01/180)
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply

1 b). Simulation of single phase fully controlled converter with RL load.

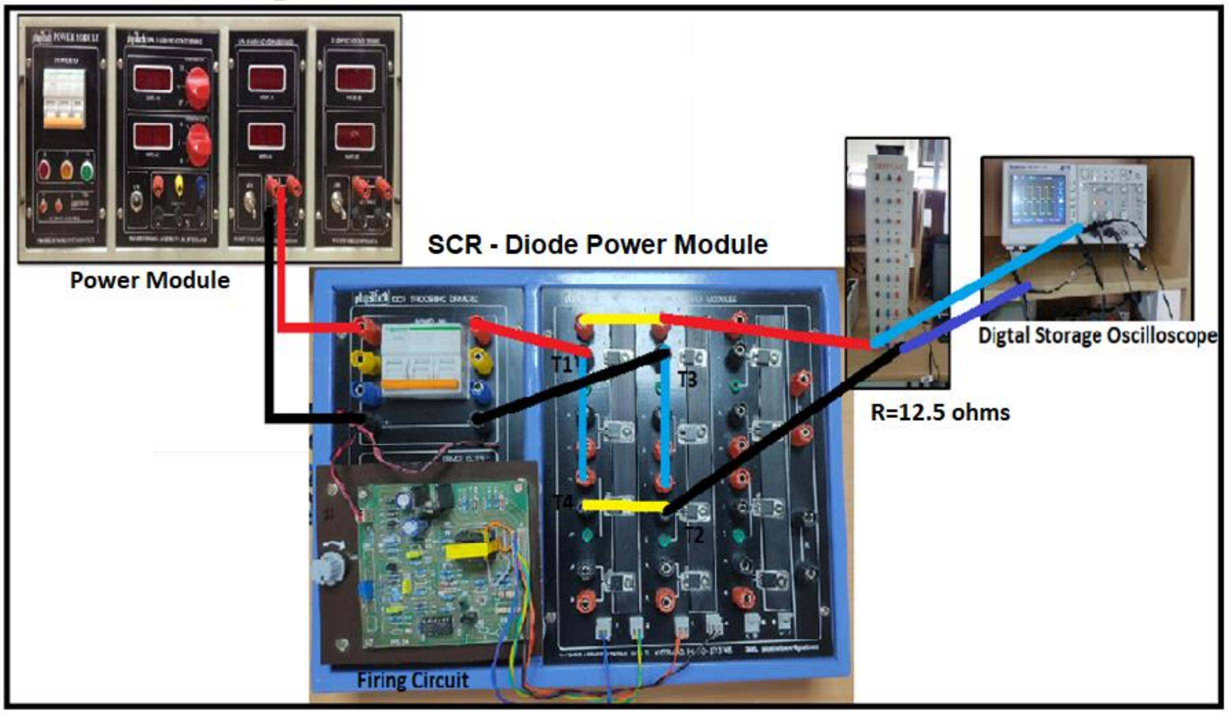
Aim: To simulate Single phase fully controlled converter with RL load in MATLAB Simulink

PROBLEM 2:

b. Implement the 1-phase *fully controlled* full wave rectifier with the R load of **12.5 Ω** and L of **6mH** and observe the changes in the output voltage waveform at different firing angles. (Input voltage: 50V Peak = **35.35V (RMS) and 50Hz**)



1b. Hardware Implementation of 1-Phase R Load



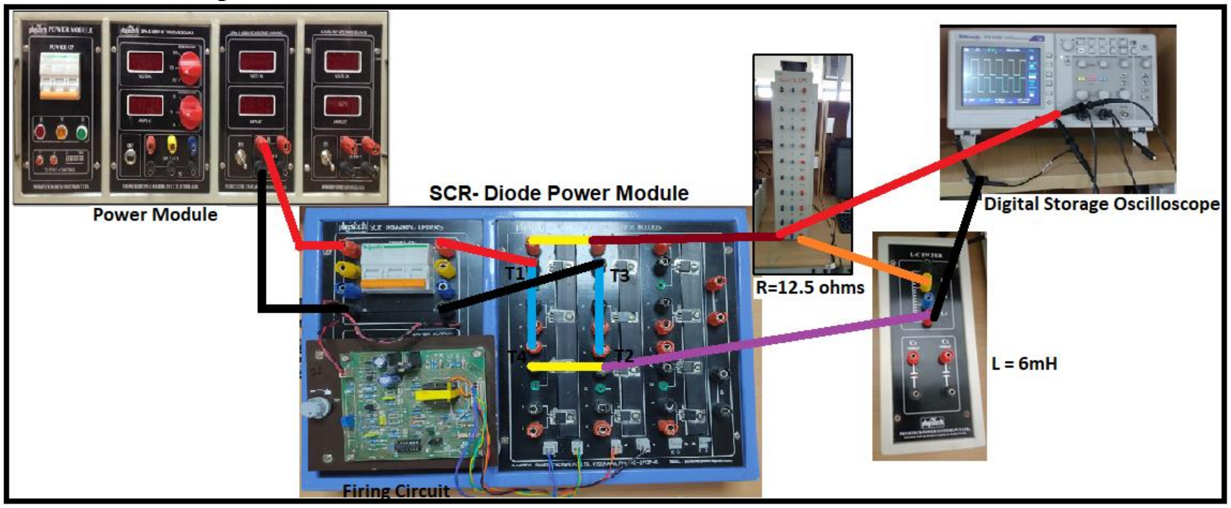
Procedure:

1. Connect the circuit as shown in above figure (with R load (**R=12.5 ohms**))
2. Switch ON the MCB of 3Ø supply on the Left hand side of your Experimental Table.
3. Switch ON the MCB on the POWER MODULE kit.
4. Switch ON the MCB on the SCR-Diode Power module and slowly increase the Voltage to reach up to 35.35 V in RMS using **+** symbol Push Button in the Power Module kit.

   Note: The Voltage Adjustment Controls are a pair of push buttons to finely adjust the voltage to required value.

5. Switch on the driver power switch
6. Connect CRO probes across the **R** load to measure the output voltage
7. Vary the firing angle as mentioned in the “Exp5_Part B.doc” file.
8. Observe the Output voltage waveforms in the DSO.

Hardware Implementation of 1-Phase RL Load



Procedure:

1. Connect the circuit as shown in above figure (with RL load (**R=12.5 ohms, L = 6mH**))
2. Switch ON the MCB of 3Ø supply on the Left hand side of your Experimental Table.
3. Switch ON the MCB on the POWER MODULE kit.
4. Switch ON the MCB on the SCR-Diode Power module and slowly increase the Voltage to reach up to 35.35 V in RMS using **+** symbol Push Button in the Power Module kit.

Note: The Voltage Adjustment Controls are a pair of push buttons to finely adjust the voltage to required value.

5. Switch on the driver power switch
6. Connect DSO probes across the **R** and **L** load to measure the output voltage.
7. Vary the firing angle as mentioned in the "Exp5_Part B.doc" file.
8. Observe the Output voltage waveforms in the DSO.

Conclusion: Obtain the results as per "Exp5_Part B.doc" file.