LABORATORY MANUAL

SIMULATION LAB

MATLAB
SIMULINK®

Rajiv Gandhi University of Knowledge Technologies
Basar

List of Experiments

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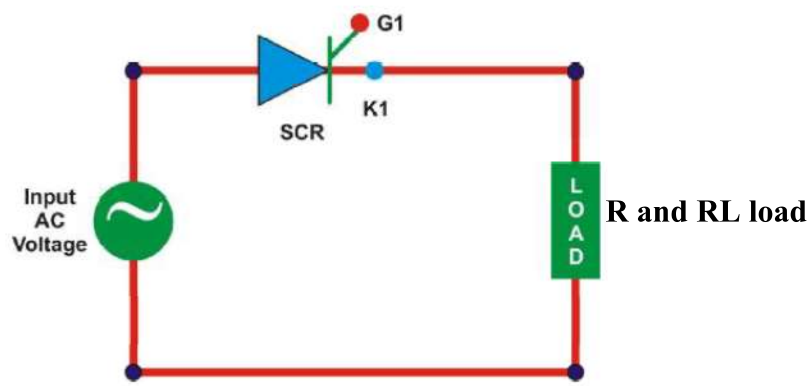
Experiment 1

Study of Single Phase Half Wave Controlled Rectifier with R and RL Load

Objective: To Study the simulation of Single Phase Half Wave Controlled Rectifier with R and RL Load using Simulink.

Software Needed: Matlab R2013a.

Circuit Diagram:



Single Phase Half Wave Controlled Rectifier with R and RL Load

Theory: Single-phase half wave controlled rectifier means that the single SCR is used to convert the ac to dc. During the positive half cycle of the input voltage, thyristor T1 is forward biased and current flows through the load when the thyristor is fired, at wt=α. The thyristor conducts only when the anode is positive with respect to cathode and a positive gate signal is applied, otherwise, it remains in the forward blocking state and blocks the flow of the load current. In the negative half cycle, i.e., at wt =π, the thyristor is in the reverse biased condition and no current flows through the load. Thus, varying the firing angle at which the thyristor starts conducting in positive half controls the average dc output voltage cycle. The waveforms of the above circuit are shown in fig the output load voltage and current is positive, i.e., they are one quadrant; it is called a half –wave semi converter.

Procedure:

1. Connect the Circuit as shown in circuit diagram.
2. Give the firing angle from pulse generator to generate suitable pulses.
3. Observe output voltage, current and thyristor voltages from the simuink model.
4. From display values note down the average and rms values of voltage and current .

5. Compare theoretical and practical values where both calculated and theoretical values must be same.

Observation table:

R load:

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	96.60	96.81	160.27	159.2	3.22	3.094	5.342	5.308
60	77.35	77.42	144.9	145.4	2.59	2.582	4.78	4.847
90	51.58	51.68	114.39	114.6	1.69	1.723	3.78	3.821

RL load :

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	89.665	89.48	162.634	162.3	2.988	2.983	4.643	4.683
60	70.74	70.75	148.0	148.1	2.34	2.358	4.024	4.028
90	45.29	45.39	117.56	117.7	1.510	1.513	2.856	2.899

Equations:

R load:

$$V_0 = \frac{V_m}{2\pi}\left(1+\cos\alpha\right)$$

$$V_{rms} = V_m\left[\frac{1}{4\pi}\left[\left(\pi-\alpha\right)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load :

$$V_0 = \frac{V_m}{2\pi}\left(\cos\alpha-\cos\beta\right)$$

$$V_{rms} = V_m\left[\frac{1}{4\pi}\left[(\beta-\alpha)+\frac{(\sin 2\beta - \sin 2\alpha)}{2}\right]\right]^{\frac{1}{2}}$$

Theoretical calculations:

$\alpha=30^0$ for R load where $R=30\Omega$

$V_0=\frac{230\sqrt{2}}{2\pi}\left(1+\cos 30^0\right)$=96.60 v.

$I_0=\frac{V_0}{R}=\frac{96.60}{30}$=3.22 A.

$$V_{rms} = 230*1.414\left[\frac{1}{4\pi}\left[(180-30)\frac{\pi}{180}+\frac{\sin 2(30)}{2}\right]\right]^{\frac{1}{2}} = 160.27 \text{ V.}$$

$I_{rms}=\frac{V_{rms}}{R}=\frac{160.27}{30}$=5.342 A.

$\alpha=30$, $\beta=210$, $R=30$ for RL load

$V_0=\frac{230\sqrt{2}}{2\pi}\left(\cos 30 - \cos 210\right)$=89.665V

$I_0=\frac{V_0}{R}=\frac{89.665}{30}$=29.88 A.

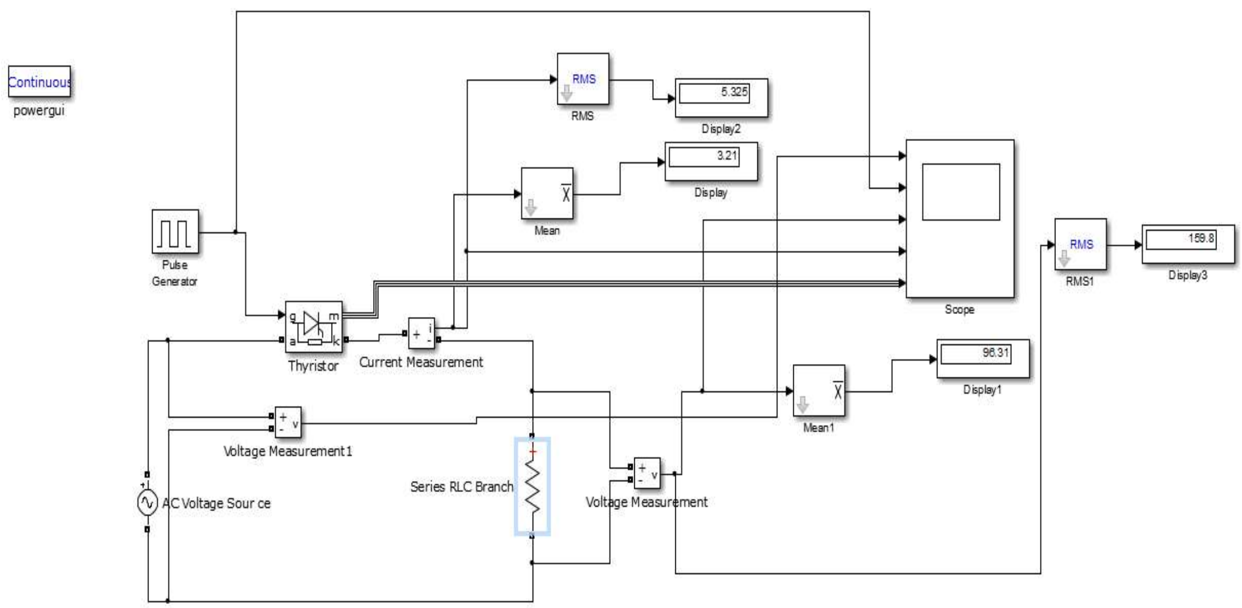
$$V_{rms} = 230*1.414\left[\frac{1}{4\pi}\left[(210-30)\frac{\pi}{180}+\frac{\sin 2(210)-\sin 2(30)}{2}\right]\right]^{\frac{1}{2}}$$

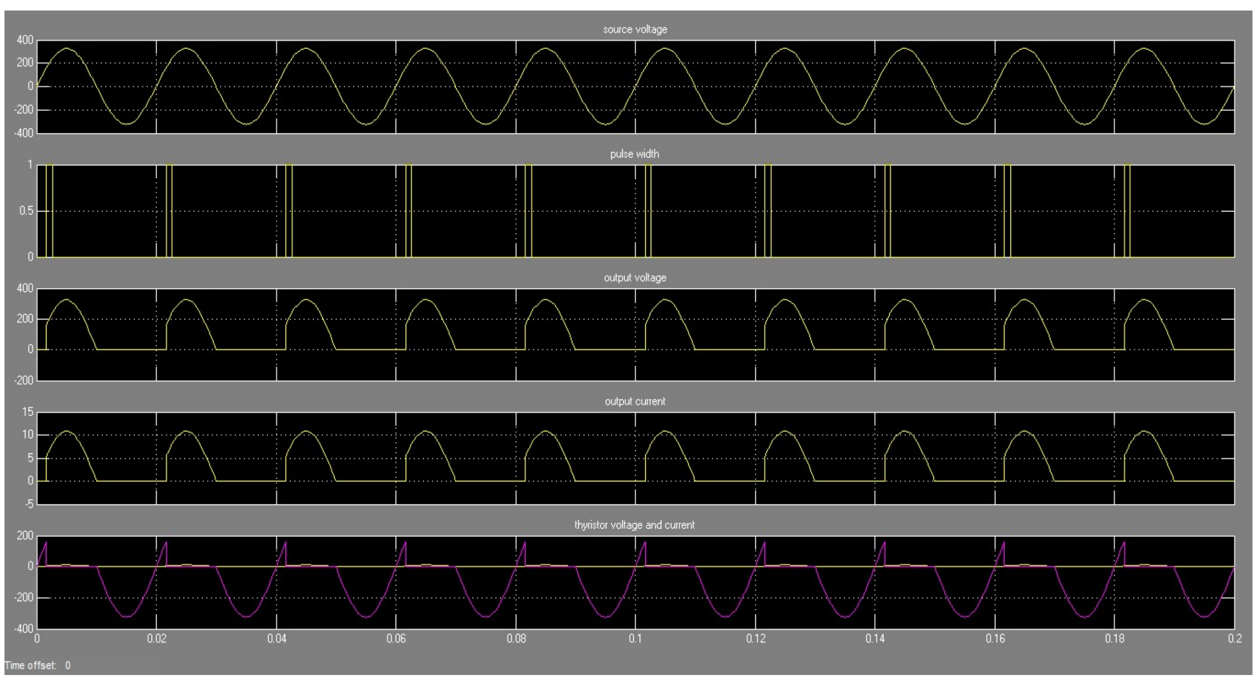
= 162.634 V

$I_{rms}=\frac{V_{rms}}{R}=\frac{162.634}{30}$=5.42 A.

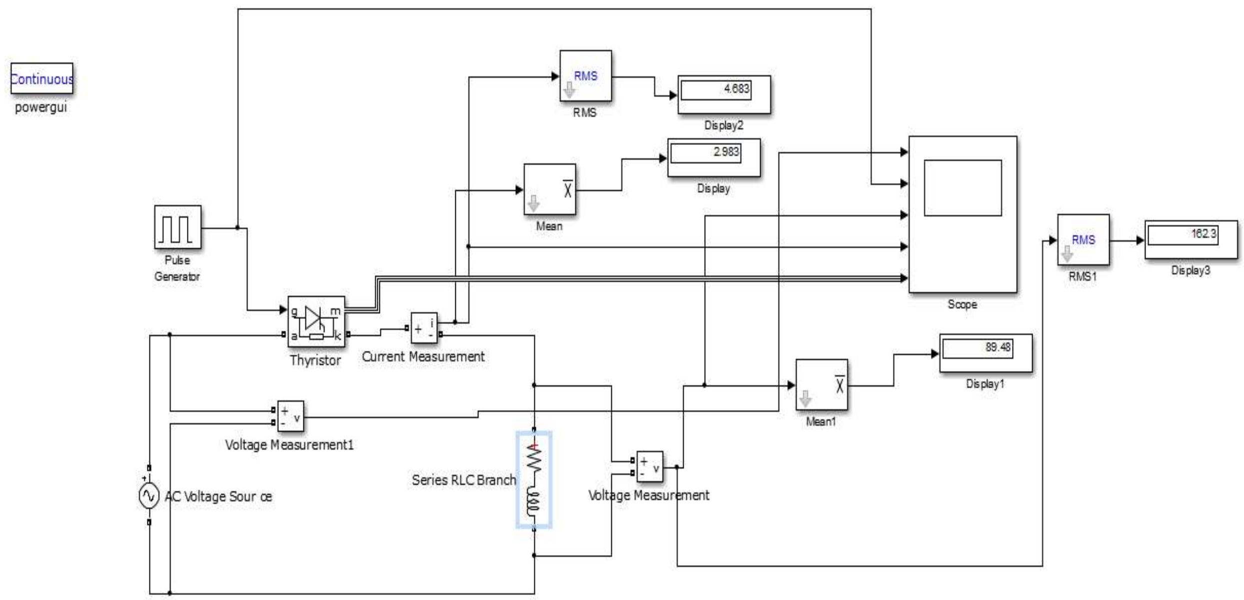
Experimental Matlab Model and Wavforms:

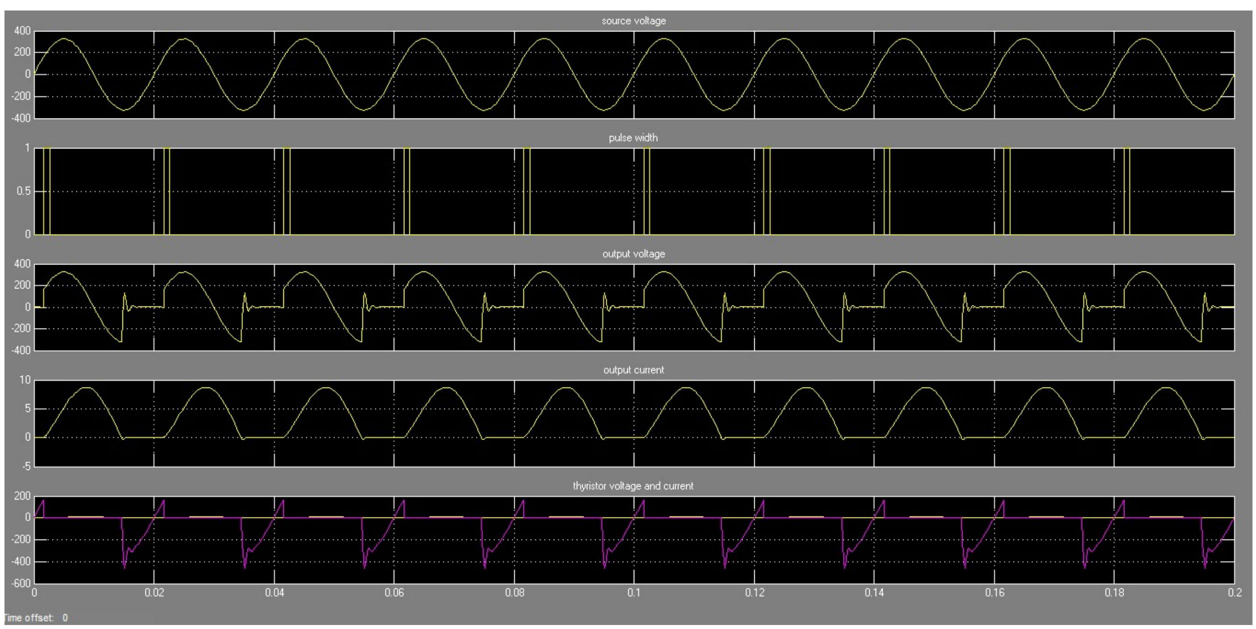
Single Phase Half Wave Controlled Rectifier R load model and waveform for α=30:





Single Phase Half Wave Controlled Rectifier Rl load model and waveform for α=30:





Result: Simulation of Single Phase Half Wave Controlled Rectifier with R and RL load is done successfully and the theoretical and practical results are verified.

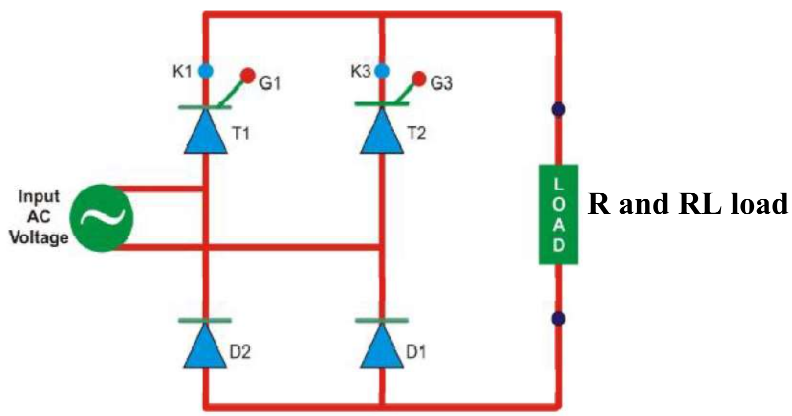
Experiment 2

Study of Single Phase semi converter with R and RL Load

Objective: To Study the simulation of Single Phase semi converter with R and RL Load using Simulink.

Software Needed: Matlab R2013a.

Circuit Diagram:



Single Phase semi converter with R and RL Load

Theory: In this configuration two thyristors are replaced by power diodes and can be connected in either arm of the bridge. Depending on the connections, these are further classified as

1. Symmetrical
2. Asymmetrical

Symmetrical configuration is in two types

1. Common cathode
2. Common anode

Out of these configurations, the common cathode symmetrical configuration is the most commonly used configuration, because a single trigger can be used to fire both thyristors without any electrically isolation. During the positive half cycle, when thyristor T1 is triggered, the load currents flows through T1 and the diode D2 in the circuit shown in figure. During the negative half –cycle, the thyristor T2 and the diode D1 constitute the load current.

Procedure:

1. Connect the Circuit as shown in circuit diagram.
2. Give the firing angle from pulse generator to generate suitable pulses.
3. Observe output voltage, current and thyristor voltages from the simuink model.
4. From display values note down the average and rms values of voltage and current .
5. Compare theoretical and practical values where both calculated and theoretical values must be same.

Observation table:

R load:

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	193.2	191.7	226.63	225.2	6.44	6.396	7.55	7.506
60	156.2	154.2	204	205	5.04	5.147	6.78	6.836
90	105	103	160.6	161.6	3.276	3.342	5.298	5.386

RL load :

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	193.2	191.7	226.63	225.2	6.44	6.391	7.55	7.438
60	156.12	154.2	204	205	5.04	5.4	6.78	6.694
90	104.5	102.7	160.6	161.6	3.276	3.424	5.298	5.178

Equations:

R load:

$$V_{0=}\frac{V_m}{\pi}\left(1+\cos\alpha\right)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[\left(\pi-\alpha\right)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load:

$$V_{0=}\frac{V_m}{\pi}\left(1+\cos\alpha\right)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[\left(\pi-\alpha\right)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

Theoretical calculations:

$\alpha=30^0$ for R load

$V_0=\dfrac{230\sqrt{2}}{\pi}\left(1+\cos 30^0\right)$=193.2 v.

$$V_{rms}=230\left[\frac{1}{\pi}\left[\left(180-30\right)\frac{\pi}{180}+\frac{\sin 2(30)}{2}\right]\right]^{\frac{1}{2}}=226.66\text{v.}$$

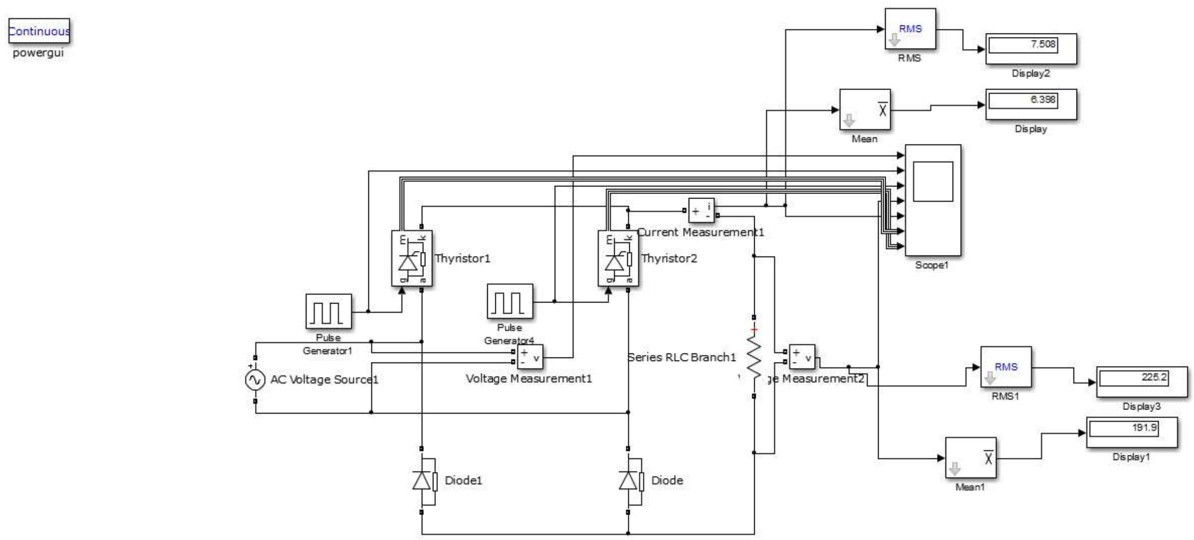
α=30 for RL load

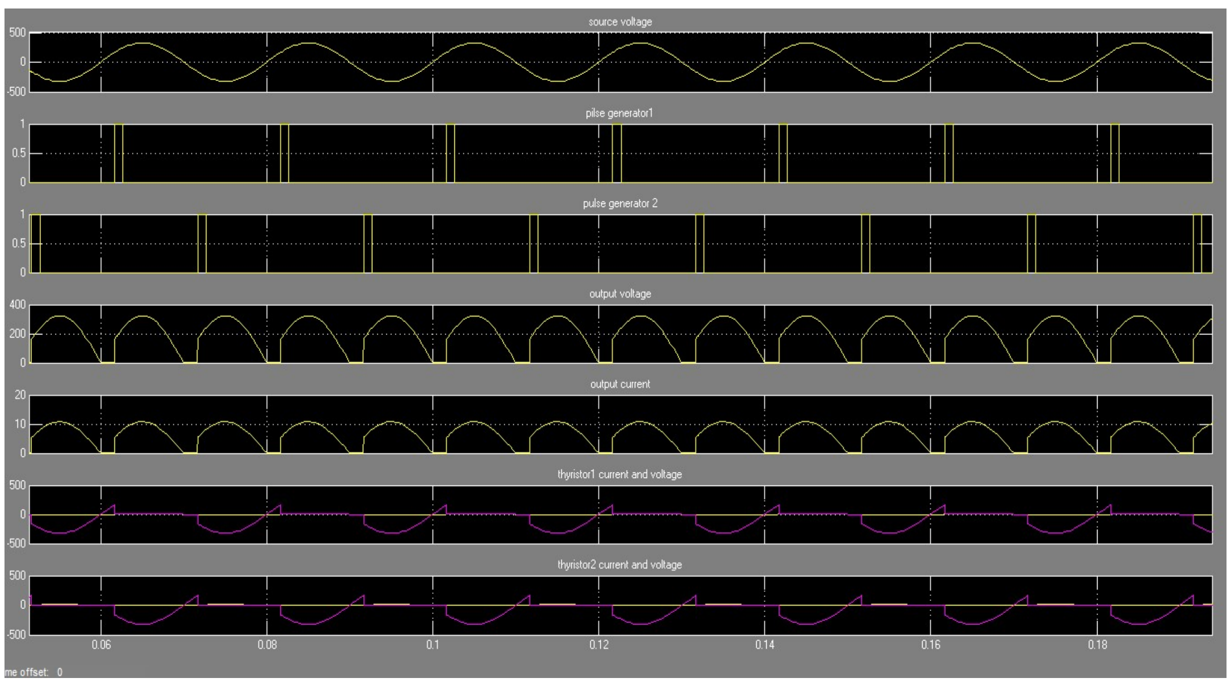
$V_0=\dfrac{230\sqrt{2}}{\pi}\left(1+\cos 30^0\right)$=193.2 v.

$$V_{rms}=230\left[\frac{1}{\pi}\left[\left(180-30\right)\frac{\pi}{180}+\frac{\sin 2(30)}{2}\right]\right]^{\frac{1}{2}}=226.67\text{v.}$$

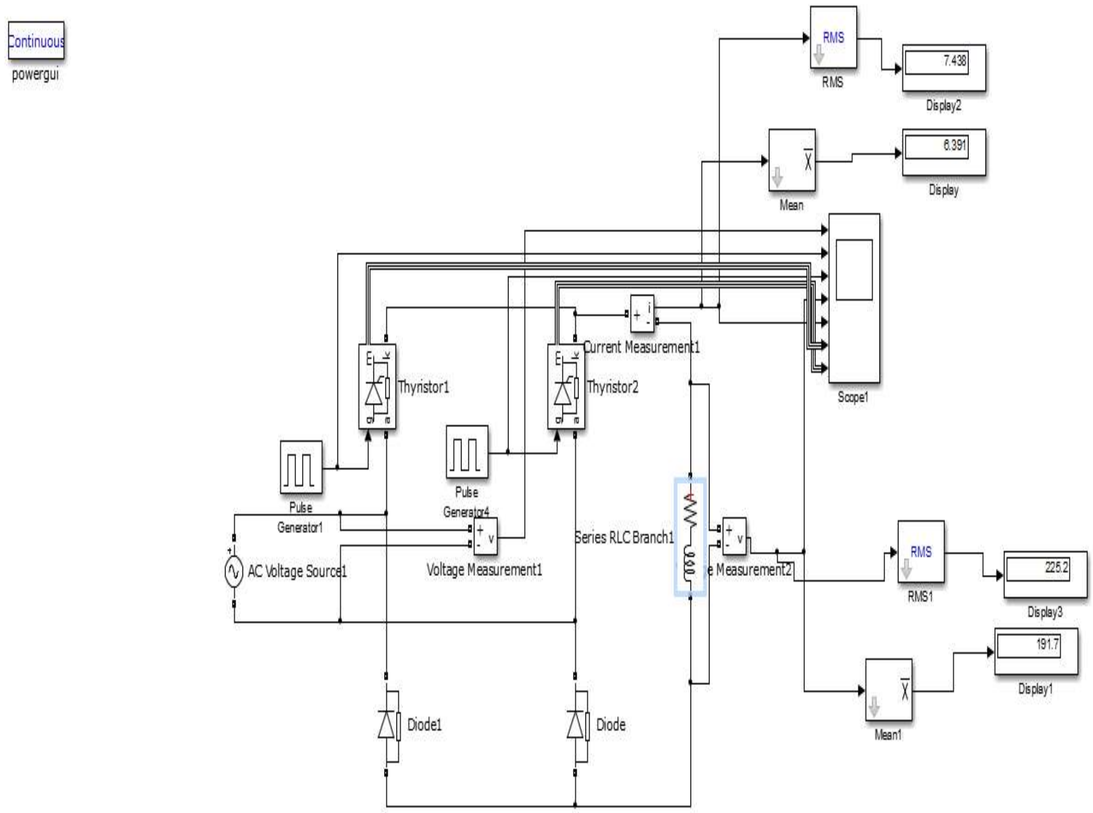
Experimental Mat lab Model and Waveforms:

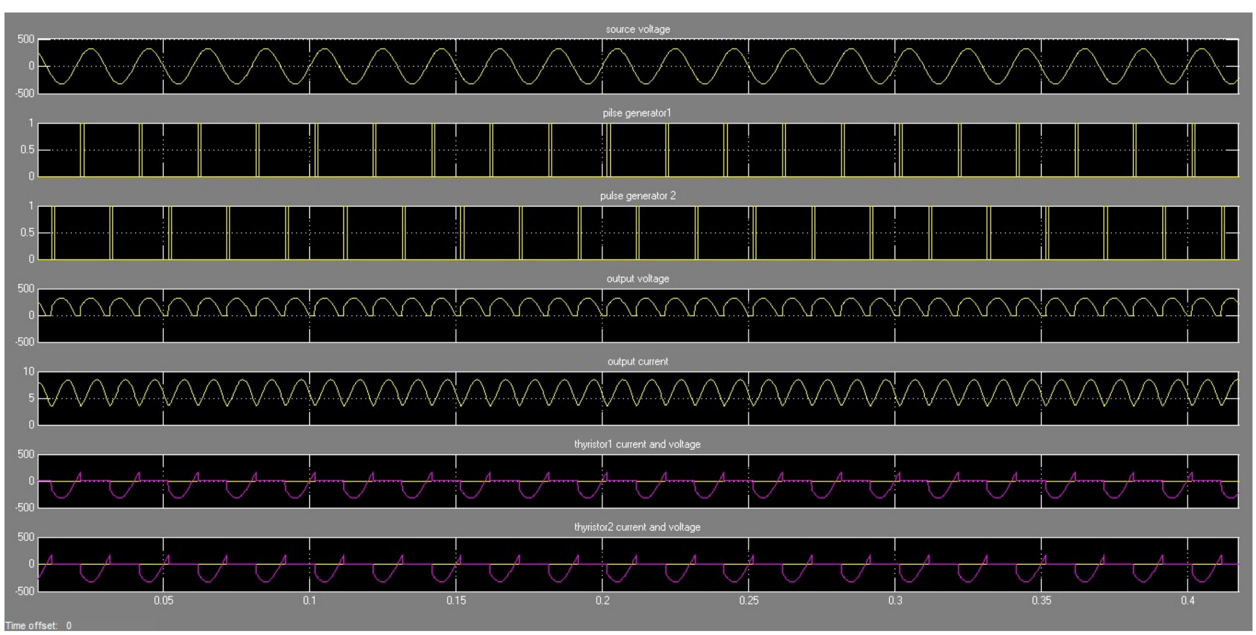
Single Phase Half Wave Controlled Rectifier R load model and waveform for α=30:





Single Phase Half Wave Controlled Rectifier Rl load model and waveform for α=30:





Result: Simulation of Single Phase Semi-Converter with R and RL load is done successfully and the theoretical and practical results are verified.

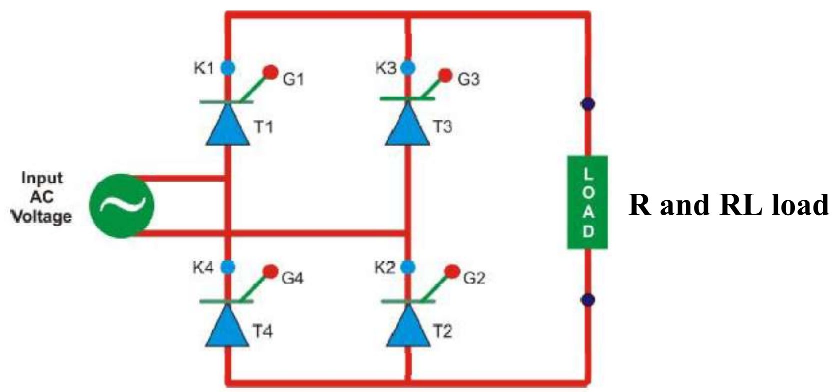
Experiment 3

Study of Single Phase Bridge Controlled Rectifier with R and RL load

Objective: To Study the simulation of Single Phase Bridge Controlled Rectifier with R and RL Load using Simulink.

Software Needed: Matlab R2013a.

Circuit Diagram:



Single Phase Bridge Controlled Rectifier with R and RL load

Theory: A single-phase fully controlled bridge circuit consists of four thyristor as shown in figure, with a resistive load. During the positive half cycle thyristors T1and T2 are in the forward blocking state and when these thyristors fire simultaneously at wt =α , the load is connected to the input through T1 and T2. During negative half cycle i.e., after wt =π , thyristor T3 and T4 are in the forward blocking state, and simultaneous firing of these thyristors reverse biases the previously conducting thyristors T1 and T2. These reverse biased thyristors turn off due to line or natural commutation and the load current transfers from T1and T2 to T3 and T4.

Procedure:

1. Connect the Circuit as shown in circuit diagram.
2. Give the firing angle from pulse generator to generate suitable pulses.
3. Observe output voltage, current and thyristor voltages from the simuink model.
4. From display values note down the average and rms values of voltage and current .
5. Compare theoretical and practical values where both calculated and theoretical values must be same.

Observation table:

R load:

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	193.2	191.7	226.65	225.1	6.44	6.396	7.55	7.506
60	156.2	154.2	203.9	204.9	5.24	5.147	6.78	6.836
90	104	102.7	160.5	161.5	3.45	3.342	5.28	5.386

RL load :

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
30	179.33	179.1	228	227.9	5.937	5.97	6.76	6.688
60	141.9	142.4	206.9	207.9	4.67	4.747	5.67	5.789
90	90.63	91.63	164	165	3.033	3.054	4.09	4.192

Equations:

R load:

$$V_{0=}\frac{V_m}{\pi}(1+\cos\alpha)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[(\pi-\alpha)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load :

$$V_{0=}\frac{V_m}{\pi}(\cos\alpha-\cos\beta)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[(\beta-\alpha)+\frac{\sin 2\alpha-\sin 2\beta}{2}\right]\right]^{\frac{1}{2}}$$

Theoretical calculations:

$\alpha=30^0$ for R load

$V_0=\frac{230\sqrt{2}}{\pi}\left(1+\cos 30^0\right)=193.2$ v.

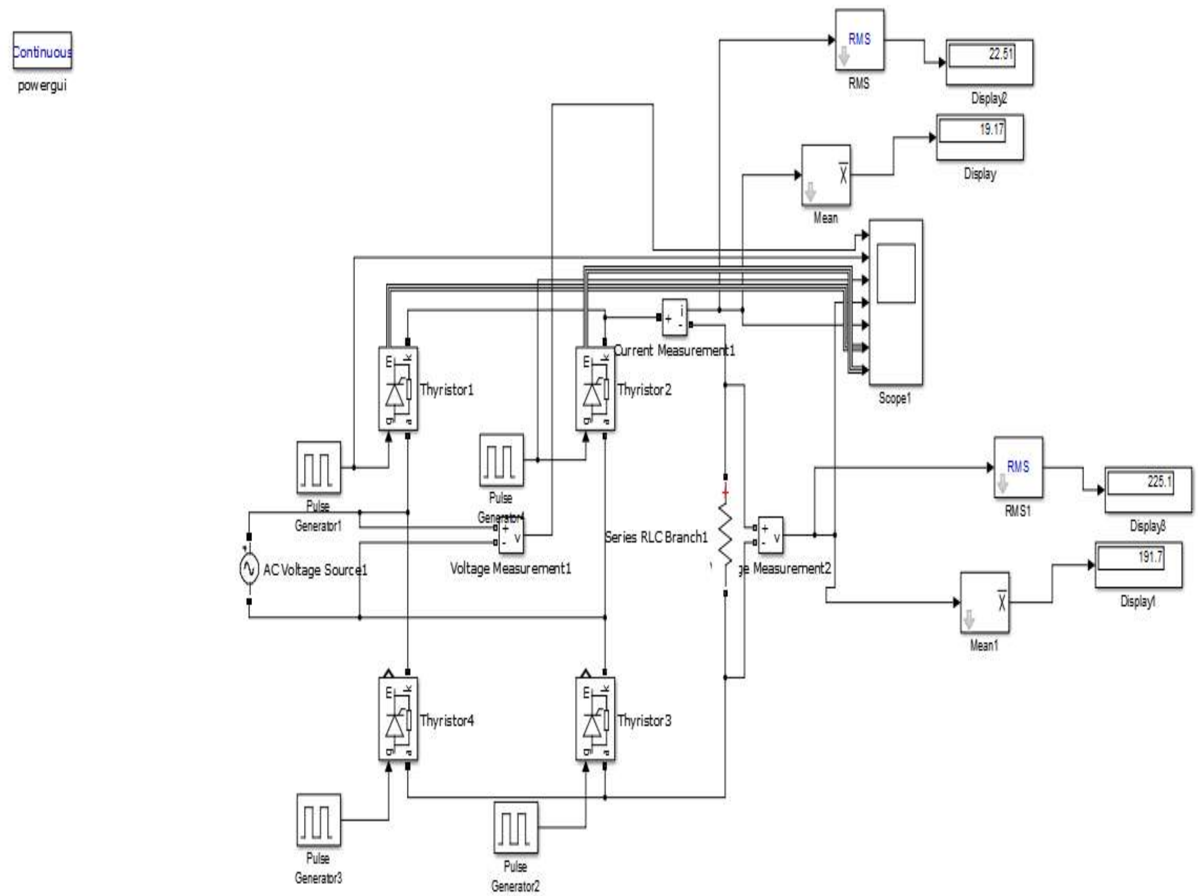
$I_0=\frac{V_0}{R}=\frac{193.2}{30}=6.44$ A.

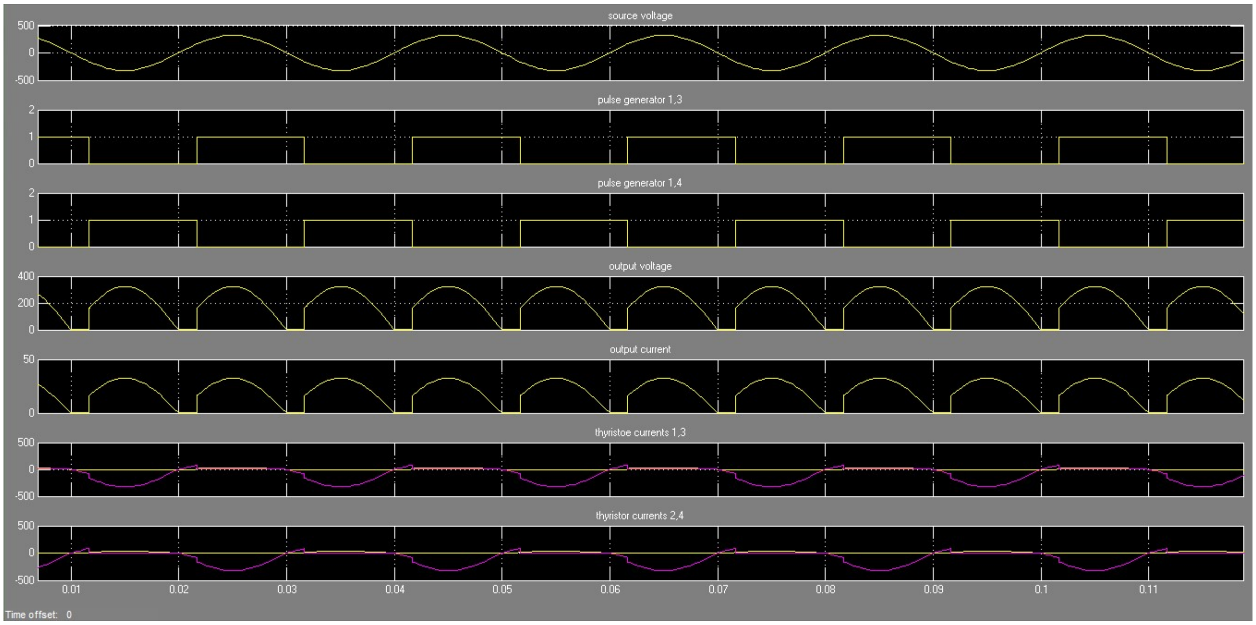
$$V_{rms}=230\left[\frac{1}{\pi}\left[\left(180-30\right)\frac{\pi}{180}+\frac{\sin 2(30)}{2}\right]\right]^{\frac{1}{2}} = 226.66\text{v.}$$

$I_{rms}=\frac{V_{rms}}{R}=\frac{226.66}{30}=7.666$ A.

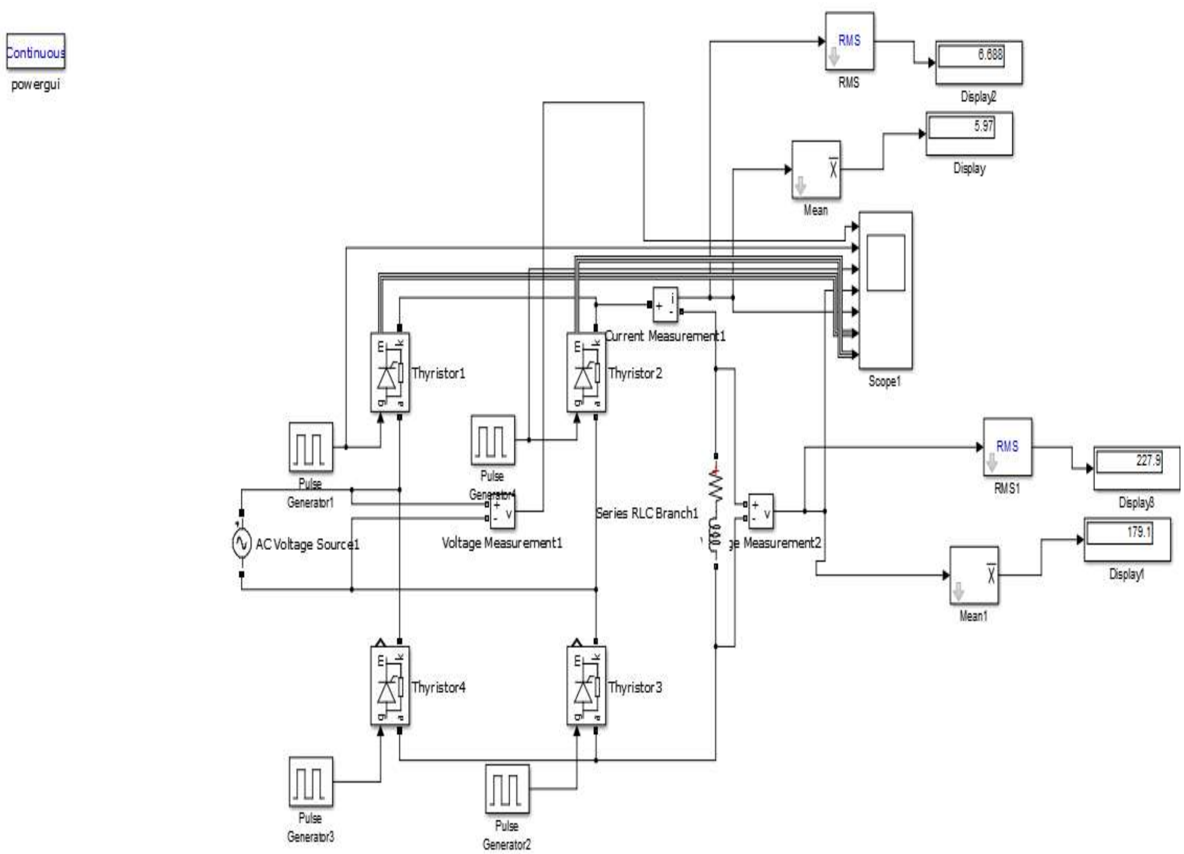
Experimental Mat lab Model and Waveforms:

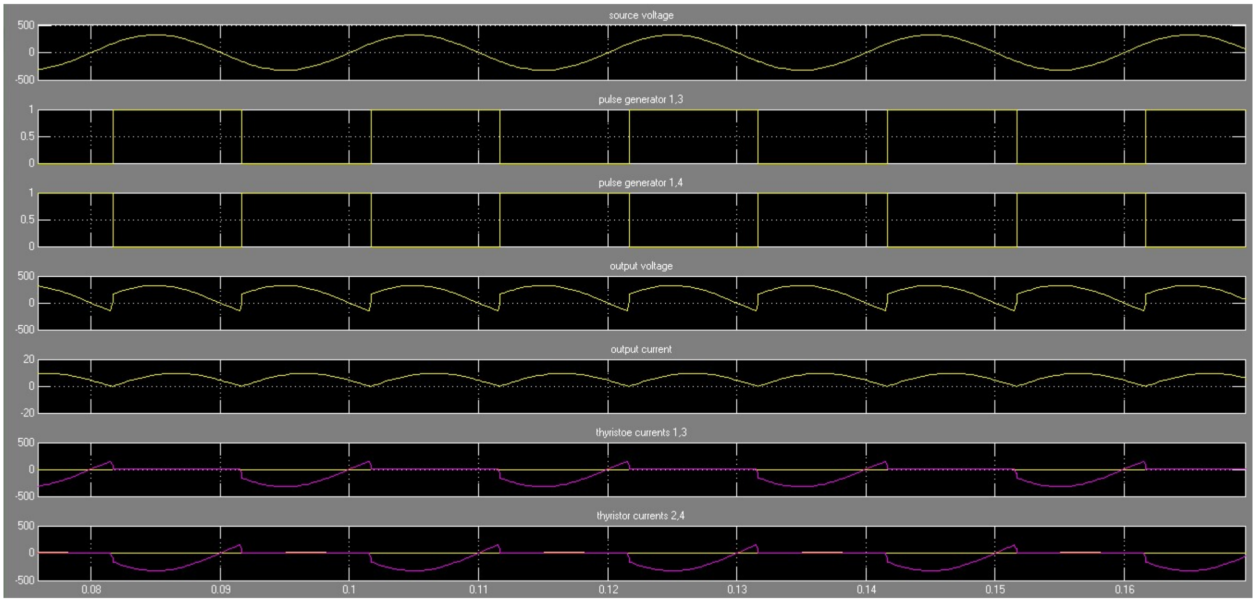
Single Phase Bridge Controlled Rectifier R load model and waveform for α=30:





Single Phase Bridge Controlled Rectifier RL load model and waveform for α=30:





Result: Simulation of Single Phase Bridge Controlled Rectifier with R and RL load is done successfully and the theoretical and practical results are verified.

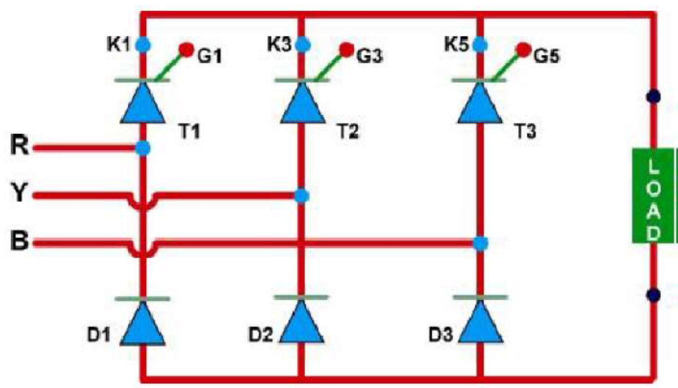
Experiment 4

Study of Three Phase Semi-Converter with R and RL load

Objective: To Study the simulation of Three Phase Semi-Converter with R and RL Load using Simulink.

Software Needed: Matlab R2013a.

Circuit Diagram:



R and RL load

Three Phase Semi-Converter with R and RL Load

Theory: The circuit of three phase semi-converter consists of three SCRs and three diodes. The circuit diagram of three phase semi converter is shown in Figure. The output load voltage Vo across the load terminals is controlled by varying the firing angles of SCRs T1, T2 and T3. The diodes D1, D2 and D3 provide merely a return path for the current to the most negative line terminal. For a firing angle delay of α=0 thyristors T1, T2, T3 would behave as diodes and the output voltage of semi-converter would be symmetrical six pulse per cycle .The output voltage consisting of pulses Vcb, Vab, Vac, Vbc. When the firing angle is delayed to α=15 SCRs T1, T2, T3 is delayed but return diodes D1, D2, D3 remain unaffected so that only alternate pulses are altered. The load current is continuous and has little ripple. The FD does not come into play for α=15. Each SCR and diode conduct for 120 degree. Vcb is the load voltage from wt =0 to 60 . As the first subscript indicates conducting element in the positive group, Vcb shows that T3 is already conducting through diode B2 of negative group. Voltages Vab, Vac indicate that, according to the first subscript, T1 conducts for 120 and it begins to conduct at t =60 for t =0 Similarly, Vbc, Vba indicate that T2 conducts for 120 and it begins to conduct at t =180 for α=0 . An SCR with zero degree firing angle behaves like a simple diode. Thus, per the definition of firing angle, it should be measured from wt =60 for T1, from wt =180 for T2, from wt =300 for T3 and so on. For wt =60 , figure The thyristor are fired so that current returns through one diode during each 120 conduction period. For voltage Vac, T1 and D3 conduct simultaneously for 120 Similarly, other elements conduct. FD does not come into play even for α = wt =60 . Further note that vltage pulses Vab, Vbc, Vca do not appear in the output voltage waveform for α=60 . It will be seen that for α greater than or equal to 60 , voltage pulses Vab, Vbc, Vca are eliminated. The load current, assumed continous for α = 60 is not shown.

For firing angle delay of 90 , voltage and current waveformare shown in figure The output voltage Vo is discontinous. As Vo made up of Vcb, Vac, Vba, Vcb., tends to become negative at t =120 , 240 , 360 , FD gets forward biased. Therefore, for each periodic cycle of 120 , output voltage is equal to line voltage for only 90 and for the remaining 30 , when FD conducts, Vo =0. For α=90 , conduction angle of SCRs

and diodes is seen to be less than 120 for every output pulse. In other words, conduction angle for both positive and negative group elements is 90 and for the remaining 30 , current completes its path through FD .For α=90 voltage pulses Vab, Vbc, Vca are absent from output voltage Vo for this firing angle as well. Without FD, after load voltage Vo reaches Zero, a diode from negative group would begin to conduct reducing Vo to zero till next SCR in sequence is triggered. For example, at wt =120 , Vo= Vcb =0 and without FD, D3 from negative group would start conducting through T3 from t =120 to t =150 when SCR T1 is gated. This means that without FD, T3 would conduct for 120 from t =30 to 150 , D2 for 90 from t =30 to t =120 and D3 for 30 from t =120 to t =150 for this periodic cycle of 120 extending from t =30 to t =150 . For firing angle delay of 120 .The load current is now assumed discontinuous. For each periodic cycle of 120 , Vo is seen to have three components. When an SCR is gated, thyristor and diode conduct for 60 only. As Vo reaches zero and tends to become negative, FD gets forward biased and therefore starts conducting for some angle and holds the load voltage to zero. When all the energy stored n inductance is dischared, FD stops conducting and as a result, load voltage rises to load counter emf E. When Vo=E, none of the elements of semicoverter bridge is conducting, this is indicated by 0, 0 in figure It may be seen fromabove that in a three phase semi-converter , SCRs are gated at an interval of 120 in proper sequence. In a single phase semi-converter , SCRs are firied at an interval of 180 . In order to obtain full control of the DC output voltage Vo, the range of firing angle is from 0 to 180 . A three phase semi-converter has a unique feature of working as a six pulse converter for α < 60 and as a three pulses converter for α greater than or equal to 60 , a careful observation . For a three phase semiconerter, each periodic cycle of output voltage has a periodicity of 120 . Average output voltage should, therefore, be calculated over 120 only.

Procedure:

1. Connect the Circuit as shown in circuit diagram.
2. Give the firing angle from pulse generator to generate suitable pulses.
3. Observe output voltage, current and thyristor voltages from the simuink model.
4. From display values note down the average and rms values of voltage and current .
5. Compare theoretical and practical values where both calculated and theoretical values must be same.

Observation table:

R load:

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
0	540.8	538.6	540.6	539	18.006	17.95	18.02	17.97
15	530.986	531.2	532.4	532.4	17.69	17.71	17.746	17.75
30	405.14	391.1	439	430.4	13.5	13.04	14.63	14.35

RL load :

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
0	540.8	538.6	540.6	539	18.006	17.95	18.02	17.97
15	530.986	531.2	532.4	532.4	17.69	17.71	17.746	17.75
30	405.14	391.1	439	430.4	13.5	13.04	14.63	14.35

Equations:

R load and RL load:

$$V_0 = \frac{3V_m}{2\pi}\left(1+\cos\alpha\right)$$

$$V_{rms} = \frac{V_{ml}}{2}\left[\frac{3}{\pi}\left[\frac{2\pi}{3}+\frac{\sqrt{3}}{2}\left(1+\cos 2\alpha\right)\right]\right]^{\frac{1}{2}}$$

Theoretical calculations for R and RL load:

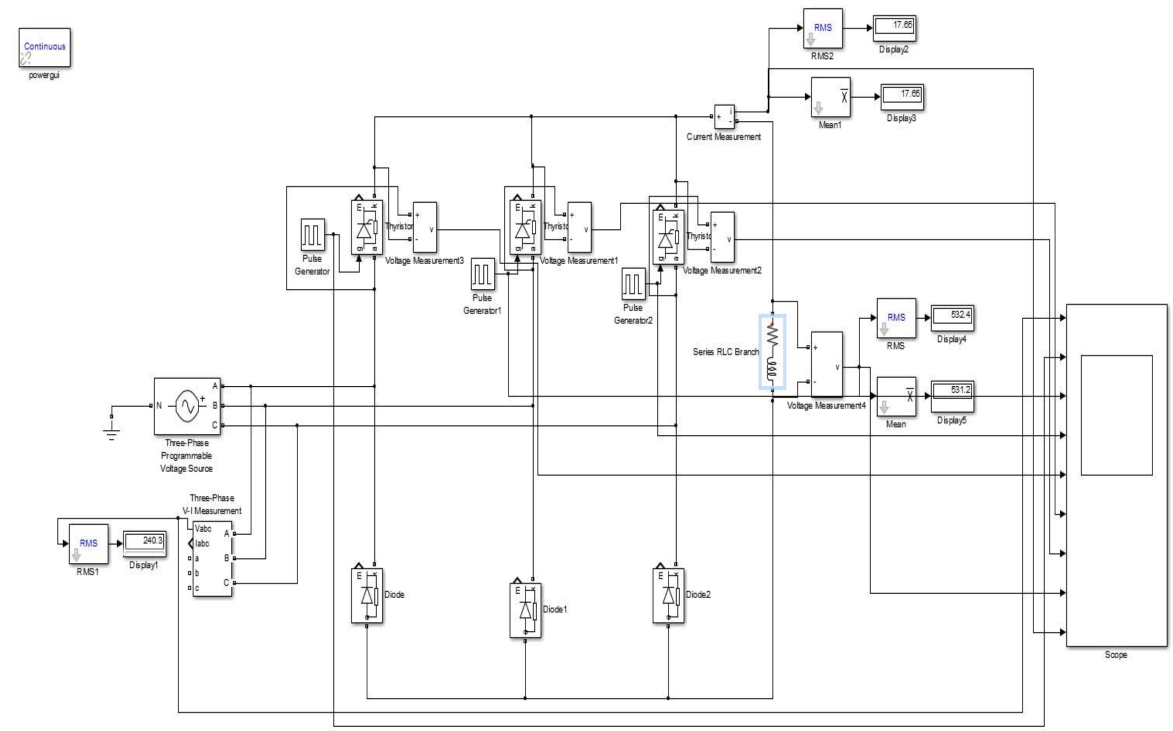
α =0 ,R=30.

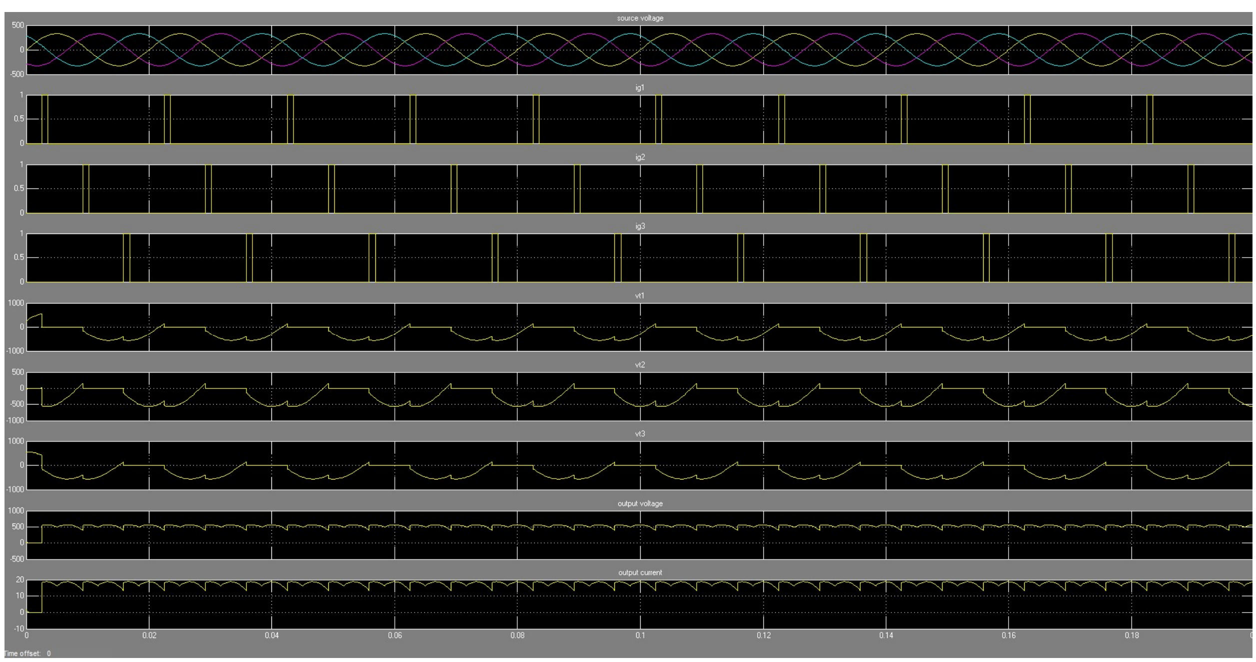
$$V_0 = \frac{3*\sqrt{2}*400}{2\pi}\left(1+\cos 0\right) = 540.189$$

$$V_{rms} = \frac{\sqrt{2}*400}{2}\left[\frac{3}{\pi}\left[\frac{2\pi}{3}+\frac{\sqrt{3}}{2}\left(1+\cos 2(0)\right)\right]\right]^{\frac{1}{2}} = 509$$

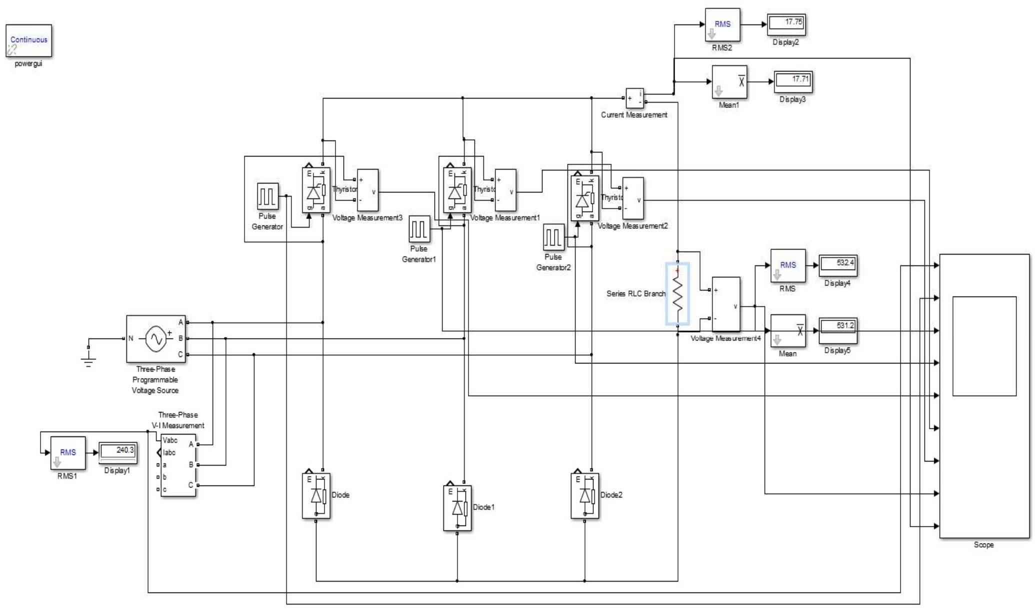
Experimental Mat lab Model and Waveforms:

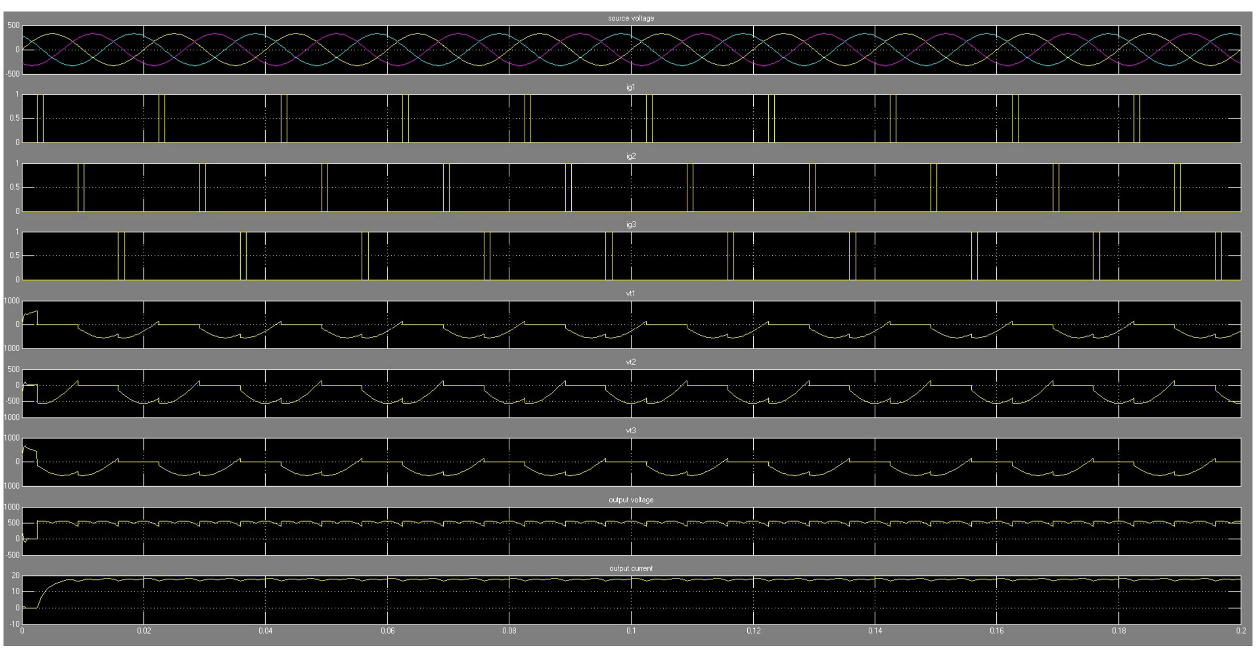
Single Phase Bridge Controlled Rectifier R load model and waveform for α=15:





Single Phase Bridge Controlled Rectifier RL load model and waveform for α=15:





Result: Simulation of Three phase semi-converter with R and RL load is done successfully and the theoretical and practical results are

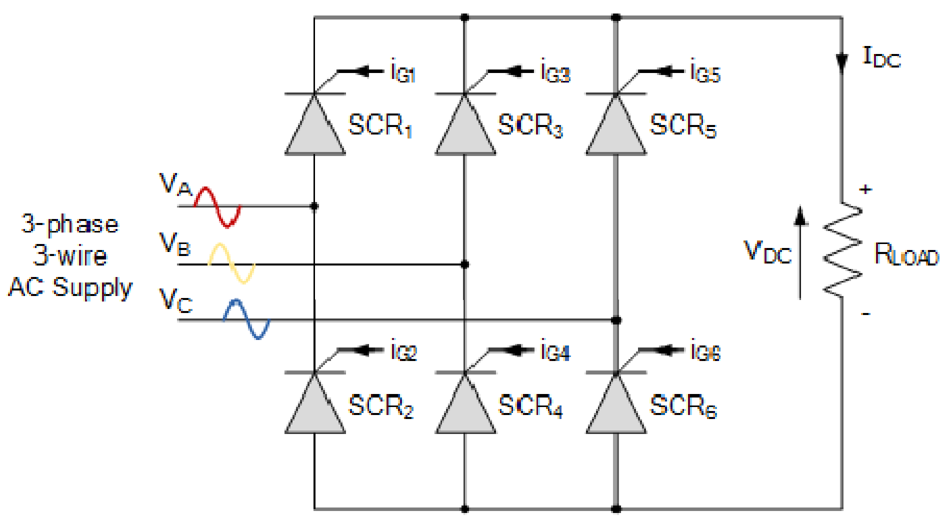
Experiment 5

Study of Three Phase Full Bridge Converter with R and RL load

Objective: To Study the simulation of Three Phase Full Bridge Converter with R and RL Load using Simulink.

Software Needed: Matlab R2013a.

Circuit Diagram:



$$V_{DC} = \frac{3\sqrt{3}}{\pi} V_S * \cos(\alpha)$$

Three Phase Full Bridge Converter with R and RL load

Theory: For any current to flow in the load at least one device from the top group (T1, T3, T5) and one from the bottom group (T2, T4, T6) must conduct. It can be argued as in the case of an uncontrolled converter only one device from these two groups will conduct. Then from symmetry consideration it can be argued that each thyristor conducts for 120° of the input cycle. Now the thyristors are fired in the sequence T1 → T2 → T3 → T4 → T5 → T6 → T1 with 60° interval between each firing. Therefore thyristors on the same phase leg are fired at an interval of 180° and hence can not conduct simultaneously. This leaves only six possible conduction mode for the converter in the continuous conduction mode of operation. These are T1T2, T2T3, T3T4, T4T5, T5T6, T6T1. Each conduction mode is of 60° duration and appears in the sequence mentioned. Each of these line voltages can be associated with the firing of a thyristor. For example the thyristor T1 is fired at the end of T5T6 conduction interval. During this period the voltage across T1 was vac. Therefore T1 is fired α angle after the positive going zero crossing of vac. Similar observation can be made about other thyristors. If the converter firing angle is α each thyristor is fired "α" angle after the positive going zero crossing of the line voltage with which it's firing is associated. Once the conduction diagram is drawn all other voltage waveforms can be drawn from the line voltage waveforms Similarly line currents can be drawn from the output current and the conduction diagram. It is clear from the waveforms that output voltage and current waveforms are periodic over one sixth of the input cycle. Therefore this converter is also called the "six pulse" converter. The input current on the other hand contains only odds harmonics of the input frequency other than the triplex (3rd, 9th etc.) harmonics. The next section will analyze the operation of this converter in more details.

Procedure:

1. Connect the Circuit as shown in circuit diagram.
2. Give the firing angle from pulse generator to generate suitable pulses.
3. Observe output voltage, current and thyristor voltages from the simuink model.
4. From display values note down the average and rms values of voltage and current .
5. Compare theoretical and practical values where both calculated and theoretical values must be same.

Observation table:

R load:

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
0	540.8	538.6	540.6	539	18.006	17.95	18.02	17.97
30	467.81	466.2	475.7	474	15.59	15.54	15.85	15.8
60	270.09	268.6	306.33	305	9.003	8.953	10.211	10.17

RL load :

Firing angle(α)	V_{avg}(cal)	V_{avg}(sim)	V_{rms}(cal)	V_{rms}(sim)	I_{avg}(cal)	I_{avg}(sim)	I_{rms}(cal)	I_{rms}(sim)
0	540.8	538.6	540.6	539	18.006	17.95	18.02	17.97
30	467.81	466.2	475.7	474	15.59	15.54	15.85	15.8
60	270.09	268.6	306.33	305	9.003	8.953	10.211	10.17

Equations:

R load and RL load:

α <60 , R=30, L=0.03 H

$$V_0 = \frac{3V_m}{\pi}(\cos\alpha)$$

$$V_{rms} = V_m\left[\frac{3}{2\pi}\left[\frac{\pi}{3}+\frac{\sqrt{3}}{2}(\cos 2\alpha)\right]\right]^{\frac{1}{2}}$$

α >60

$$V_0 = \frac{3V_m}{\pi}\left(1+\cos(\alpha+\frac{\pi}{3}\right)$$

$$V_{rms} = \frac{3V_{ml}}{2\pi}\left[\left[\left(\frac{2\pi}{3}-\alpha\right)+\frac{1}{2}\left(1+\left(\sin\left(\frac{2\pi}{3}+2\alpha\right)\right)\right)\right]\right]^{\frac{1}{2}}$$

Thoretical Calculations:

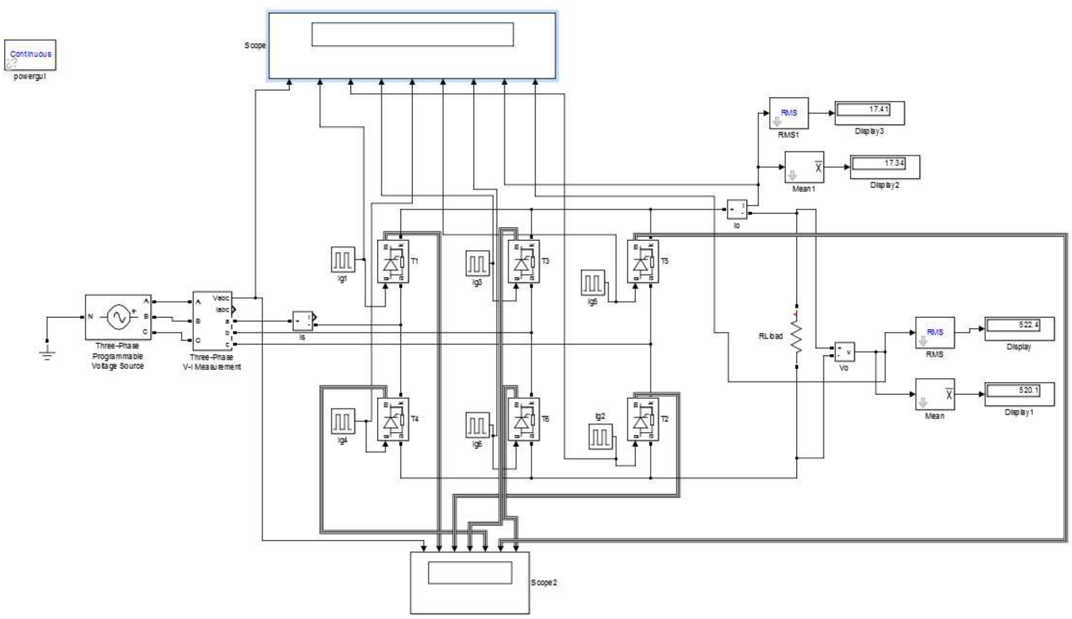
α 30 , R=30, L=0.03 H

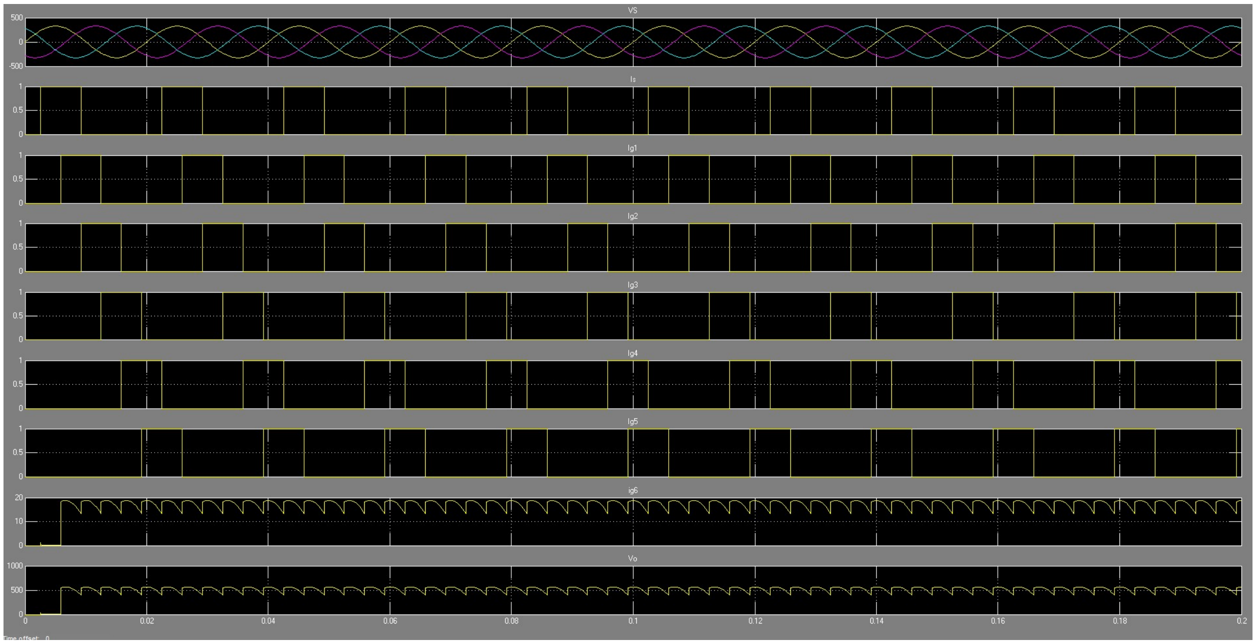
$$V_0 = \frac{3*\sqrt{2}*400}{\pi}(\cos 30) = 467.818$$

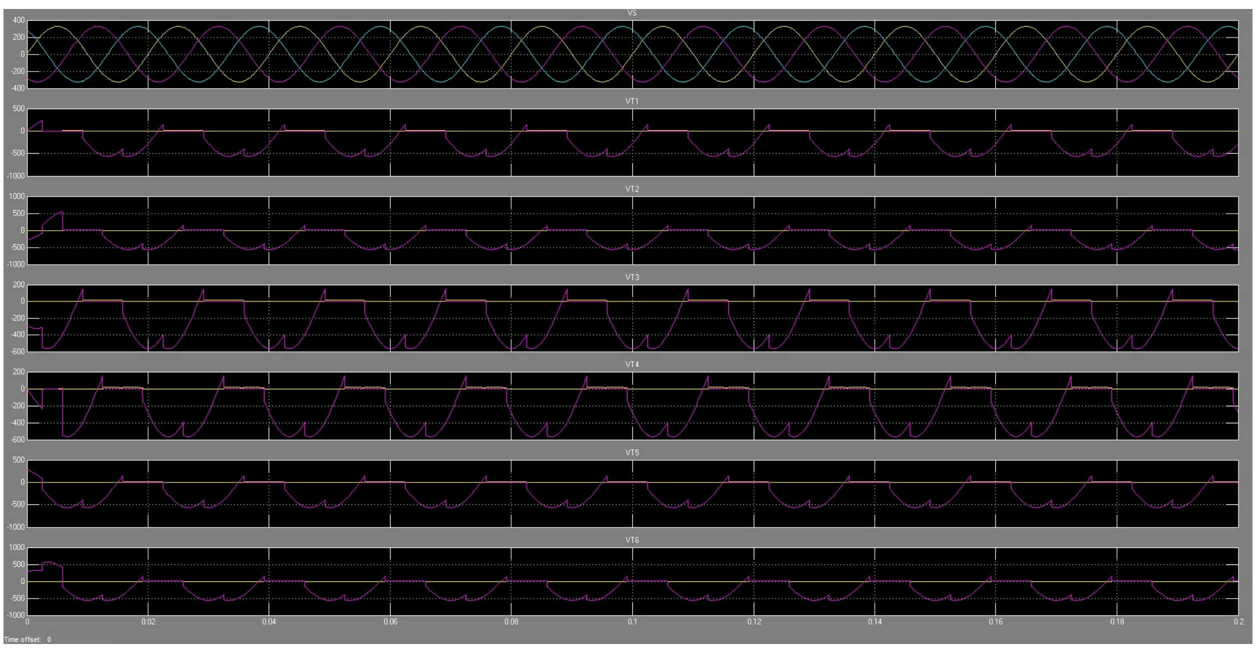
$$V_{rms} = \sqrt{2} * 400\left[\frac{3}{2\pi}\left[\frac{\pi}{3} + \frac{\sqrt{3}}{2}\left(\cos 2(30)\right)\right]\right]^{\frac{1}{2}} = 475.56$$

Experimental Mat lab Model and Waveforms:

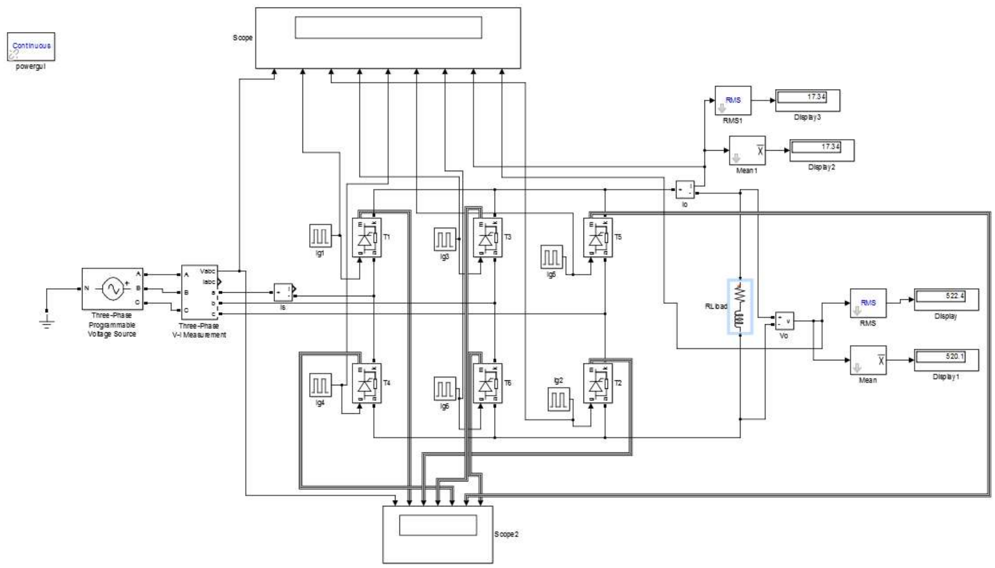
Three Phase Bridge Controlled Rectifier R load model and waveform :

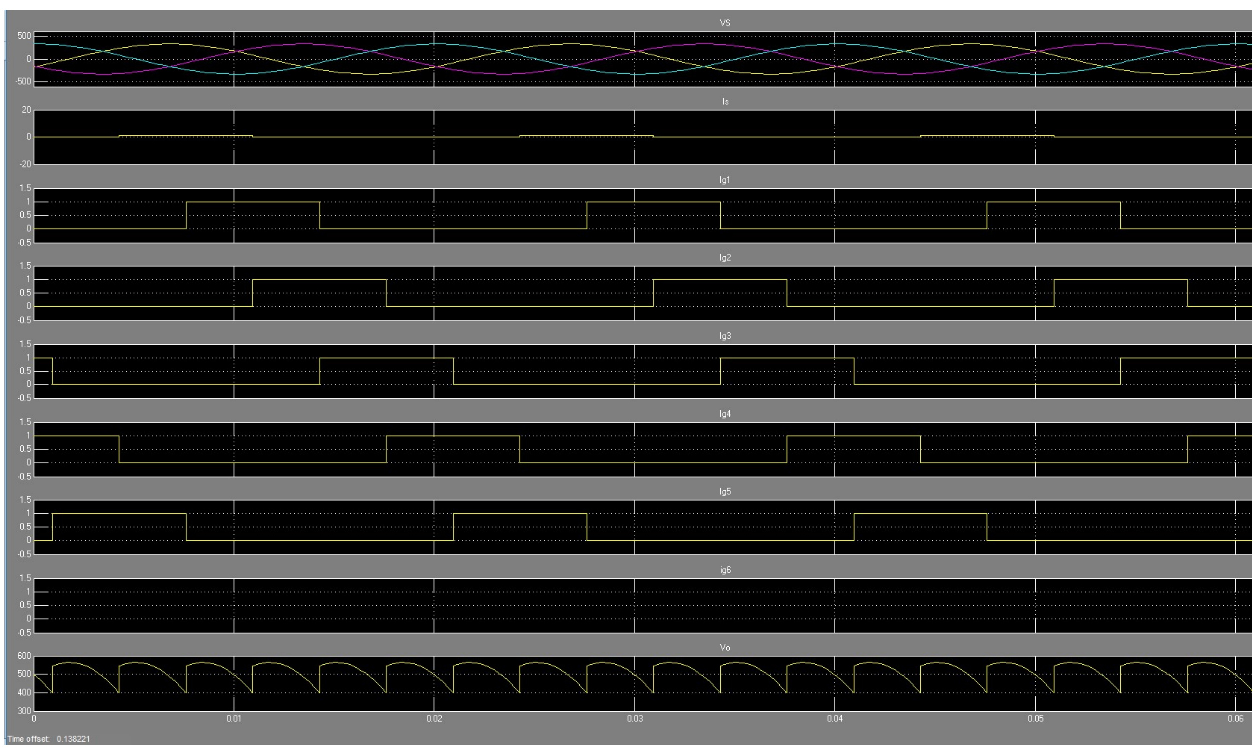


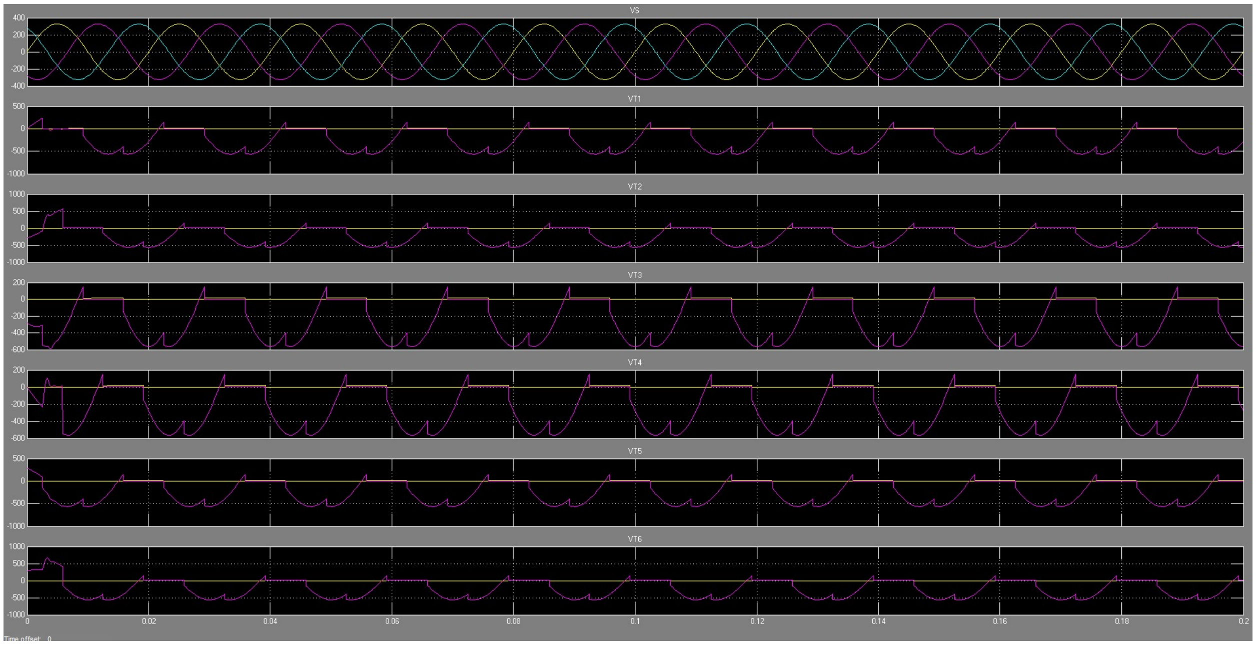

VS
Is
Ig1
Ig2
Ig3
Ig4
Ig5
Ig6
Vo
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2
Time offset: 0


VS
VT1
VT2
VT3
VT4
VT5
VT6
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2
Time offset: 0

Three Phase Bridge Controlled Rectifier Rl load model and waveform:







Result: Simulation of Three phase full bridge converter with R and RL load is done successfully and the theoretical and practical results are verified.

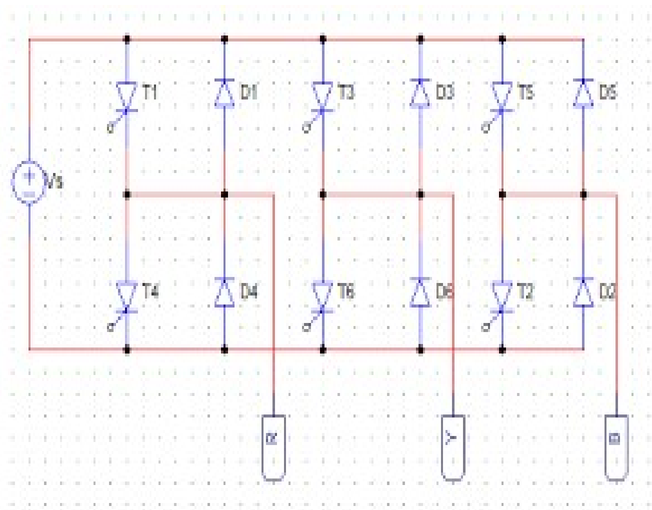
Experiment 6

Study of Three Phase Inverter With 180^0 Conduction Mode By Using Matlab Programming

Objective: To analyze the matlab programming of Three Phase Inverter With 180^0 Conduction mode

Software Needed: Matlab R2013a.

Circuit Diagram:

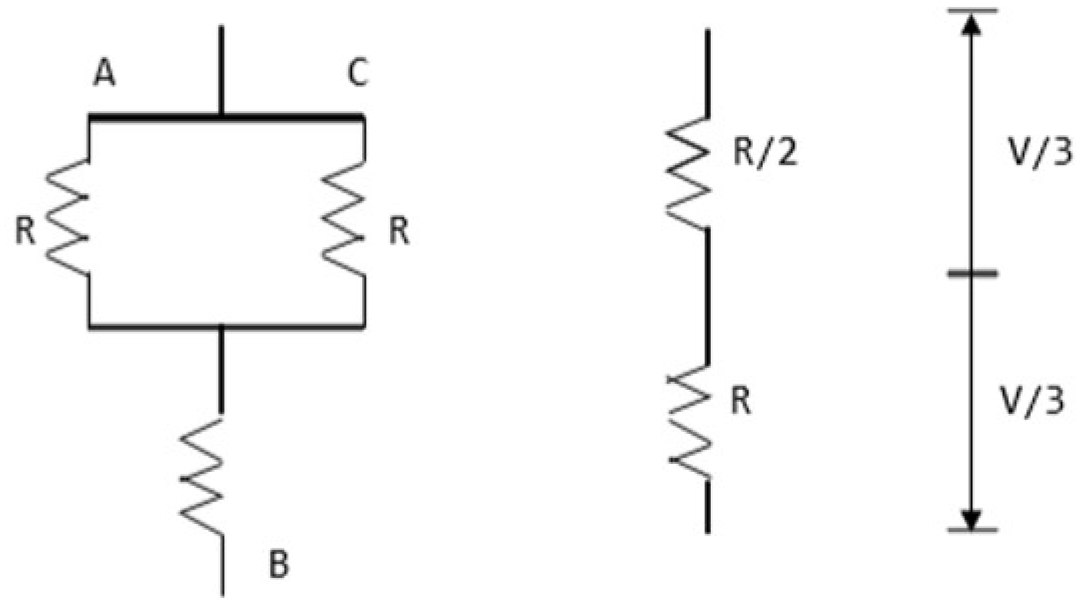


Three Phase Inverter With 180^0 Conduction Mode

Theory:

In this mode of conduction, every device is in conduction state for 180° where they are switched ON at 60° intervals. The terminals A, B and C are the output terminals of the bridge that are connected to the three-phase delta or star connection of the load.

The operation of a balanced star connected load is explained in the diagram below. For the period 0° − 60° the points S1, S5 and S6 are in conduction mode. The terminals A and C of the load are connected to the source at its positive point. The terminal B is connected to the source at its negative point. In addition, resistances R/2 is between the neutral and the positive end while resistance R is between the neutral and the negative terminal.



The load voltages are gives as follows; $V_{AN} = V/3$, $V_{BN} = -2V/3$, $V_{CN} = V/3$	The line voltages are given as follows; $V_{AB} = V_{AN} - V_{BN} = V$, $V_{BC} = V_{BN} - V_{CN} = -V$, $V_{CA} = V_{CN} - V_{AN} = 0$

Procedure:

1. Open Matlab software.
2. Open Editor / script Tab write the program.
3. Save the program with filename.m
4. Run the program and observe the output.

Simulation Programme For 180^0 Conduction Mode:

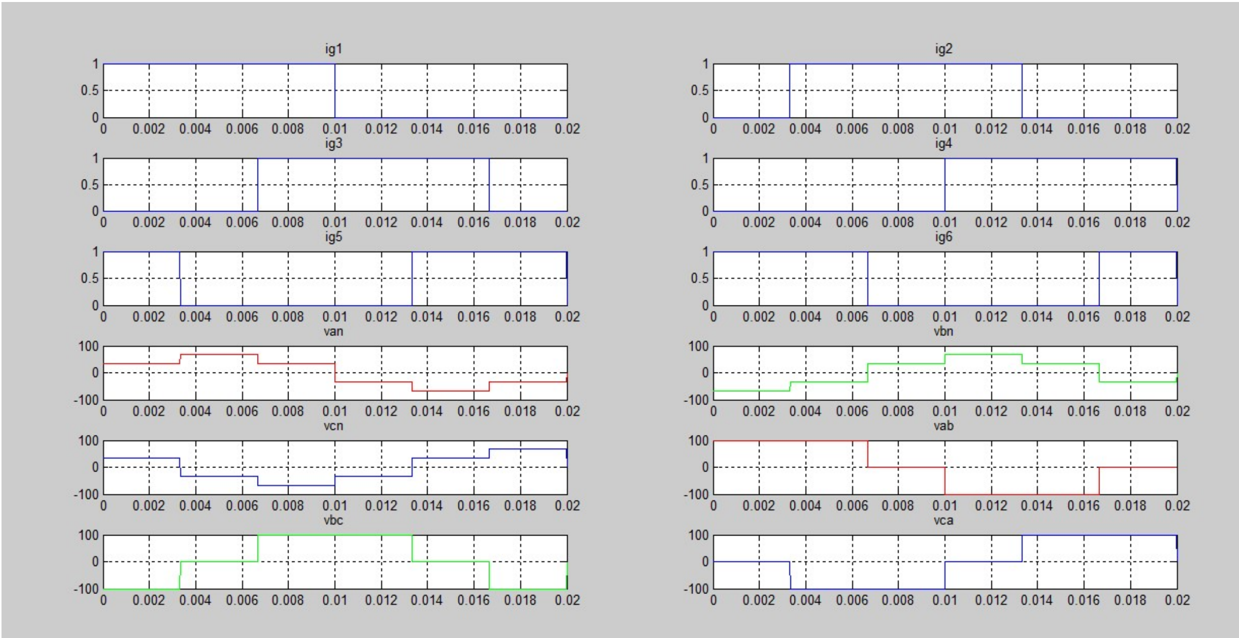
```
clc
clear all
clf
t=0:0.00001:.02;

for i=1:length(t)
    vdc(i)=100;
    if t(i)>=0 && t(i)<10e-3
        p1(i)=1;
    else
        p1(i)=0;
    end
    if t(i)>=3.3e-3 && t(i)<13.33e-3
        p2(i)=1;
```

```
else
    p2(i)=0;
end
if t(i)>=6.67e-3 && t(i)<16.67e-3
    p3(i)=1;
else
    p3(i)=0;
end
if t(i)>=10e-3 && t(i)<20e-3
    p4(i)=1;
else
    p4(i)=0;
end
 if (t(i)>=13.33e-3 && t(i)<20e-3)
     p5(i)=1
 else if (t(i)>= 0&& t(i)<3.33e-3)
    p5(i)=1;
else
    p5(i)=0;
end
 end
  if (t(i)>=16.67e-3 && t(i)<20e-3)
     p6(i)=1
 else if (t(i)>= 0&& t(i)<6.67e-3)
    p6(i)=1;
else
    p6(i)=0;
     end
  end
  if p1(i)>0 && p5(i)>0 &&p6(i)>0
      va(i)=vdc(i)/3;
    vb(i)=-2*vdc(i)/3;
    vc(i)=vdc(i)/3;
  else if  p1(i)>0 && p2(i)>0 &&p6(i)>0
          va(i)=2*vdc(i)/3;
      vb(i)=-vdc(i)/3;
       vc(i)=-vdc(i)/3;
       else if  p4(i)>0 && p5(i)>0 &&p6(i)>0
       va(i)=-vdc(i)/3;
      vb(i)=-vdc(i)/3;
      vc(i)=2*vdc(i)/3;
       else if  p1(i)>0 && p2(i)>0 &&p3(i)>0
      va(i)=vdc(i)/3;
      vb(i)=vdc(i)/3;
      vc(i)=-2*vdc(i)/3;
       else if  p3(i)>0 && p4(i)>0 &&p5(i)>0
               va(i)=-2*vdc(i)/3;
      vb(i)=vdc(i)/3;
      vc(i)=vdc(i)/3;
       else if  p2(i)>0 && p3(i)>0 &&p4(i)>0
      va(i)=-vdc(i)/3;
      vb(i)=2*vdc(i)/3;
      vc(i)=-vdc(i)/3;
           else
               va(i)=0;
               vb(i)=0;
               vc(i)=0;
```

```
               end
               end
               end
               end
          end
      end
end
      vab=va-vb;
      vbc=vb-vc;
      vca=vc-va;

subplot (6,2,1)
    plot(t,p1)
    grid
    title('ig1')
    subplot (6,2,2)
    plot(t,p2)
    grid
    title('ig2')
    subplot (6,2,3)
    plot(t,p3)
    title('ig3')
    grid
    subplot (6,2,4)
    plot(t,p4)
    title('ig4')
    grid
    subplot (6,2,5)
    plot(t,p5)
    title('ig5')
    grid
    subplot (6,2,6)
    plot(t,p6)
    title('ig6')
    grid
    subplot (6,2,7)
    plot(t,va,'r')
    title('van')
    grid
    subplot (6,2,8)
    plot(t,vb,'g')
    title('vbn')
    grid
    subplot (6,2,9)
    plot(t,vc)
    title('vcn')
    grid
    subplot (6,2,10)
    plot(t,vab,'r')
    title('vab')
    grid
    subplot (6,2,11)
    plot(t,vbc,'g')
    title('vbc')
    grid
    subplot (6,2,12)
    plot(t,vca)
```

```
title('vca')
grid
```

Output Waveform for 180^0 conduction mode:



Result: Three Phase inverter with 180^0 Conduction mode by using matlab programming done successfully and output waveforms obtained.

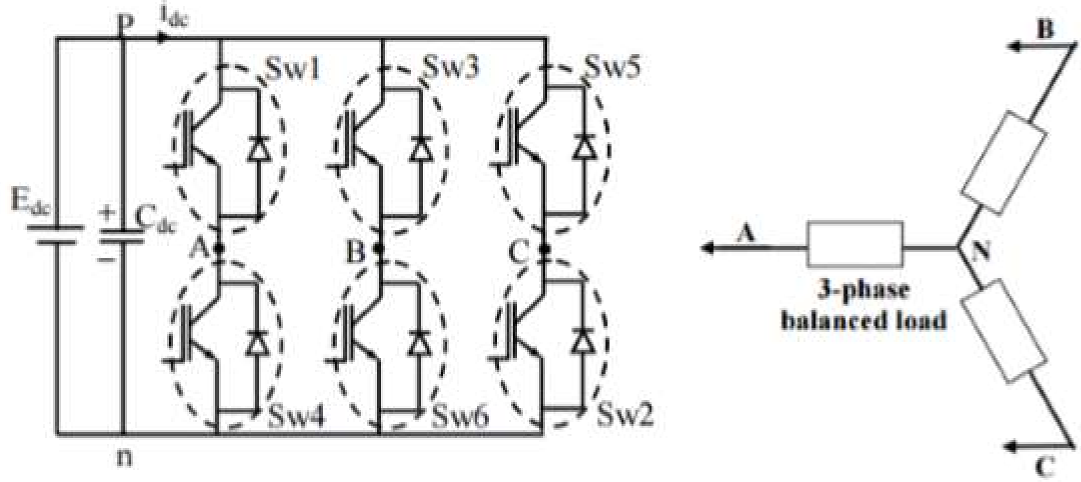
Experiment 7

Study of Three Phase Inverter With 120^0 Conduction Mode By Using Matlab Programming

Objective: To analyze the matlab programming of Three Phase Inverter With 120^0 Conduction mode.

Software Needed: Matlab R2013a.

Circuit Diagram:



Three Phase Inverter With 120^0 Conduction Mode

Theory: In this mode of conduction, each electronic device is in a conduction state for 120°. It is most suitable for a delta connection in a load because it results in a six-step type of waveform across any of its phases. Therefore, at any instant only two devices are conducting because each device conducts at only 120°.

The terminal A on the load is connected to the positive end while the terminal B is connected to the negative end of the source. The terminal C on the load is in a condition called floating state. Furthermore, the phase voltages are equal to the load voltages as shown below.

Phase voltages = Line voltages

$V_{AB} = V$

$V_{BC} = -V/2$

$V_{CA} = -V/2$

Procedure:

1. Open Matlab software.
2. Open Editor / script Tab write the program.
3. Save the program with filename.m
4. Run the program and observe the output.

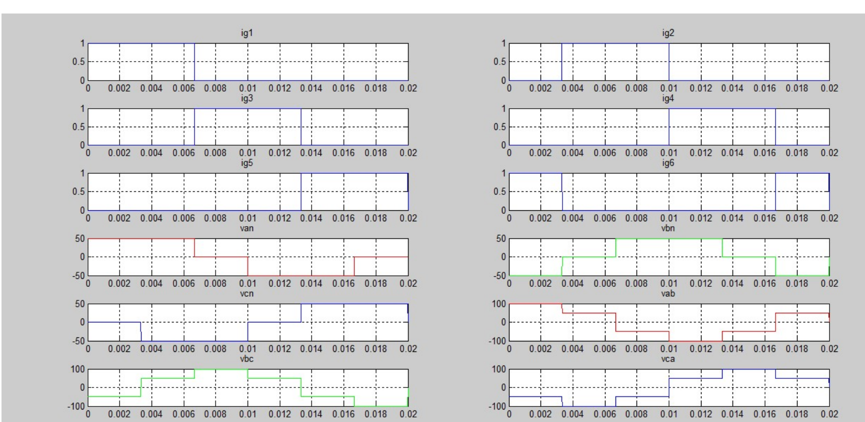
Simulation Programme For 120^0 Conduction Mode:

```
clc
clear all
clf

t=0:0.00001:.02;

for i=1:length(t)
    vdc(i)=100;
    if t(i)>=0 && t(i)<6.67e-3
        p1(i)=1;
    else
        p1(i)=0;
    end
    if t(i)>=3.3e-3 && t(i)<10e-3
        p2(i)=1;
    else
        p2(i)=0;
    end
    if t(i)>=6.67e-3 && t(i)<13.33e-3
        p3(i)=1;
    else
        p3(i)=0;
    end
    if t(i)>=10e-3 && t(i)<16.67e-3
        p4(i)=1;
    else
        p4(i)=0;
    end
     if (t(i)>=13.33e-3 && t(i)<20e-3)
         p5(i)=1
     else if (t(i)>= 0&& t(i)<3.33e-3)
        p5(i)=0;
    else
        p5(i)=0;
    end
     end
      if (t(i)>=16.67e-3 && t(i)<20e-3)
         p6(i)=1;
     else if (t(i)>= 0&& t(i)<3.33e-3)
        p6(i)=1;
    else
```

```
        p6(i)=0;
         end
      end


      if p1(i)>0 && p6(i)>0
          va(i)= vdc(i)/2;
        vb(i)=-vdc(i)/2;
        vc(i)=0;
      else if p1(i)>0 && p2(i)>0
          va(i)=vdc(i)/2;
        vb(i)=0;
        vc(i)=-vdc(i)/2;
          else if p2(i)>0 &&p3(i)>0
          va(i)=0;
        vb(i)=vdc(i)/2;
        vc(i)=-vdc(i)/2;
              else if p4(i)>0 &&p3(i)>0
          va(i)=-vdc(i)/2;
        vb(i)=vdc(i)/2;
        vc(i)=0;
                  else if p4(i)>0 &&p5(i)>0
          va(i)=-vdc(i)/2;
        vb(i)=0;
        vc(i)=vdc(i)/2;
                      else if p6(i)>0 &&p5(i)>0
          va(i)=0;
        vb(i)=-vdc(i)/2;
        vc(i)=vdc(i)/2;



               else
                   va(i)=0;
                   vb(i)=0;
                   vc(i)=0;
               end
               end
               end
               end
          end
      end
end
      vab=va-vb;
      vbc=vb-vc;
      vca=vc-va;

subplot (6,2,1)
    plot(t,p1)
    grid
    title('ig1')
    subplot (6,2,2)
    plot(t,p2)
    grid
    title('ig2')
    subplot (6,2,3)
```

```
plot(t,p3)
title('ig3')
grid
subplot (6,2,4)
plot(t,p4)
title('ig4')
grid
subplot (6,2,5)
plot(t,p5)
title('ig5')
grid
subplot (6,2,6)
plot(t,p6)
title('ig6')
grid
subplot (6,2,7)
plot(t,va,'r')
title('van')
grid
subplot (6,2,8)
plot(t,vb,'g')
title('vbn')
grid
subplot (6,2,9)
plot(t,vc)
title('vcn')
grid
subplot (6,2,10)
plot(t,vab,'r')
title('vab')
grid
subplot (6,2,11)
plot(t,vbc,'g')
title('vbc')
grid
subplot (6,2,12)
plot(t,vca)
title('vca')
grid
```

Output Waveform for 120^0 conduction mode:



Result: Three Phase inverter with 120^0 Conduction mode by using matlab programming done successfully and output waveforms obtained.

Experiment 8

Study of Load and Load Duration Curve

Objective: To write the matlab programme for load and Load Duration Curve for the given problem

The daily load on a power system varies as shown in table using the given data compute the average load, load factor, maximum demand

INTERVALS(in hours)	LOAD(in mw)
12am-2am	6
2am-6am	5
6am-9am	10
9am-12pm	15
12 pm-2pm	12
2pm-4pm	14
4pm-6pm	16
4pm-8pm	18
8pm-10pm	16
10pm-11pm	12
11pm-12am	6

Software Needed: Matlab R2013a.

Theory: A graphical plot showing the variation in demand for energy of the consumers on a source of supply with respect to time is known as the load curve. If this curve is plotted over a time period of 24 hours, it is known as daily load curve. If its plotted for a week, month, or a year, then its named as the weekly, monthly or yearly load curve respectively. The load duration curve reflects the activity of a population quite accurately with respect to electrical power consumption over a given period of time. To understand the concept better its important that we take the real life example of load distribution for an industrial load and a residential load, and have a case study on them, to be able to appreciate its utility from the perspective of an electrical engineer.

Equations:

$$Average\ Demand = \frac{kWh\ (or\ MWh) consumed\ in\ a\ given\ period\ of\ time}{hours\ in\ the\ time\ period}$$

$$Average\ Demand = \frac{area\ under\ the\ load\ duration\ curve}{base\ of\ the\ load\ duration\ curve}$$

$$Daily\ load\ factor = \frac{Total\ kwh\ during\ 24\ h\ of\ the\ day}{(peak\ load\ in\ kW)\ \times 24\ h}$$

Theoretical Calculations:

Maximum demand from the question is 18 KW

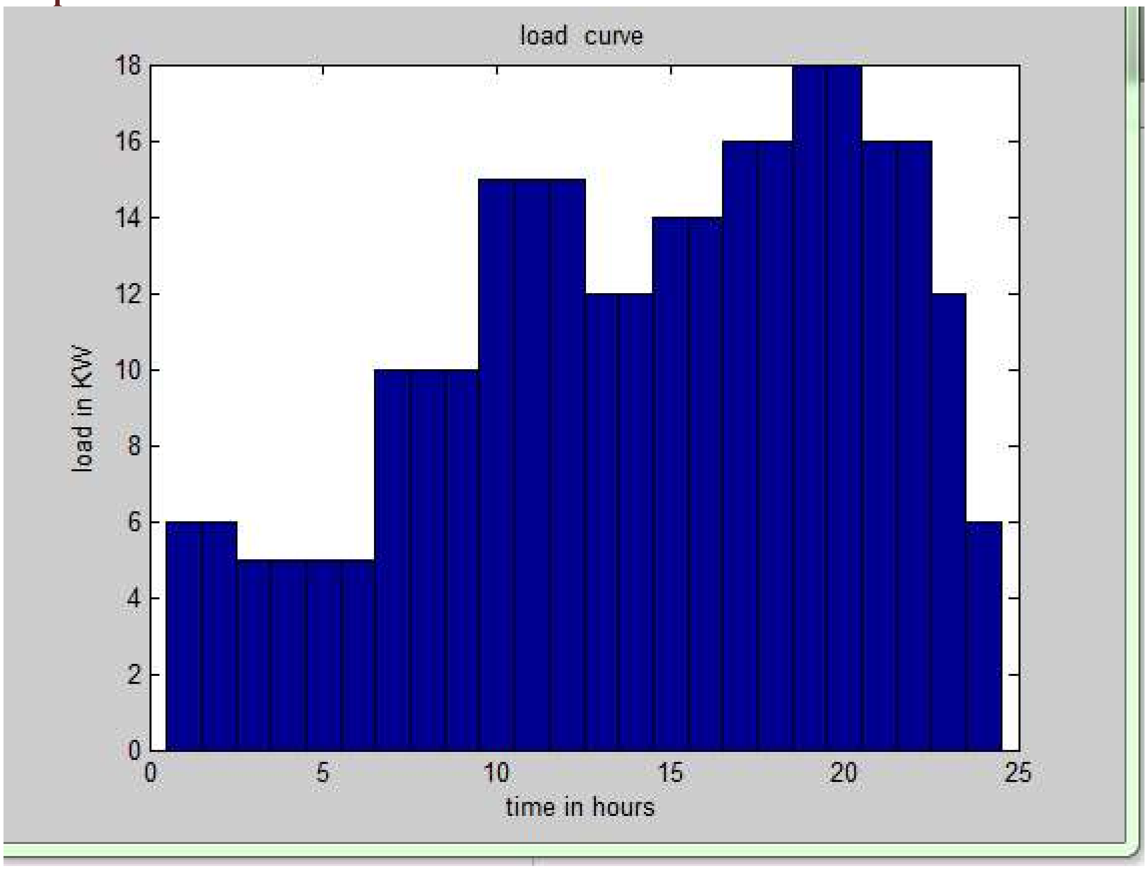
Average load=$\frac{(6*2)+(5*4)+(10*3)+(15*3)+(12*2)+(14*2)+(16*2)+(18*2)+(16*2)+(12*1)(6*1)}{24}$=11.5416

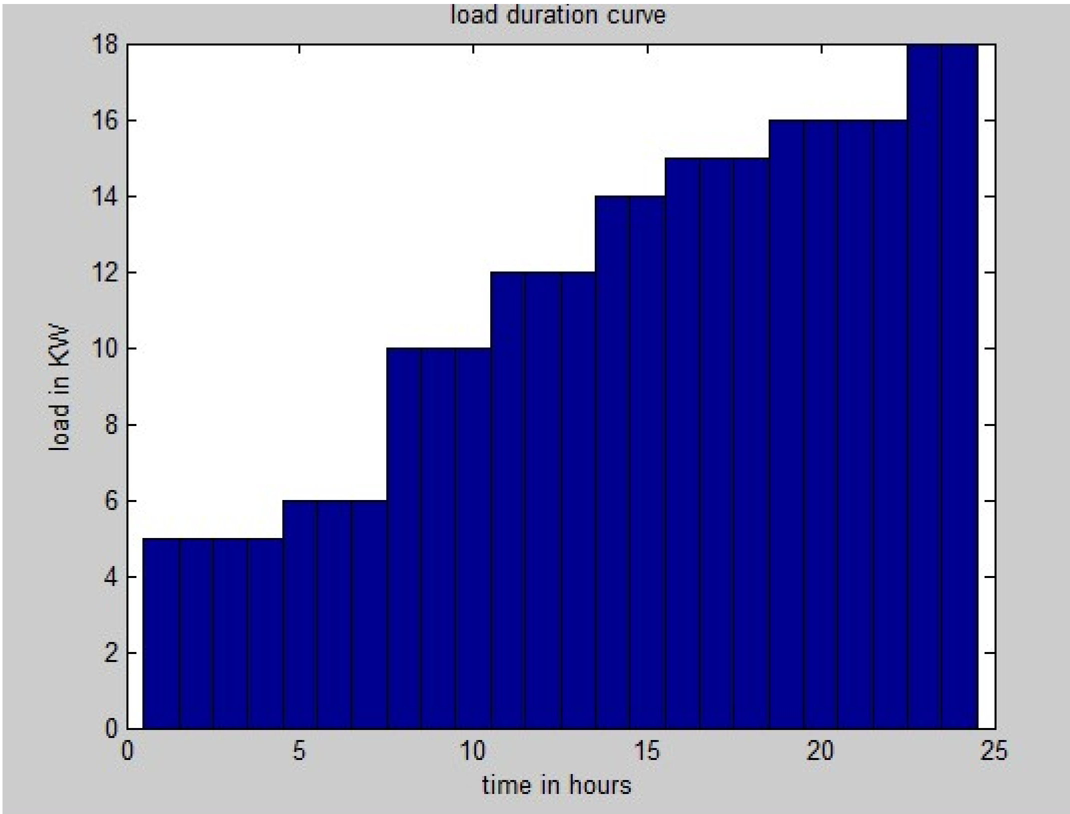
Load factor=$\frac{11.5416}{18} = 0.6412$

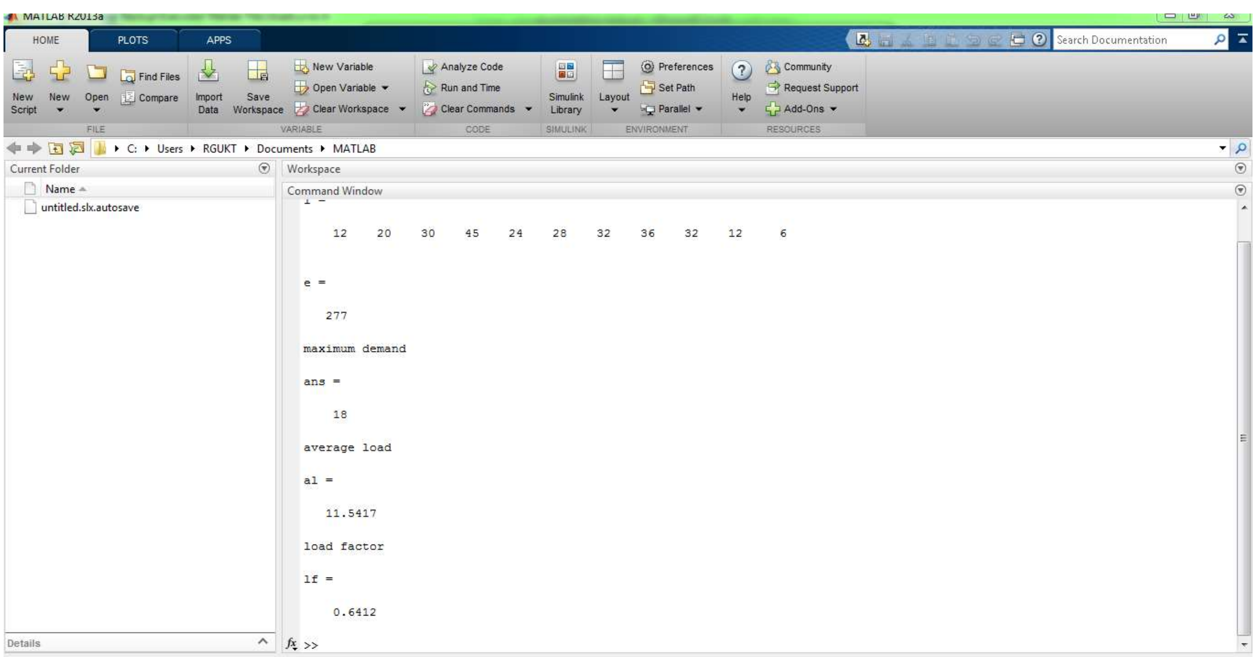
Simulation Programme For load and Load duration curve:

```
clc;
clear all;
close all;
a=[6 5 10 15 12 14 16 18 16 12 6];
b=[2 4 3 3 2 2 2 2 2 1 1];
t=sum(b);
l=a.*b
e=sum(l)
disp('maximum demand');
max(a)
disp('average load');
al=e/t
disp('load factor');
lf=al/max(a)
c=[ 6 6  5 5 5 5 10 10 10 15 15 15 12 12 14 14 16 16 18 18 16 16 12 6];
bar(c,'hist')
title('load  curve')
xlabel('time in hours')
ylabel('load in KW')
figure;
d=sort(c);
bar(d,'hist')
title('load duration curve')
xlabel('time in hours')
ylabel('load in KW')
```

Output Waveform for load and load duration curve:







Result: Load and Load duration curve is doneby using matlab programming and output waveforms obtained.

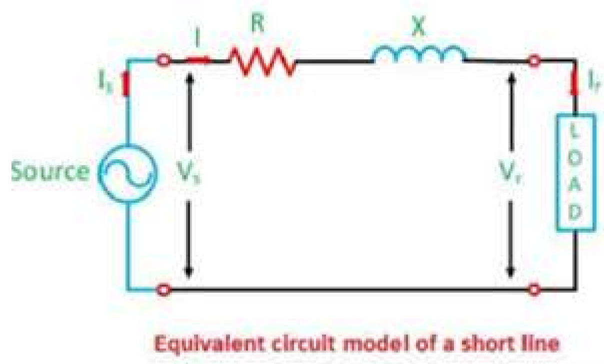
Experiment 9

Performance Evaluation of Short Transmission Line

Objective: To write the matlab programming for Performance Evaluation of Short Transmission Line

Software Needed: Matlab R2013a.

Circuit Diagram:



Equivalent circuit model of a short line

Theory: A short transmission line is defined as a transmission line with an effective length less than 80 km (50 miles), or with a voltage less than 69 kV. Unlike medium transmission lines and long transmission lines, the line charging current is negligible, and hence the shunt capacitance can be ignored.

For short length, the shunt capacitance of this type of line is neglected and other parameters like electrical resistance and inductor of these short lines are lumped, hence the equivalent circuit is represented as given below. Let's draw the vector diagram for this equivalent circuit, taking receiving end current I_r as reference. The sending end and receiving end voltages make angle with that reference receiving end current, of φ_s and φ_r, respectively.

As the shunt capacitance of the line is neglected, hence the sending end current and the receiving end current is same, i.e.

$$I_s = I_r$$

We can see from the short transmission line phasor diagram above that V_s is approximately equal to:

$$V_s \cong V_r + I_r.R.cos\varphi_r + I_r.X.sin\varphi_r$$

That means,

$$V_r + I_r.R.cos\varphi_r + I_r.X.sin\varphi_r$$

As it is assumed that:

$$\varphi_s \cong \varphi_r$$

As there is no capacitance, during no-load condition the current through the line is considered as zero, hence at no load condition, receiving end voltage is the same as sending end voltage.
As per dentition of voltage regulation of power transmission line,

$$\% \text{ regulation} = \frac{V_s - V_r}{V_r} X\ 100\ \%$$

$$= \frac{I_r.R.cos\varphi_r + I_r.X.sin\varphi_r}{V_r} X\ 100\ \%$$

$$\text{per unit regulation} = \frac{I_r.R}{V_r}cos\varphi_r + \frac{I_r.X}{V_r}sin\varphi_r = v_r cos\varphi_r + v_x sin\varphi_r$$

Here, V_r and V_x are the per unit resistance and reactance of the short transmission line respectively.
Any electrical network generally has two input terminals and two output terminals. If we consider any complex electrical network in a black box, it will have two input terminals and output terminals. This network is called a two-port network. A two-port model of a network simplifies the network solving technique. Mathematically, a two-port network can be solved by 2 by 2 matrix.
A transmission as it is also an electrical network, and hence the transmission line can be represented as a two-port network.

Hence two-port network of the transmission line can be represented as 2 by 2 matrix. Here the concept of ABCD parameters comes into play. Voltage and currents of the network can be represented as:

$$V_s = AV_r + BI_r \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$
$$I_s = CV_r + DI_r \quad \cdots\cdots\cdots\cdots\cdots\cdots (2)$$

Where, A, B, C and D are the different constants of the transmission network.

If we put $I_r = 0$ at equation (1), we get,

Hence A is the voltage impressed at the sending end per volt at the receiving end when receiving end is open. It is dimensionless. If we put $V_r = 0$ at equation (1), we get

$$A = \left.\frac{V_s}{V_r}\right| I_r = 0$$

Hence B indicates the impedance of the transmission line when the receiving terminals are short-circuited. This parameter is referred to as the transfer impedance.

$$B = \left.\frac{V_s}{I_r}\right| V_r = 0$$

C is the current in amperes into the sending end per volt on open circuited receiving end. It has the dimension of admittance.

$$C = \left.\frac{I_s}{V_r}\right| I_r = 0$$

D is the current in amperes into the sending end per amp on the short-circuited receiving end. It is dimensionless.

$$D = \left.\frac{I_s}{I_r}\right| V_r = 0$$

Now from the equivalent circuit, it is found that,

$$V_s = V_r + I_r Z \ and \ I_s = I_r$$

Comparing these equations with equation 1 and 2 we get, A = 1, B = Z, C = 0 and D = 1. As we know that the constant A, B, C, and D are mathematically related to a passive network as:

$$AD - BC = 1$$

Here, A = 1, B = Z, C = 0, and D = 1

$$\Rightarrow 1.1 - Z.0 = 1$$

So the values calculated are correct for a short transmission line. From the equation

$$V_s = AV_r + BI_r$$

When $I_r = 0$ that means receiving end terminals is open circuited and then from equation 1, we get receiving end voltage at no load.

$$V_r' = \frac{V_s}{A}$$

and as per definition of voltage regulation of power transmission line,

$$\%\ \text{voltage regulation} = \frac{V_s / A - V_r}{V_r} X100\ \%$$

Performance of Short Transmission Line

The performance (i.e. the efficiency) of a short transmission line as simple as efficiency equation of any other electrical equipment, that means

$$\%\ \text{efficiency}\ (\mu) = \frac{\text{Power received at receiving end}}{\text{Power delivered at sending end}} X\ 100\ \%$$

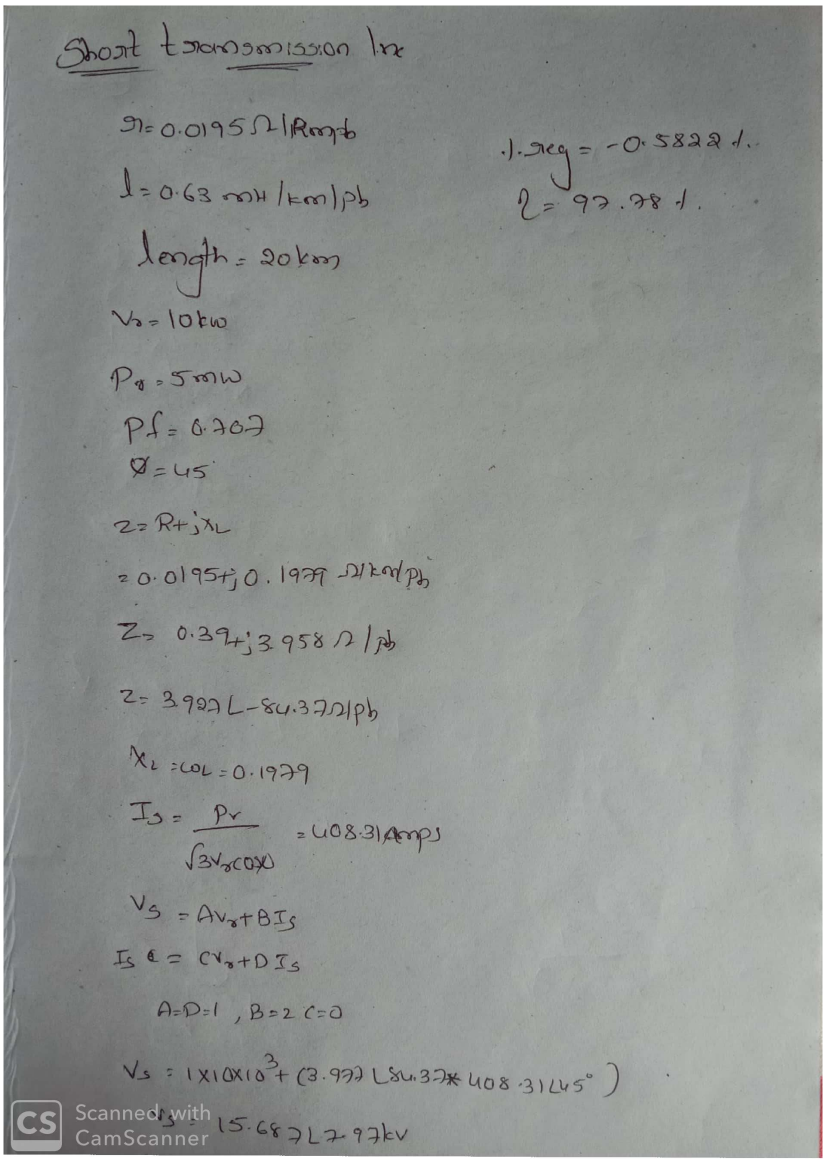
$$\%\ \mu = \frac{\text{Power received at receiving end}}{\text{Power received at receiving end} + 3I_r^2.R} X\ 100\ \%$$

Where R is the per phase electrical resistance of the transmission line.

Procedure:

1. Open Matlab software.
2. Open Editor / script Tab write the program.
3. Save the program with filename.m
4. Run the program and observe the output.

Theoretical calculations:



Short transmission line

$r = 0.0195\ \Omega/km/ph$

$l = 0.63\ mH/km/ph$

length = 20 km

$V_r = 10\ kV$

$P_r = 5\ MW$

$pf = 0.707$

$\phi = 45°$

$Z = R + jX_L$

$= 0.0195 + j0.1979\ \Omega/km/ph$

$Z = 0.39 + j3.958\ \Omega/ph$

$Z = 3.977\angle -84.37\ \Omega/ph$

$X_L = \omega L = 0.1979$

$$I_s = \frac{P_r}{\sqrt{3} V_r \cos\phi} = 408.31\ Amps$$

$V_s = AV_r + BI_s$

$I_s = CV_r + DI_s$

$A = D = 1,\ B = Z,\ C = 0$

$V_s = 1 \times 10 \times 10^3 + (3.977\angle 84.37 * 408.31\angle 45°)$

$V_s = 15.687\angle 7.97\ kV$

% reg = -0.5822 %

η = 97.78 %

Programme for short transmission line:

```
clc;
clear all;
close all;
a=1;
r=0.0195;
l=0.63e-3;
sl=20;
pf=0.707;
Vr=10e+03
Pr=5e+06
s=acos(pf)
cs=-s*(180/3.14);
R=r*sl;
Xl=2*3.14*50*l*sl;
z=complex(R,Xl);
I=Pr/(1.732*Vr*pf);
Ip=complex(I*cos(cs)+I*sin(cs));
A=1
B=0.390+3.9564i
C=0
D=1
disp('sending voltage per phase');
Vsp=(A*Vr)+(B*Ip)
disp('sending voltage in volts');
Vs=1.732*Vsp
disp('sending current in amperes');
Is=(C*Vr)+(D*Ip)
Ps=Pr+I^2*R;
disp('voltage reg in percentage');
V=((real(Vsp)-real(Vr))/real(Vr))*100
disp('efficiency  in percentage');
n=(Pr/Ps)*100
```

OUTPUT:

Result: Short transmission line performance parameters evaluated and verified.

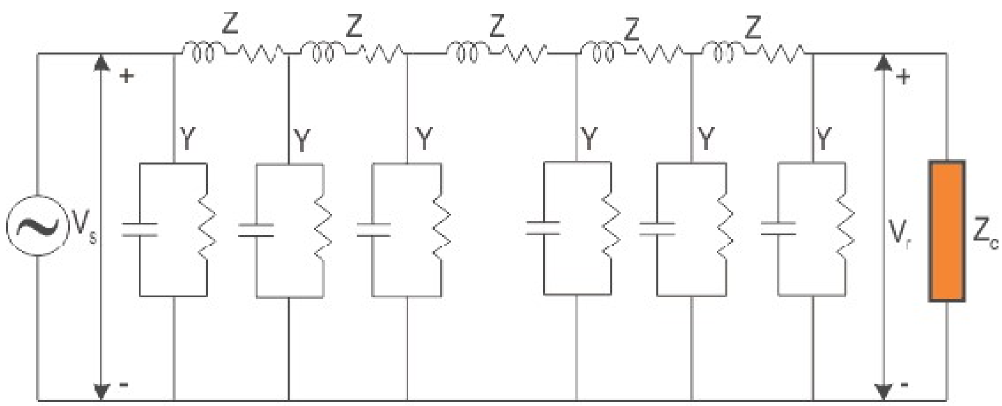
Experiment 10

Performance Evaluation of long Transmission Line

Objective: To write the matlab programming for Performance Evaluation of long Transmission Line

Software Needed: Matlab R2013a.

Circuit Diagram:



Long Transmission Line Model

Theory: A long transmission line is defined as a transmission line with an effective length more than 250 km (150 miles). Unlike short transmission lines and medium transmission lines, it is no longer reasonable to assume that the line parameters are lumped. To accurately model a long transmission line we must consider the exact effect of the distributed parameters over the entire length of the line. Although this makes the calculation of ABCD parameters of transmission line more complex, it also allows us to derive expressions for the voltage and current at any point along the line.

Theoretical Calculations:

Long transmission line

$R = 0.133\ \Omega\,\text{km/ph}$

$L = 0.398\ \text{mH}$

$q = 0\Omega$

$C = 31.83\ \text{nF}$

length $l = 300\ \text{km}$

$V_r = 220\ \text{kV}/\phi$

$P_r = 50\ \text{MW}$

$Pf = 0.8$ / lag

$X_L = \omega L = 2\pi f l = 0.125\ \Omega/\text{km/ph}$

$X_L = 37.5\ \Omega/\phi$

$R = 0.133\ \Omega/\text{km/ph} = 39.9\ \Omega/\phi$

$Y = j\omega X_c = 1\mu F$

$Y = 2\pi f c l = j3\ \text{HP/ph}$

$Z = R + jX$

$= 39.9 + j37.5$

$= 54.76\angle 43.22$

$Z_0 = \sqrt{\dfrac{Z}{Y}}$

$= \sqrt{\dfrac{54.76\angle 43.22}{3\times10^{-3}\angle 90}}$

$= 135.1\angle -23.39$

$\delta = \sqrt{Z.Y}$

$\delta s = \sqrt{154.76\angle 43.22 \times 3\times10^{-3}\angle 90}$

$\delta_s = 0.405\angle 66.61$

$\delta_s = 0.161 + j\,2k31$

$A = D = \cosh(\alpha s + j\beta_s)$

$= \frac{1}{2}\left[e^{\alpha s}(\beta s) + e^{-\alpha s}\angle -\beta s\right]$

$= 0.944 + j0.059$

$\cosh(\alpha s + j\beta s) = 0.946\angle 3.57$

$\sinh(\alpha s + j\beta s) = \frac{1}{2}\left[e^{\alpha s}(\beta_s - e^{-\alpha s}\angle -\beta_s\right]$

$= 0.151 + j0.368$

$= 0.398\angle 67.69$

$B = Z_0 \sinh(\alpha s + j\beta_s)$

$= 38.48 + j37.55$

$= 53.76\angle 44.3$

$C = \dfrac{1}{Z_0}\sinh(\alpha s + j\beta_s)$

$= -5.55\times10^{-5} + j\,2.93\times10^{-3}$

$= 2.94\times10^{-3}\angle 91.08$

$I_r = \dfrac{P_r}{\sqrt{3}\,V_r\cos\phi_r} = 164.02\ A$

$V_s = AV_r + BI_s = \left[0.946\angle 3.57 \times 220kV + 53.76\angle 44.3 \times 164.02\angle -36.87\right]$

$= 216459 + j140995$

$= 216918.5\angle 3.73$

$V_s = 217\,kV\angle 3.73$ /ph

$I_s = CV_r + DI_s$

$= \left[294\times10^{-3}\angle 91.08 \times 220k\right] + 0.963\angle 3.57 \times 164.02\angle -36.87\right]$

$= 117.5 + j56.15$

$I_s = 573.66\angle 78.18$

$V_s = 3758k\angle 3.73V$

$\%\, V_{reg} = \dfrac{V_s - V_R}{V_R} \times 100$

$= -1.36\%$

$\%\, \eta = \dfrac{P_r}{P_r + losses} \times 100 = \dfrac{P_r}{P_s} \times 100$

$= 97.8982$

$A = 0.9437 + 0.0587i$

$D = 0.9437 + 0.0587i$

$B = 38.4127 + 37.5753i$

$C = -0.0001 + j0.029$

$V_{reg} = -1.6557$

$\eta = 97.8982$

Matlab Programme for Long Transmission Line

```
clc;
clear all;
close all;
r=0.133;
l=0.398e-3;
c=31.83e-9;
g=0;
tl=300;
pf=0.8;
Vr=220e+03
Pr=50e+06
R=r*tl;
Xl=2*3.14*50*l*tl;
y=2*3.14*50*c*tl;
z=complex(R,Xl);
Y=complex(0,y);
Z0=(z/Y)^(1/2);
gs=(z*Y)^0.5;
A=cosh(gs)
D=cosh(gs)
B=Z0*sinh(gs)
C=(1/Z0)*sinh(gs)
I=Pr/(1.732*Vr*pf);
Ip=complex(I*pf,-I*(1-pf^2)^0.5);
disp('sending voltage per phase');
Vsp=(A*Vr)+(B*Ip)
disp('sending voltage in volts');
Vs=1.732*Vsp
disp('sending current in amperes');
Is=(C*Vr)+(D*Ip)
Ps=Pr+I^2*R;
disp('voltage reg in percentage');
V=((real(Vsp)-real(Vr))/real(Vr))*100
disp('efficiency  in percentage');
n=(Pr/Ps)*100
```

Output:

```
Workspace
Command Window
   2.1636e+05 + 1.4064e+04i

sending voltage in volts

Vs =

   3.7473e+05 + 2.4360e+04i

sending current in amperes

Is =

   1.1661e+02 + 5.6210e+02i

voltage reg in percentage

V =

  -1.6552

efficiency  in percentage

n =

   97.8982

>>
```

Result: Long transmission line performance parameters evaluated and verified.