THREE PHASE FULLY CONTROLLED AND HALF CONTROLLED BRIDGE RECTIFIER

Aim:

To simulate three phase fully controlled and half controlled bridge rectifier.

Software Used:

Matlab – Simulink

Circuit Diagram:

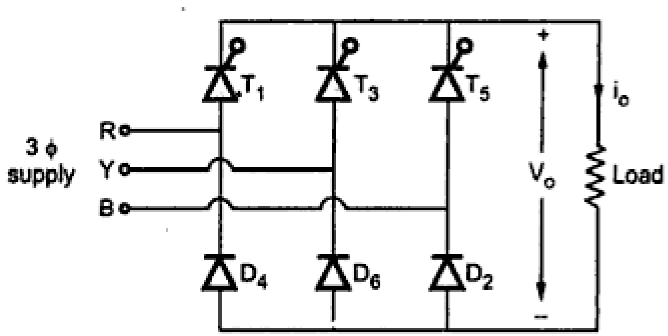


Fig 1: Three Phase Half Controlled Bridge rectifier

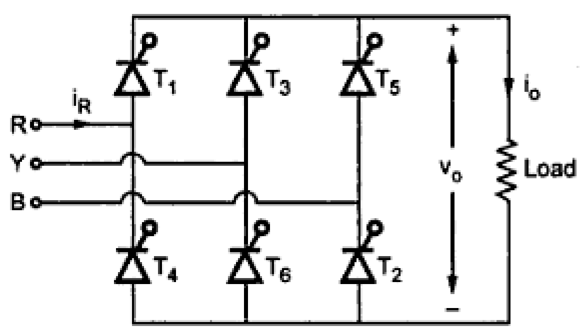


Fig 2: Three Phase Fully Controlled Bridge rectifier

Simulink Models:

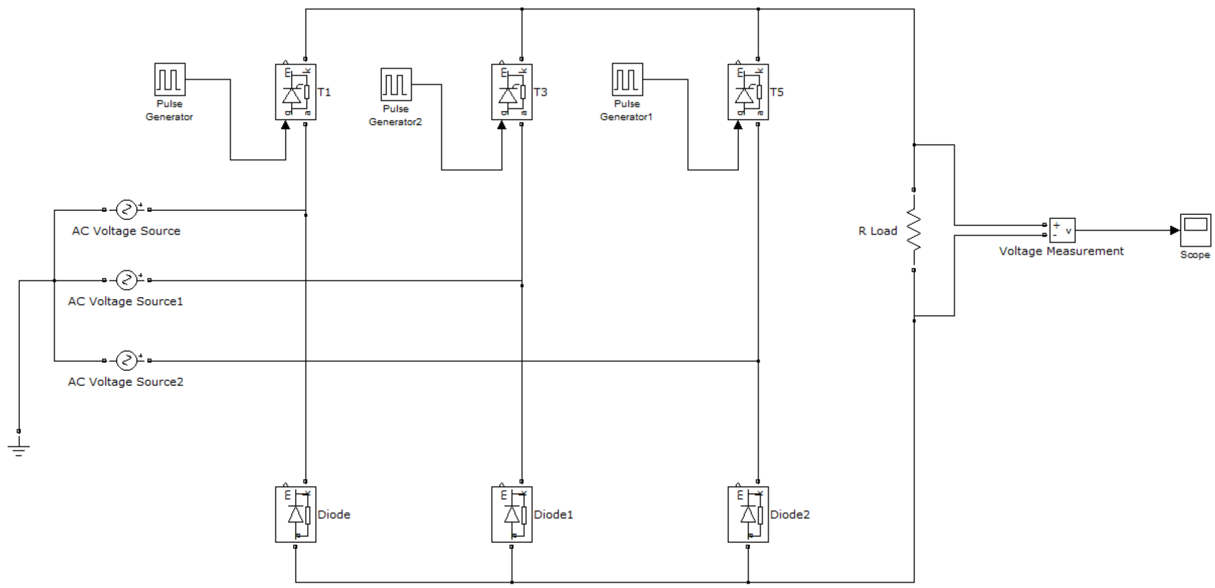


Fig: Three Phase Half Controlled Rectifier

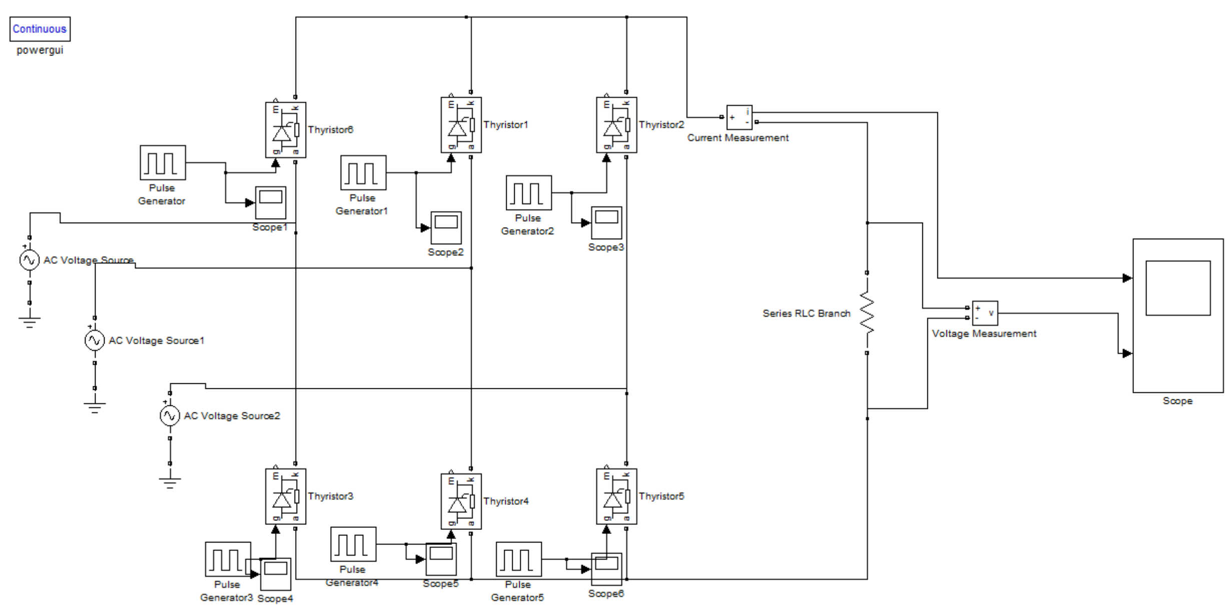
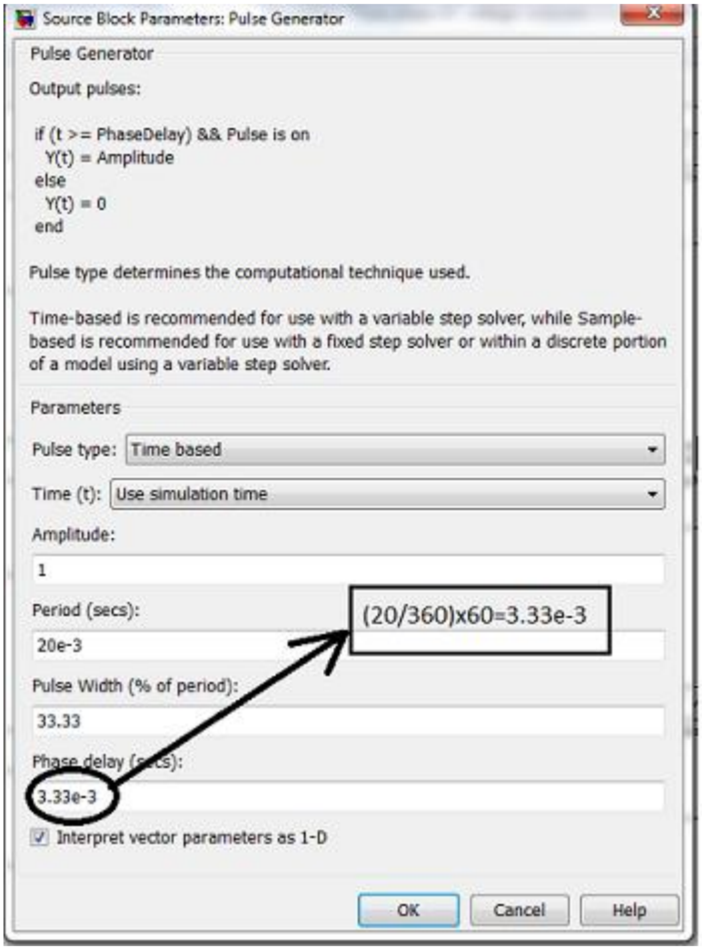


Fig: Three Phase Fully Controlled Rectifier

Entering Firing Angle Values:

In order to trigger thyristors we have to give proper triggering pulses to it using a pulse generator. We can enter values in the box which is obtained by double clicking pulse generator. It's shown in the following figure.



Complete Triggering Values

For Half controlled Rectifier:

	Firing Angle in degree	Firing Angle in sec
T1	30	1.66e-3
T3	150	8.33e-3
T5	270	15e-3

For Half controlled Rectifier:

	Firing Angle in degree	Firing Angle in sec
T1	30	1.66e-3
T2	90	5e-3
T3	150	8.33e-3
T4	210	11.66e-3
T5	270	15e-3
T6	330	18.33e-3

Graphs

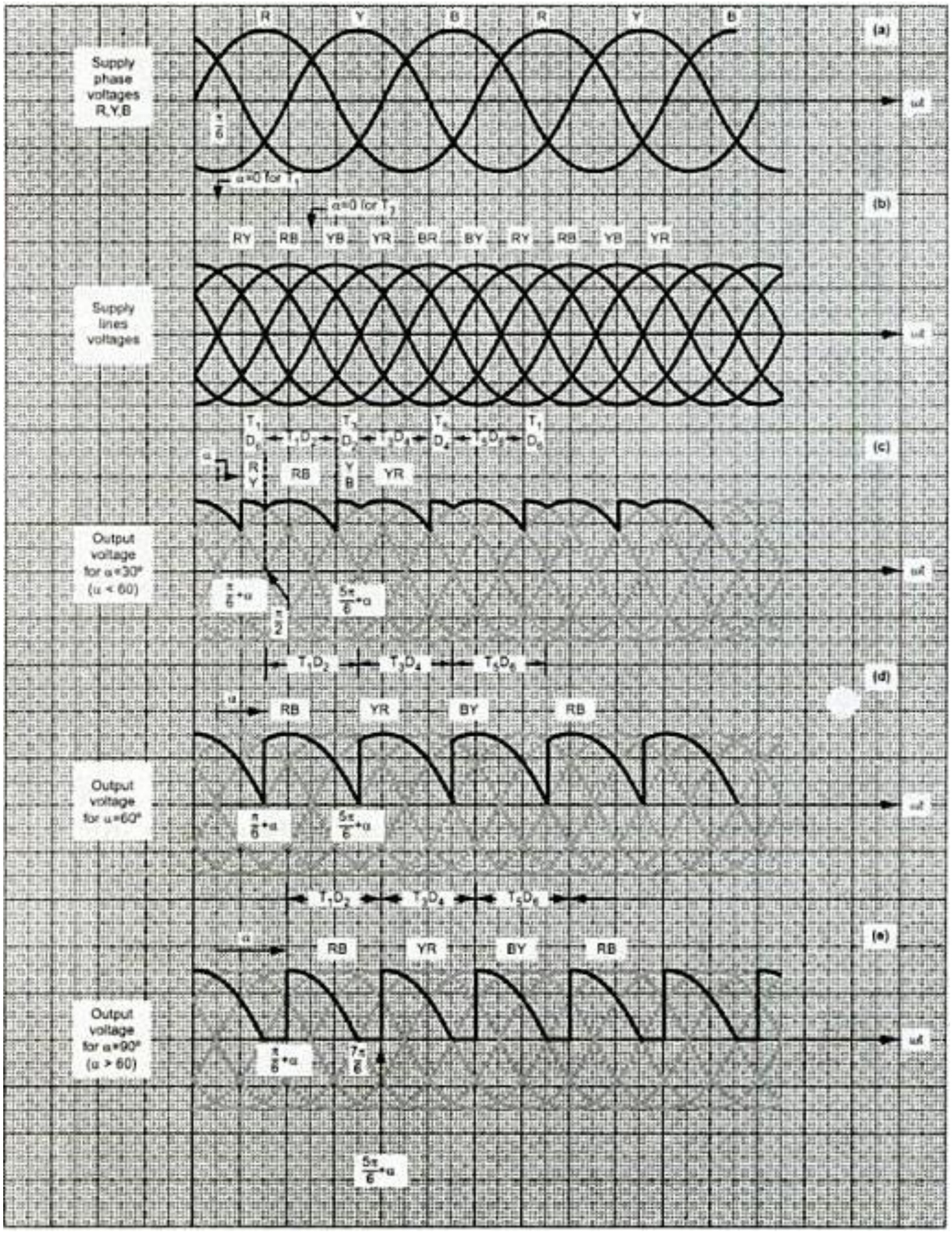


Fig 3: Wave Form of Three Phase half controlled bridge rectifier

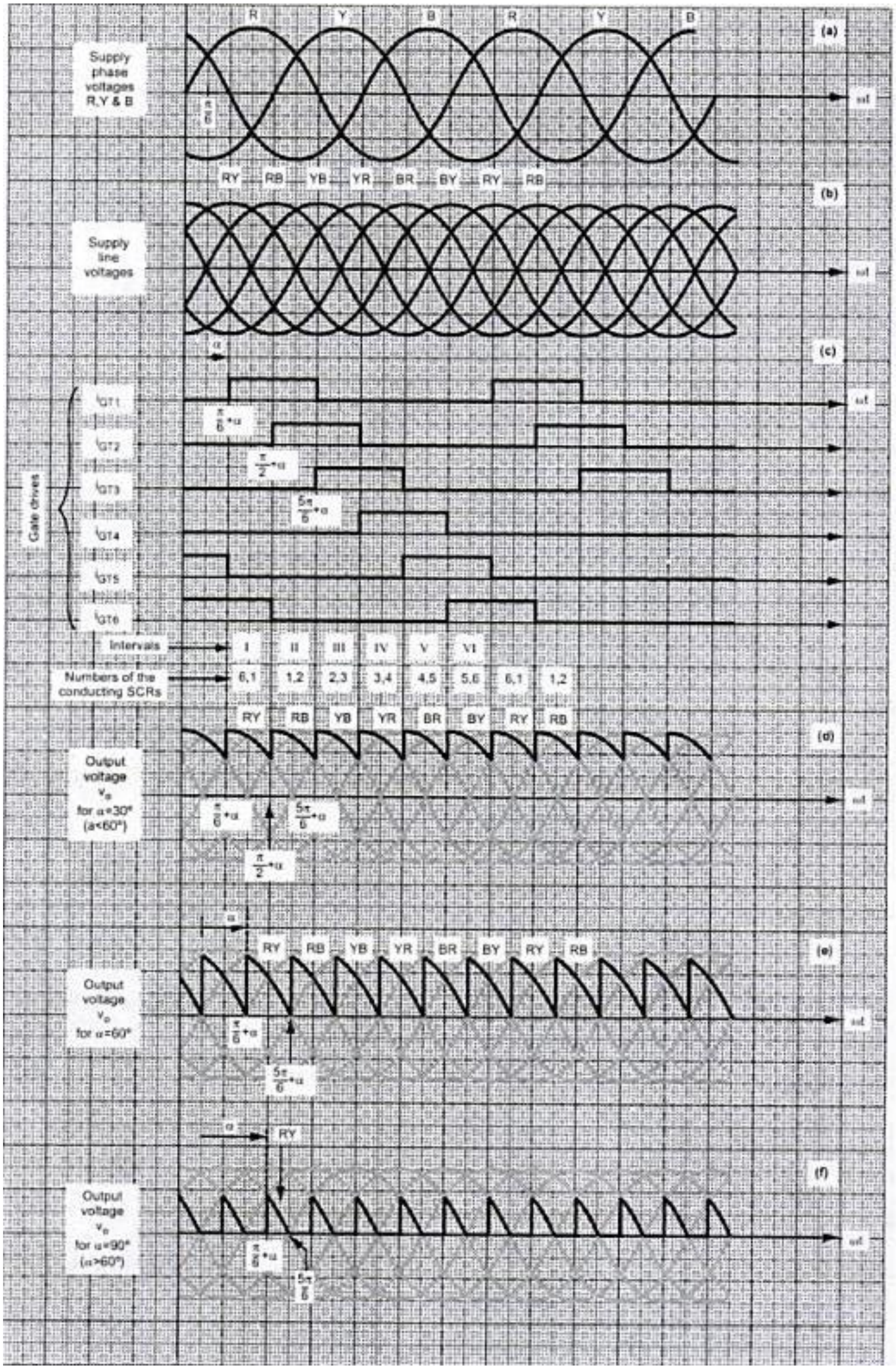


Fig 4: Waveform of Three Phase Fully Controlled Bridge Rectifier

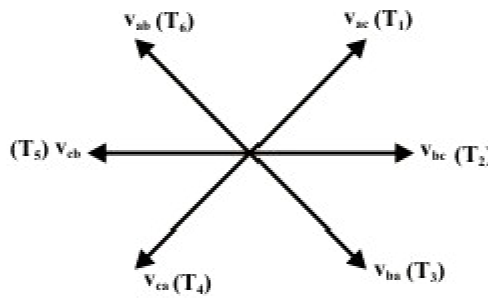
Theory:

THREE PHASE FULLY CONTROLLED CONVERTER

A three phase fully controlled converter is obtained by replacing all the six diodes of an uncontrolled converter by six thyristors as shown in Fig 2. For any current to flow in the load at least one device from the top group (T_1, T_3, T_5) and one from the bottom group (T_2, T_4, T_6) must conduct. Like an uncontrolled converter only one device from these two groups will conduct.

Device / Mode	v_{T1}	v_{T2}	v_{T3}	v_{T4}	v_{T5}	v_{T6}	v_o
T_1T_2	0	0	v_{ba}	v_{ca}	v_{ca}	v_{cb}	v_{ac}
T_2T_3	v_{ab}	0	0	v_{ca}	v_{cb}	v_{cb}	v_{bc}
T_3T_4	v_{ab}	v_{ac}	0	0	v_{cb}	v_{ab}	v_{ba}
T_4T_5	v_{ac}	v_{ac}	v_{bc}	0	0	v_{ab}	v_{ca}
T_5T_6	v_{ac}	v_{bc}	v_{bc}	v_{ba}	0	0	v_{cb}
T_6T_1	0	v_{bc}	v_{ba}	v_{ba}	v_{ca}	0	v_{ab}
NONE	-	-	-	-	-	-	E

Fig (a): Conduction Table



Fig(b): Phasor Diagram

Then from symmetry consideration we can see that each thyristor conducts for 120° of the input cycle. Now the thyristors are fired in the sequence $T_1 \rightarrow T_2 \rightarrow T_3 \rightarrow T_4 \rightarrow T_5 \rightarrow T_6 \rightarrow T_1$ 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 T_1T_2, T_2T_3, T_3T_4, T_4T_5, T_5T_6, T_6T_1. Each conduction mode is of 60° duration and appears in the sequence mentioned. The conduction table of Fig(a) shows voltage across different devices and the dc output voltage for each conduction interval. The phasor diagram of the line voltages appear in Fig. (b). Each of these line voltages can be associated with the firing of a thyristor with the help of the conduction table. For example the thyristor T_1 is fired at the end of T_5T_6 conduction interval. During this period the voltage across T_1 was V_{ac}. Therefore T_1 is fired α angle after the positive going zero crossing of V_{ac}. Similar observation can be made about other thyristors. The phaser diagram of Fig (b) also confirms that all the thyristors are fired in the correct sequence with 60° interval between each firing.

THREE PHASE HALF CONTROLLED CONVERTER

Fig:1 shows the circuit diagram of three phase half controlled converter supplying an R load. In the continuous conduction mode only one thyristor from top group and only one diode from the bottom group conduct at a time. However, unlike fully controlled converter here both devices from the same phase leg can conduct at the same time. Hence, there are nine conducting modes as shown in Fig (c).

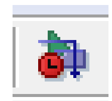
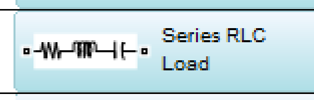
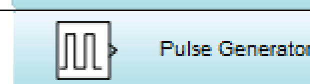
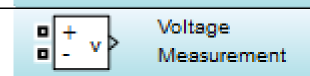
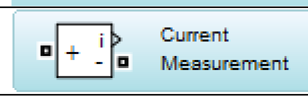
Mode / Volt	T_1D_2	D_2T_3	T_3D_4	D_4T_5	T_5D_6	D_6T_1	T_1D_4	T_3D_6	T_5D_2
V_{T1}	0	V_{ab}	V_{ab}	V_{ac}	V_{ac}	0	0	V_{ab}	V_{ac}
V_{D2}	0	0	V_{ac}	V_{ac}	V_{bc}	V_{bc}	V_{ac}	V_{bc}	0
V_{T3}	V_{ba}	0	0	V_{bc}	V_{bc}	V_{ba}	V_{ba}	0	V_{bc}
V_{D4}	V_{ca}	V_{ca}	0	0	V_{ba}	V_{ba}	0	V_{ba}	V_{ca}
V_{T5}	V_{ca}	V_{cb}	V_{cb}	0	0	V_{ca}	V_{ca}	V_{cb}	0
V_{D6}	V_{cb}	V_{cb}	V_{ab}	V_{ab}	0	0	V_{ab}	0	V_{cb}
V_0	V_{ac}	V_{bc}	V_{ba}	V_{ca}	V_{cb}	V_{ab}	0	0	0

Fig (c): Conduction Table

Now consider the conducting and blocking state of D_2. In the blocking state the voltage across D_2 is either V_{ac} or V_{bc}. Hence, D_2 can block only when these voltages are negative. Taking V_{bc} as the reference phasor (i.e., $V_{bc} = \sqrt{2}V_L \sin\omega t$) D_2 will block during $2\pi/3 \leq \omega t \leq 2\pi$ and will conduct in the interval $0 \leq \omega t \leq 2\pi/3$. Similarly it can be shown that D4 and D6 will conduct during $2\pi/3 \leq \omega t4 \leq \pi/3$ and $4\pi/3 \leq \omega t \leq 2\pi$ respectively.

Next consider conduction of T1. The firing sequence of the thyristor is T1 $\rightarrow$ T3 $\rightarrow$ T5. Therefore before T1 comes into conduction T5 conducts and voltage across T1 is $V_{ac} = \sqrt{2}V_L \sin(\omega t + \pi/3)$. If the firing angle of T1 is α then T1 starts conduction at $\omega t = \alpha - \pi/3$ and conducts upto $\alpha + \pi/3$. Similarly T3 and T5 conducts during $\alpha + \pi/3 \leq \omega t \leq \alpha + \pi$ and $\alpha + \pi \leq \omega t \leq 2\pi + \alpha - \pi/3$.

Procedure:

Operation	Path	Icon
Opening Simulink	1. Click on the Simulink icon on Matlab taskbar 2. Type Simulink on Matlab Command Window	
Selecting New File	File -> New -> Model	
Selecting Source	Libraries -> SimpowerSystems -> electrical sources	
Selecting Thyristor	Libraries -> SimPowerSystems -> PowerElectronics -> Thyristor	
Selecting Diode	Libraries -> SimPowerSystems -> PowerElectronics -> Diodes	
Selecting Series RLC branch	Libraries -> SimpowerSystems -> Elements	
Selecting Pulse Generater(Triggering)	Libraries -> Sources	
Voltage Measurement	Libraries -> SimpowerSystems -> Measurement	
Current Mesurement	Libraries -> SimpowerSystems -> Measurement	
Scope	Libraries -> Sink	

RESULT:

Three phase fully controlled and half controlled bridge rectifier is simulated and graphs are obtained.