Experiment 7: Three Phase Fully Controlled Converter

Introduction to the Experiment

This experiment is aimed at converting AC (Three phase) to DC using a fully controlled converter. The circuit is implemented in simulation as well as hardware and the performance is studied.

Learning outcomes:

Circuit Diagram:

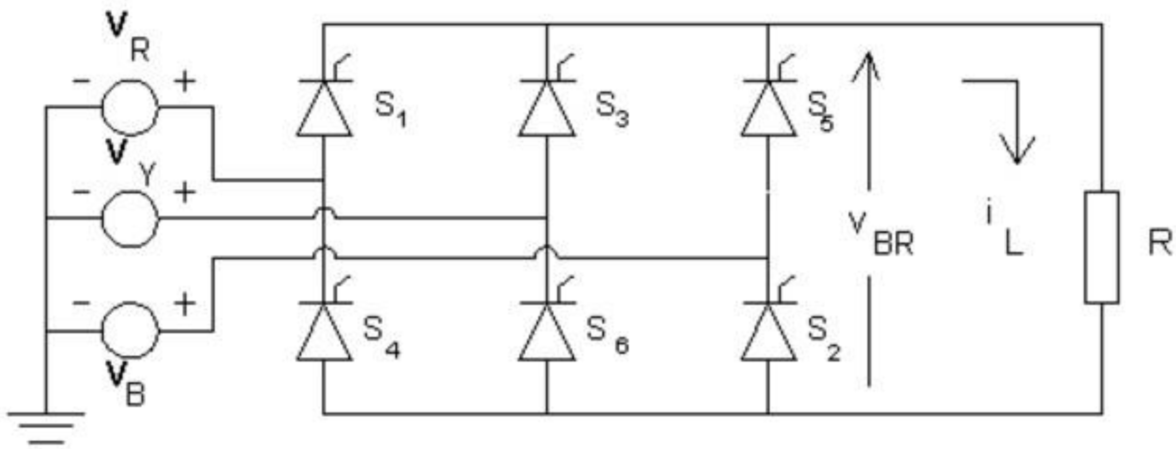


Figure 1 Circuit diagram

Theory:

The three-phase bridge rectifier circuit has three-legs, each phase connected to one of the three phase voltages. Alternatively, it can be seen that the bridge circuit has two halves, the positive half consisting of the SCRs S_1, S_3 and S_5 and the negative half consisting of the SCRs S_2, S_4 and S_6. At any time when there is current flow, one SCR from each half conducts. If the phase sequence of the source be RYB, the SCRs are triggered in the sequence S_1, S_2 , S_3 , S_4, S_5 , S_6 and S_1 and so on.
The operation of the circuit is first explained with the assumption that diodes are used in place of the SCRs. The three-phase voltages vary as shown below.

Let the three-phase voltages be defined as shown below.

$$v_R(\theta) = E*Sin(\theta), \quad v_Y(\theta) = E*Sin(\theta - 120^o), \; and \; v_B(\theta) = E*Sin(\theta + 120^o).$$

It can be seen that the R-phase voltage is the highest of the three-phase voltages when q is in the range from 30^o to 150^o. It can also be seen that Y-phase voltage is the highest of the three-phase voltages when q is in the range from 150^o to 270^o and that B-phase voltage is the highest of the three-phase voltages when q is in the range from 270^o to 390^o or 30^o in the next cycle. We also find that R-phase voltage is the lowest of the three-phase voltages when q is in the range from 210^o to 330^o. It can also be seen that Y-phase voltage is the lowest of the three-phase voltages when q is in the range from 330^o to 450^o or 90^o in the next cycle, and that

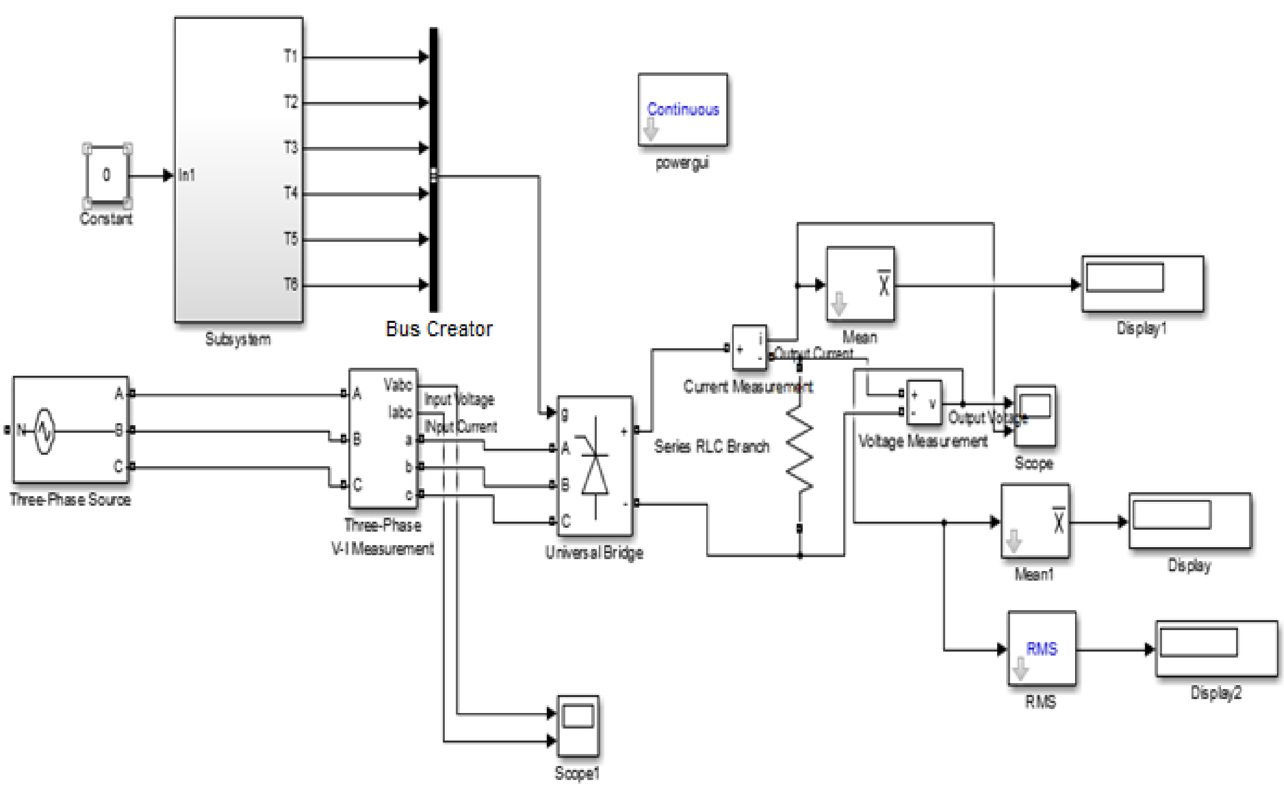
B-phase voltage is the lowest when q is in the range from 90^o to 210^o. If diodes are used, diode D_1 in place of S_1 would conduct from 30^o to 150^o, diode D_3 would conduct from 150^o to 270^o and diode D_5 from 270^o to 390^o or 30^o in the next cycle. In the same way, diode D_4 would conduct from 210^o to 330^o, diode D_6 from 330^o to 450^o or 90^o in the next cycle, and diode D_2 would conduct from 90^o to 210^o. The positive rail of output voltage of the bridge is connected to the topmost segments of the envelope of three-phase voltages and the negative rail of the output voltage to the lowest segments of the envelope.

1 a). Simulation of full wave Three phase fully controlled converter in MATLAB Simulink

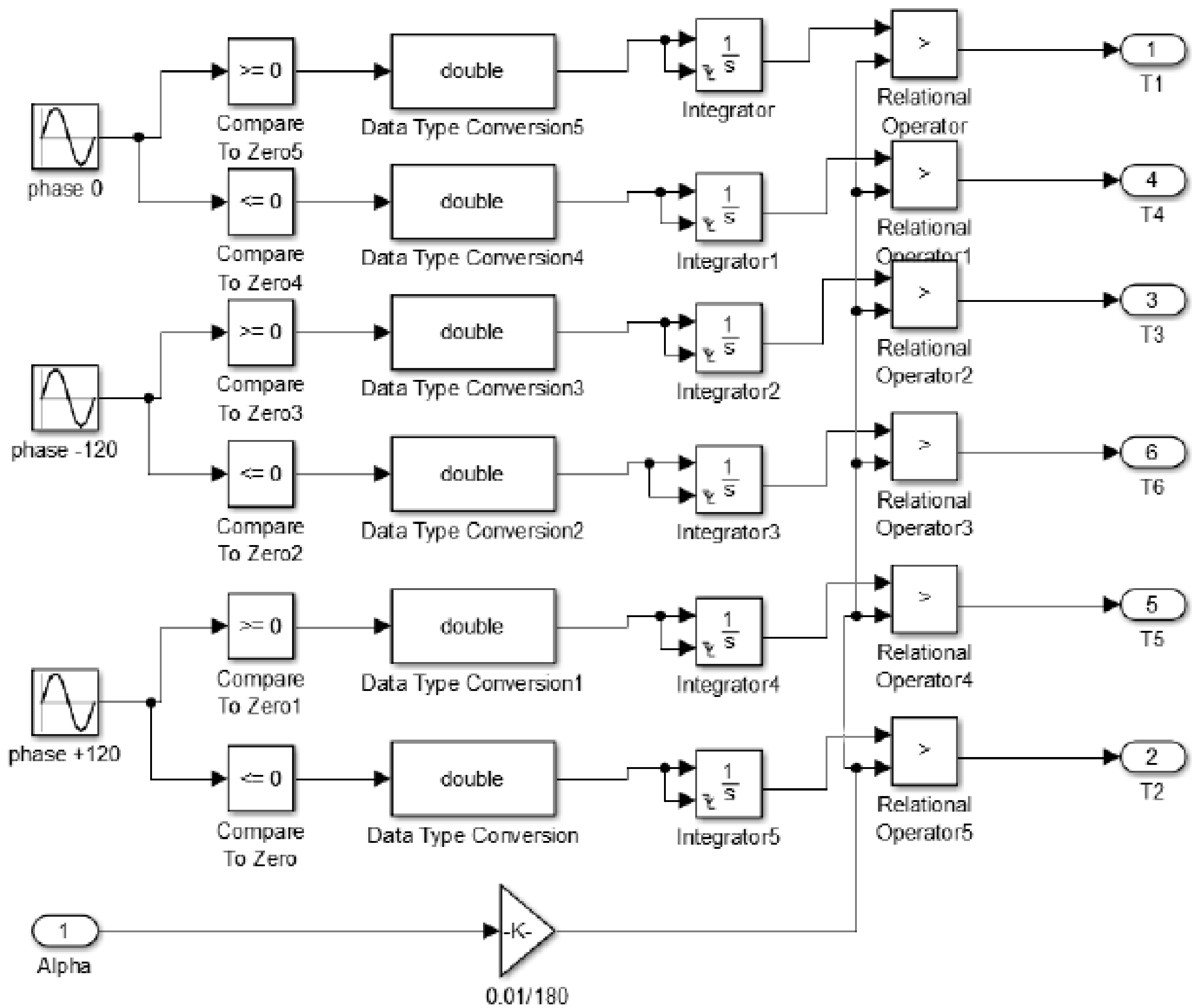
Aim: To simulate the converter in MATLAB Simulink

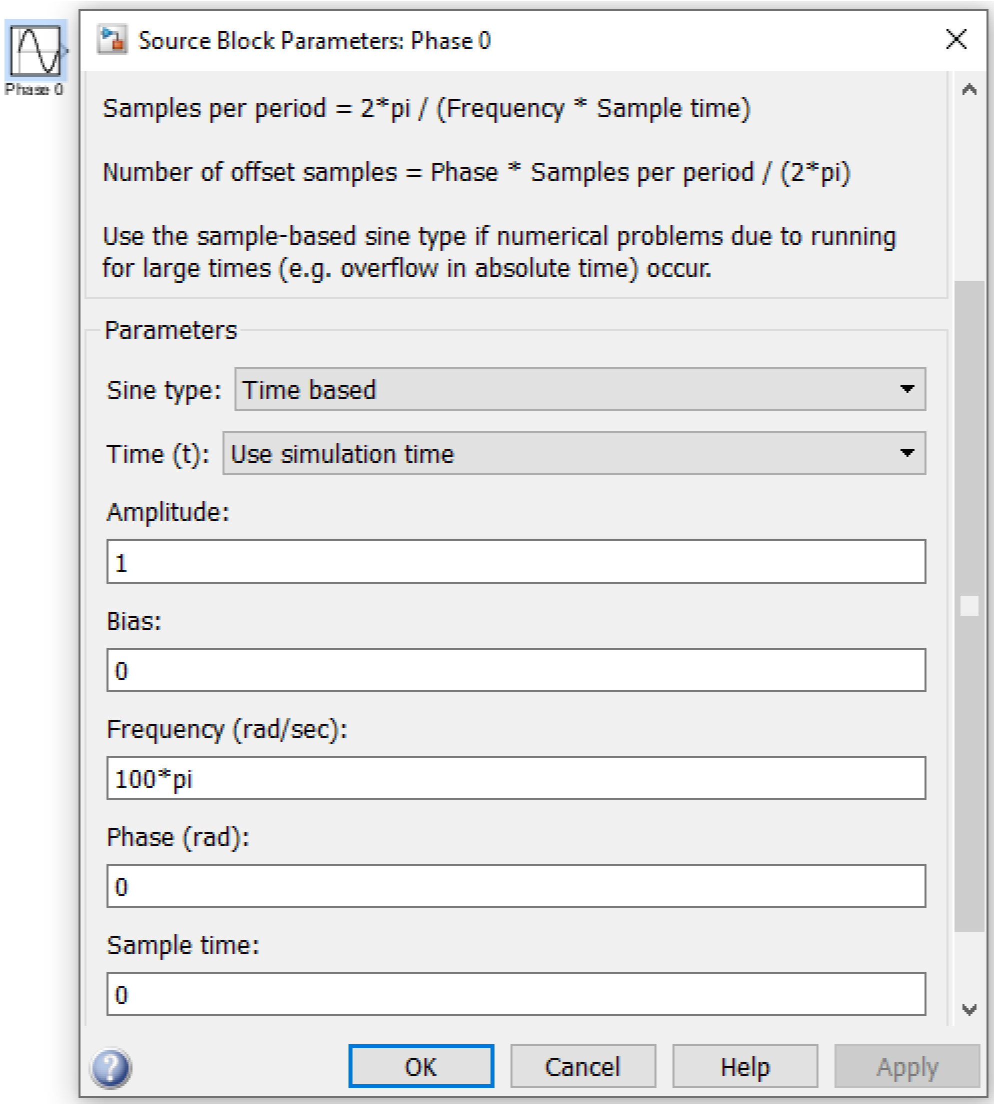
PROBLEM 1:

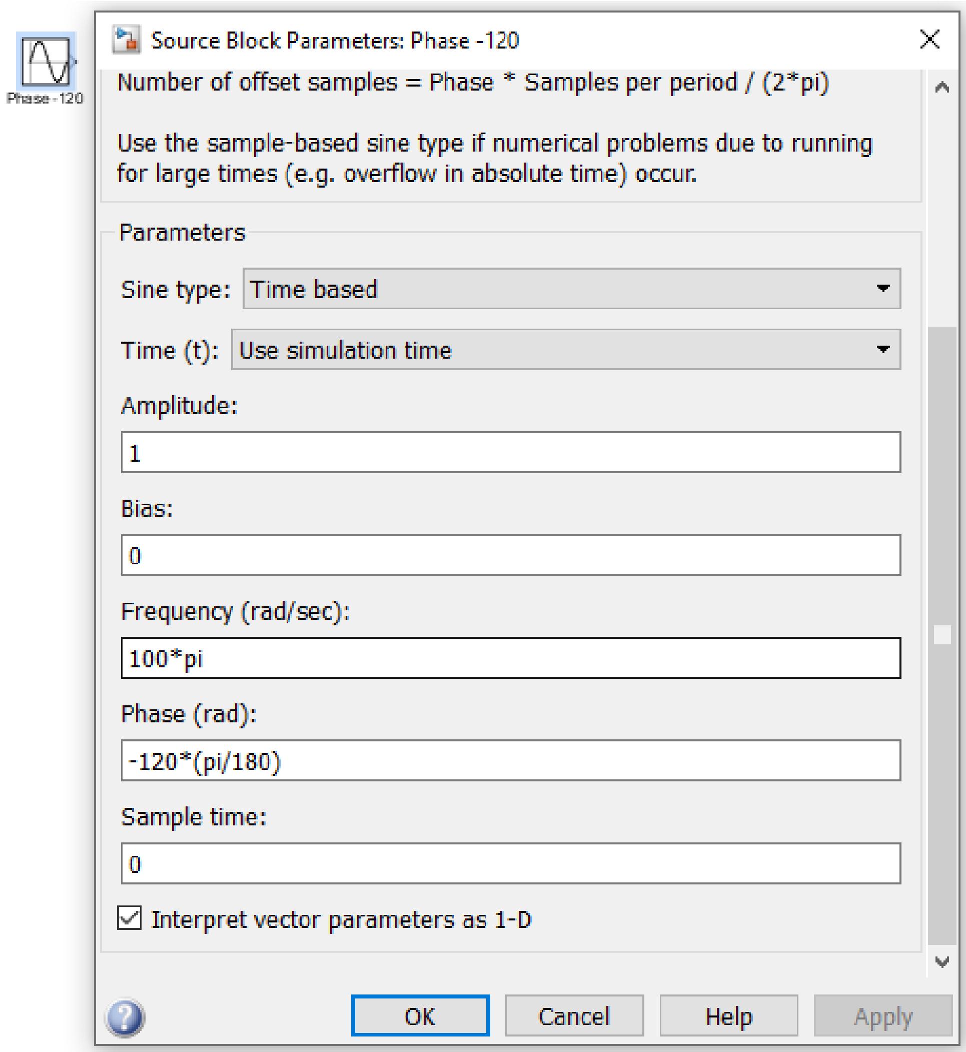
Implement the 3-phase *fully controlled* full wave converter with an R load of **100 Ω**. (Input voltage: Phase-to-phase rms voltage (V) = **61.2 V, 50Hz**)

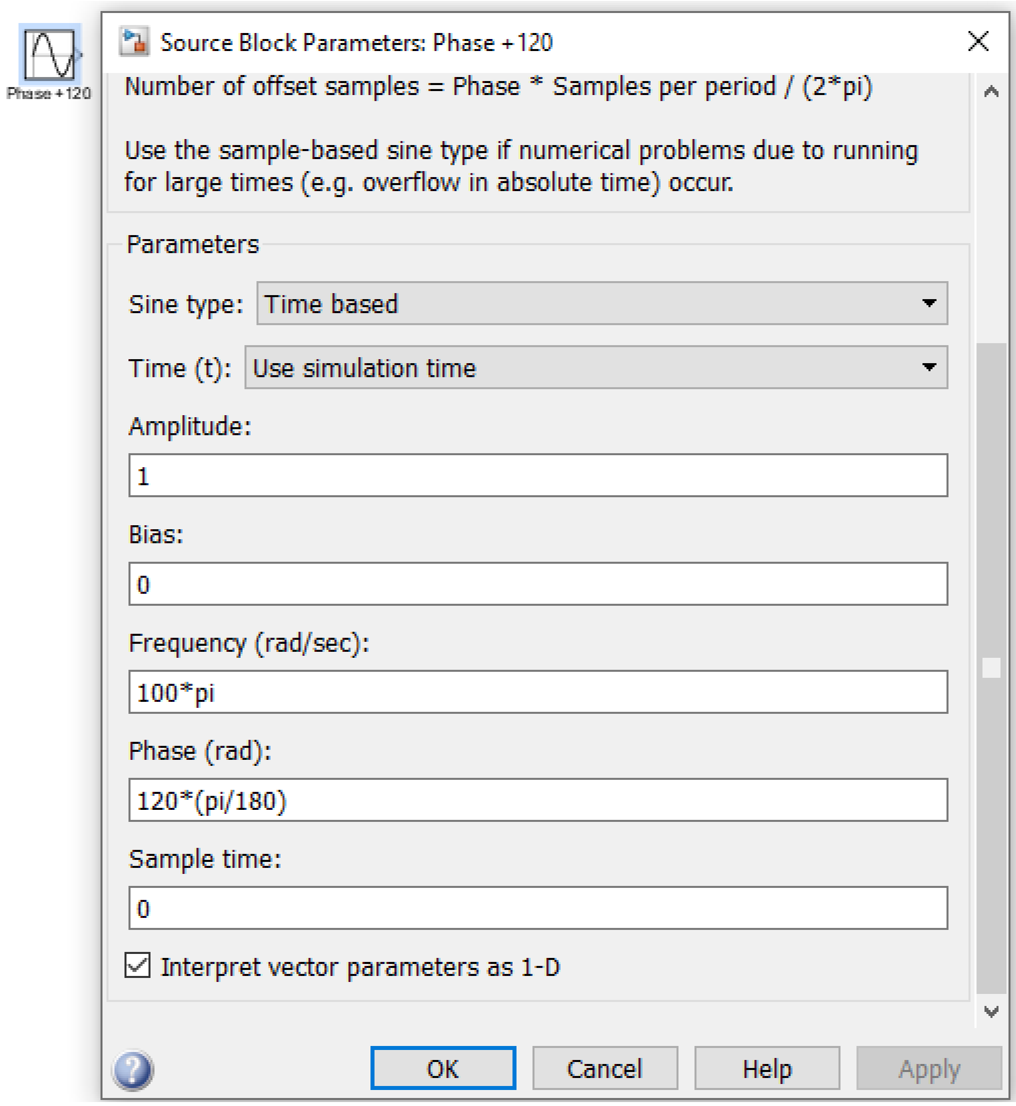


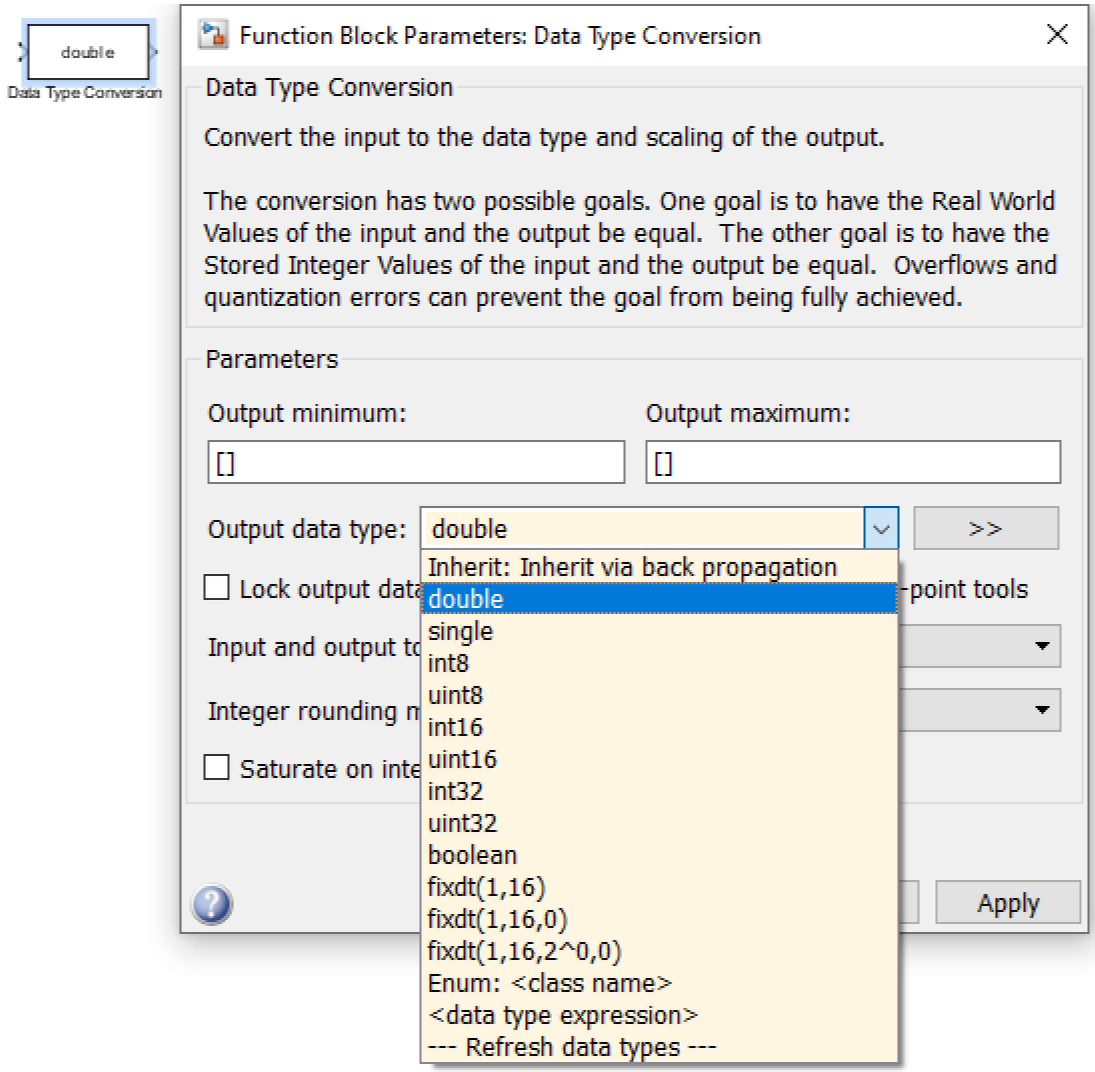
Gate Triggering circuit

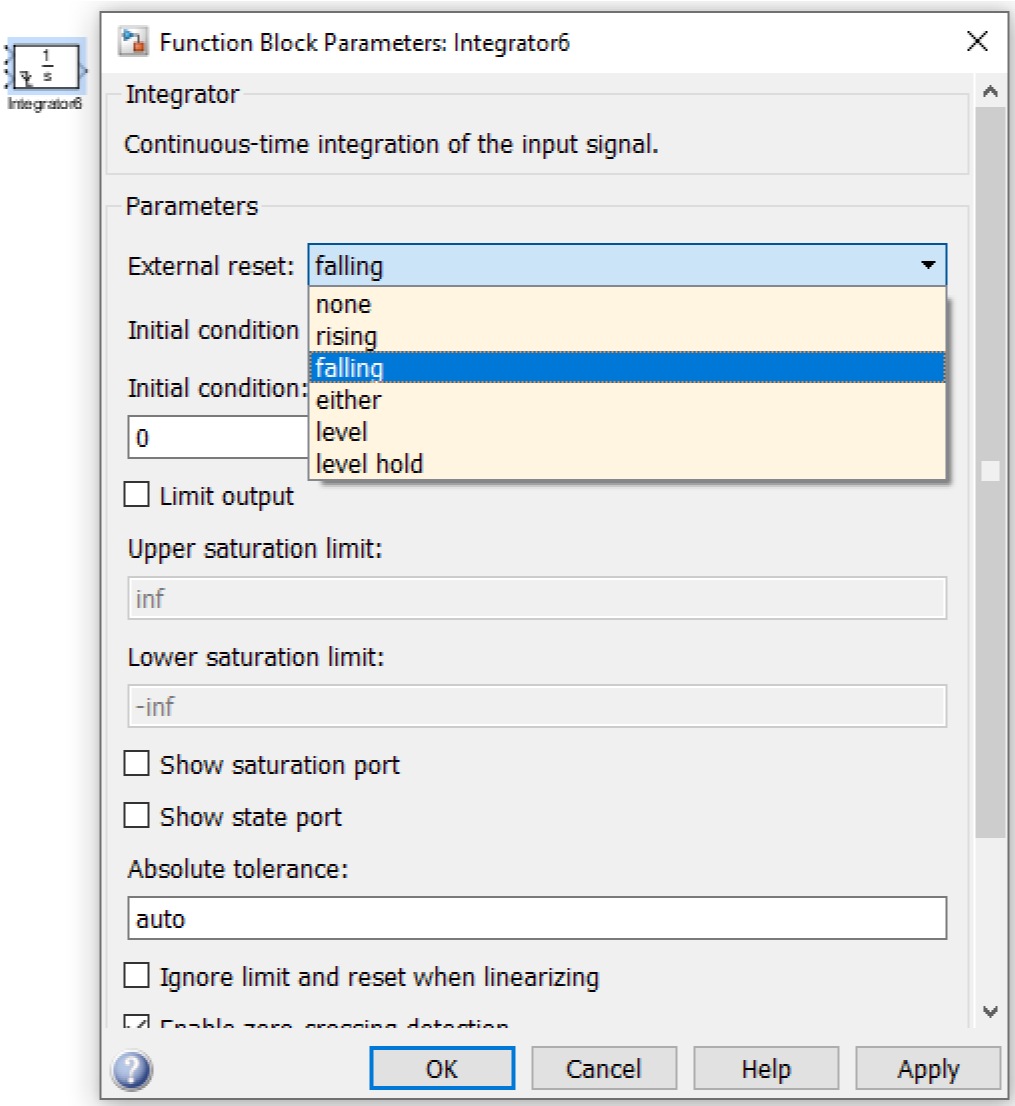



Phase 0
Source Block Parameters: Phase 0
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
1
Bias:
0
Frequency (rad/sec):
100*pi
Phase (rad):
0
Sample time:
0
OK
Cancel
Help
Apply


Phase -120
Source Block Parameters: Phase -120
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type:
Time based
Time (t):
Use simulation time
Amplitude:
1
Bias:
0
Frequency (rad/sec):
100*pi
Phase (rad):
-120*(pi/180)
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


Phase +120
Source Block Parameters: Phase +120
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
1
Bias:
0
Frequency (rad/sec):
100*pi
Phase (rad):
120*(pi/180)
Sample time:
0
Interpret vector parameters as 1-D
OK
Cancel
Help
Apply


double
Data Type Conversion
Function Block Parameters: Data Type Conversion
Data Type Conversion
Convert the input to the data type and scaling of the output.
The conversion has two possible goals. One goal is to have the Real World Values of the input and the output be equal. The other goal is to have the Stored Integer Values of the input and the output be equal. Overflows and quantization errors can prevent the goal from being fully achieved.
Parameters
Output minimum:
[]
Output maximum:
[]
Output data type:
double
>>
Lock output data
-point tools
Input and output to
Integer rounding m
Saturate on inte
Inherit: Inherit via back propagation
double
single
int8
uint8
int16
uint16
int32
uint32
boolean
fixdt(1,16)
fixdt(1,16,0)
fixdt(1,16,2^0,0)
Enum: <class name>
<data type expression>
--- Refresh data types ---
Apply



Integrator6
Function Block Parameters: Integrator6
Integrator
Continuous-time integration of the input signal.
Parameters
External reset:
falling
none
rising
falling
either
level
level hold
Initial condition
Initial condition:
0
Limit output
Upper saturation limit:
inf
Lower saturation limit:
-inf
Show saturation port
Show state port
Absolute tolerance:
auto
Ignore limit and reset when linearizing
OK
Cancel
Help
Apply

b) Hardware Implementation of 3-Phase (R Load)

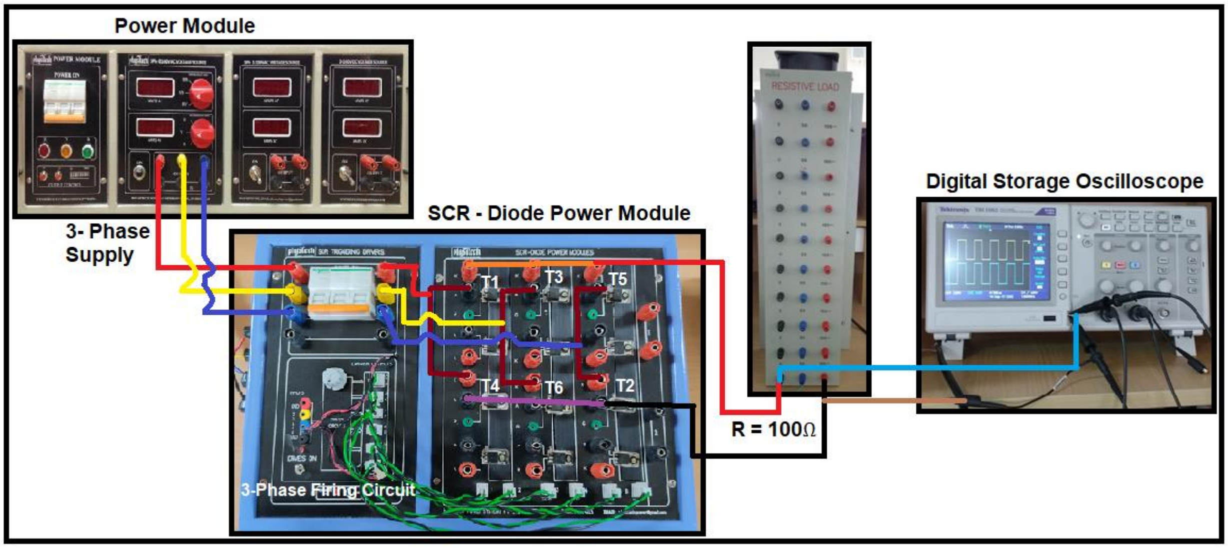


Fig. 3 Hardware implementation of 3-phase fully controlled converter

<u>Procedure:</u>

1. Connect the circuit as shown in Fig. 3 (with R load (**R=100 ohms**), Connect CRO probes across the R load to measure the output voltage.
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 **61.2 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** Load to measure the output voltage.
7. Vary the firing angle as mentioned in the “Exp7_Part B.doc” file.
8. Observe the Output voltage waveforms in the DSO.

.**<u>Conclusion:</u>** Obtain the results as per “Exp7_Part B.doc” file.