Seminar #2 Report

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Part 1:

1. Topic

Three-Phase Full Bridge Rectifier (thyristor version)

2. Simulation Model

There are two models established to simulate three-phase full bridge rectifier (thyristor version)

2.1 (Simulation model 1)

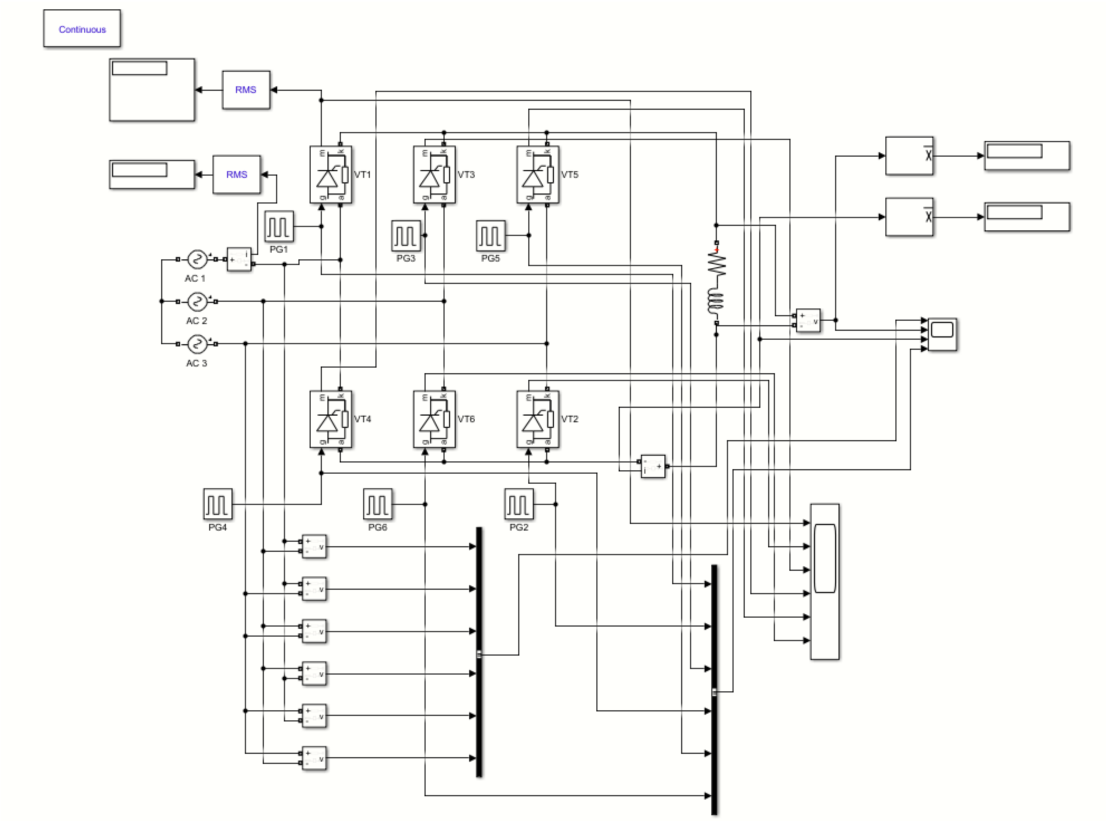


Figure 1: Simulation model 1

This model is established to simulate three-phase full bridge rectifier (thyristor version) under rectification mode. It includes three AC sources, six thyristors with six pulse generators correspondingly, and an inductive load. In order to observe the waveforms of U_d, I_d, phase to phase voltage, pulse voltage and current of thyristor, there are also some voltage measurements, current measurements, bus creators and scopes. And we also use some RMS blocks, mean blocks and displayers to display simulation results .

2.2 (model 2)

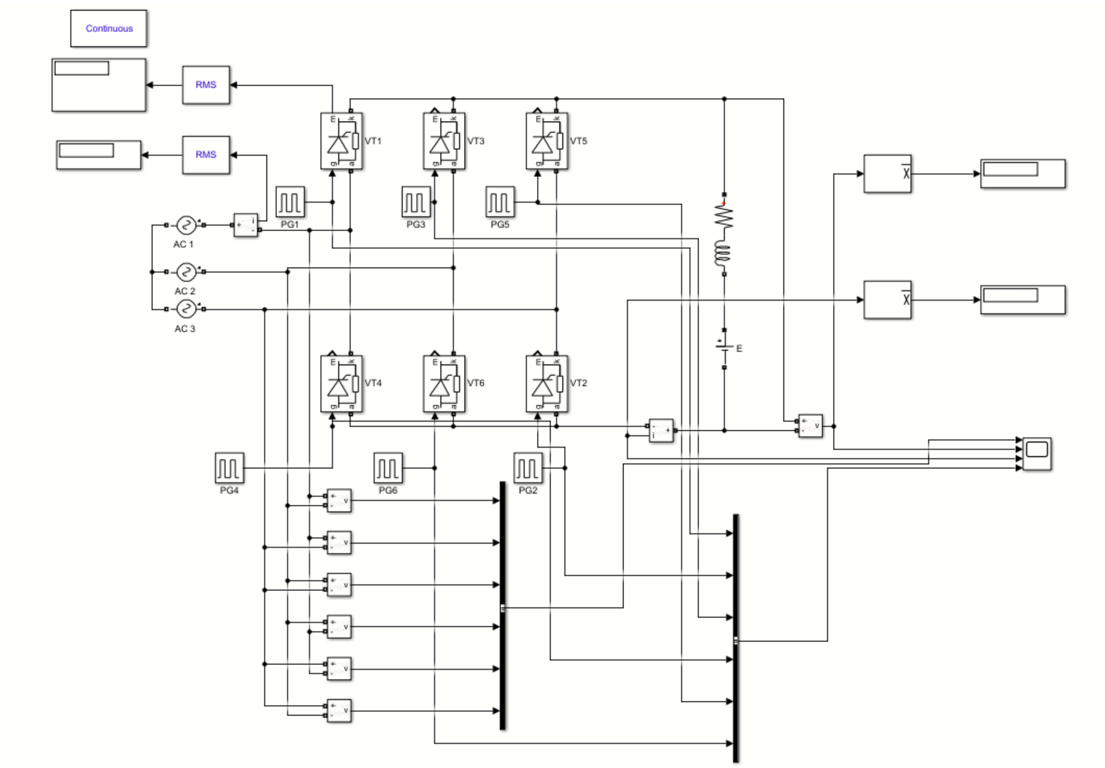


Figure 2: Simulation model 2

This model is established to simulate three-phase full bridge rectifier (thyristor version) under active inversion mode. It includes three AC sources, six thyristors with six pulse generators correspondingly, an inductive load and a back EMF. In order to observe the waveforms of U_d, I_d, phase to phase voltage and pulse voltage, there are also some voltage measurements, current measurements, bus creators and scopes. And we also use some RMS blocks, mean blocks and displayers to display simulation results .

3. Parameter Setup

3.1 (AC source parameters)

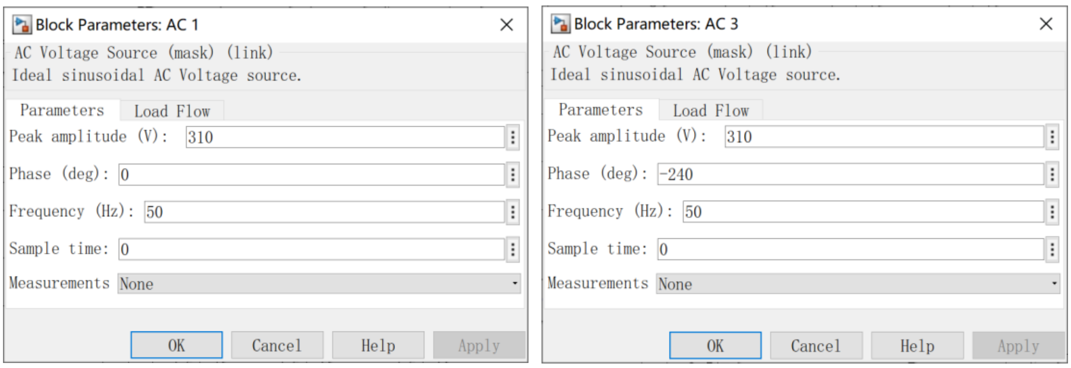


Figure 3: AC1 source parameters

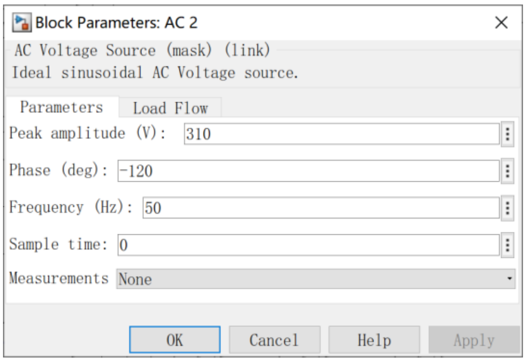


Figure 4: AC1 source parameters

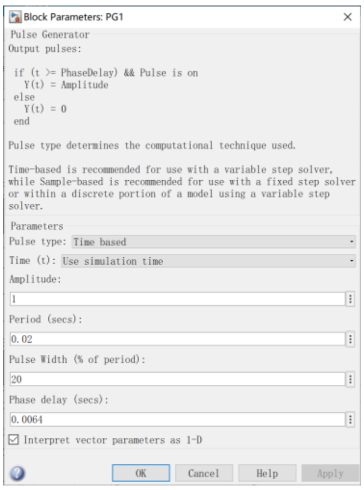
3.1(Pulse trigger time calculation)

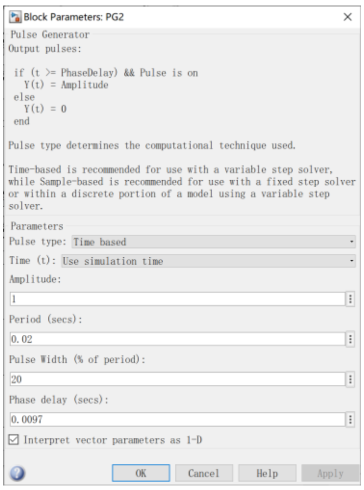
Matlab code	**result**

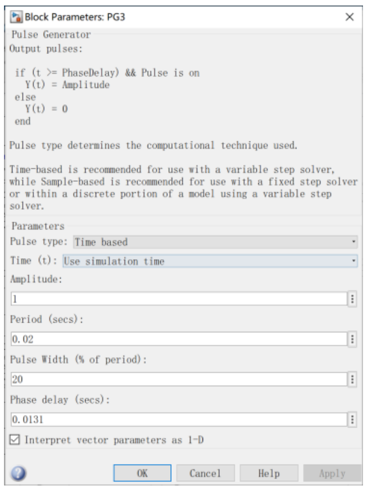
a=85;
f=50;
T=1/f;
VT1=(a+30)/360*T
VT2=(a+30+60)/360*T
VT3=(a+30+120)/360*T
VT4=(a+30+180)/360*T
VT5=(a+30+240)/360*T
VT6=(a+30+300)/360*T
	VT1 =0.0064
	VT2 =0.0097
	VT3 =0.0131
	VT4 =0.0164
	VT5 =0.0197
	VT6 =0.0231

a=170;
f=50;
T=1/f;
VT1=(a+30)/360*T
VT2=(a+30+60)/360*T
VT3=(a+30+120)/360*T
VT4=(a+30+180)/360*T
VT5=(a+30+240)/360*T
VT6=(a+30+300)/360*T
	VT1 =0.0111
	VT2 =0.0144
	VT3 =0.0178
	VT4 =0.0211
	VT5 =0.0244
	VT6 =0.0278

3.1 (Pulse parameters setup)







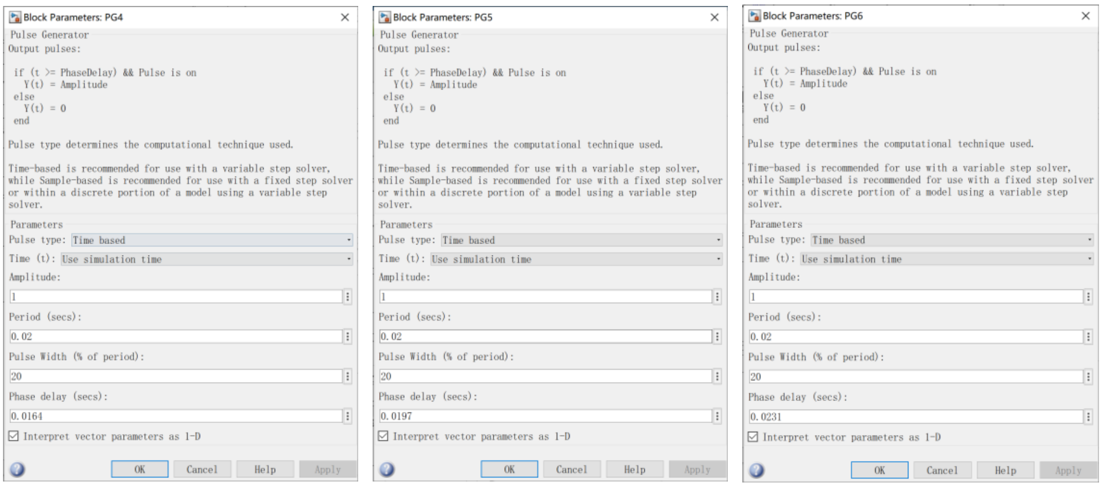


Figure 5: pulse generator parameters of part 1 model 1

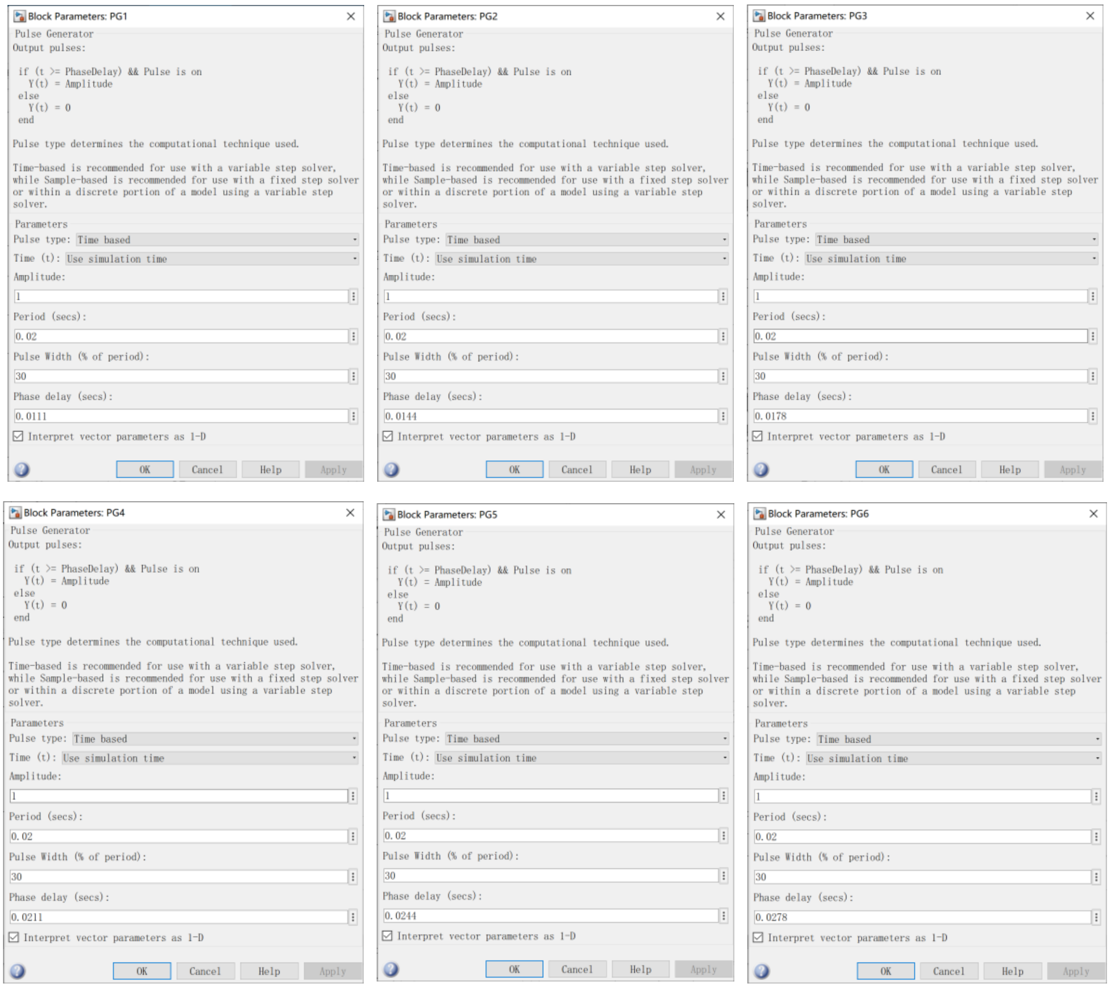


Figure 5: pulse generator parameters of part 1 model 2

3.3(other parameters

L	***R***	***E***	α_1	α_2
5mH	1Ω	-400V	85°	170°

4. Simulation Results

3.1 (Result of model 1)

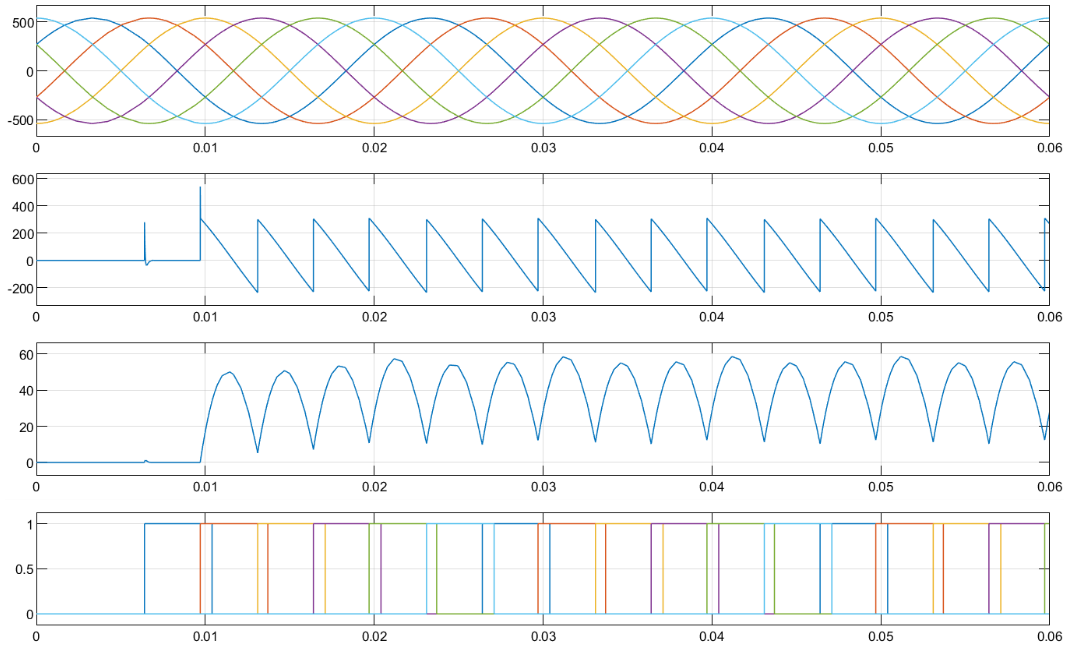


Figure 5: waveforms of phase to phase voltage, Ud, Id, and pulse voltage (α_1=85°)

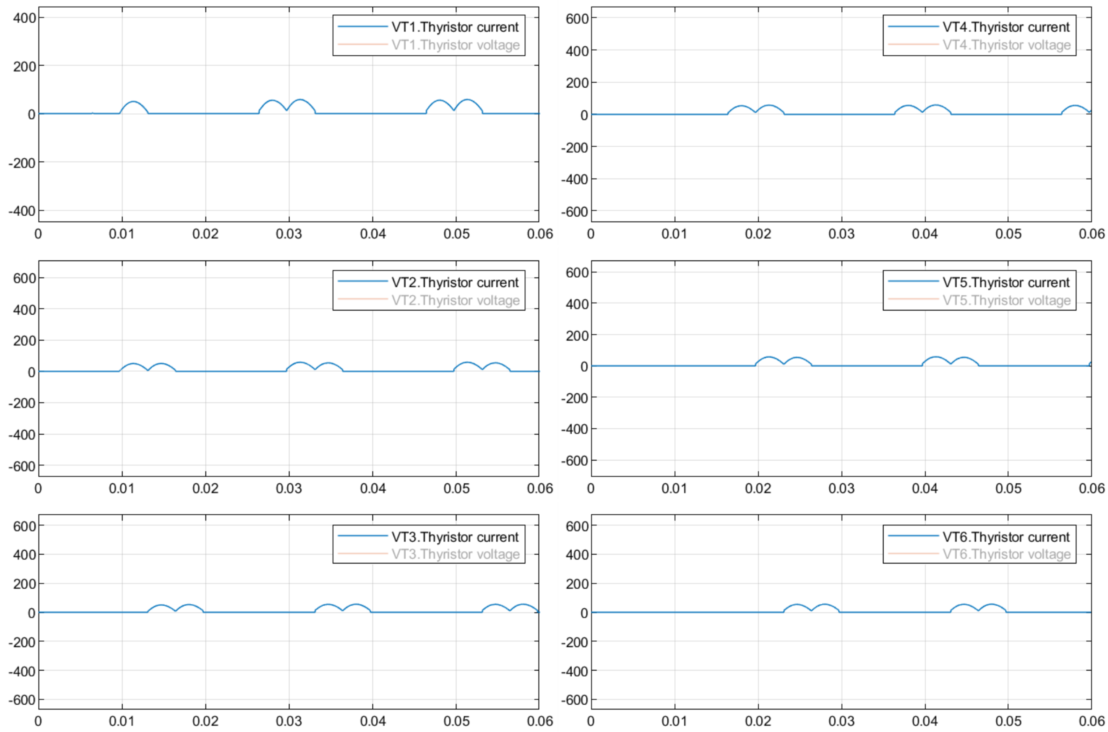


Figure 6: waveforms of current of thyristor

The sequence of driving signal of each thyristor is VT1+VT4 – VT2+VT5 – VT3+VT6.

3.1 (Result of model 2)

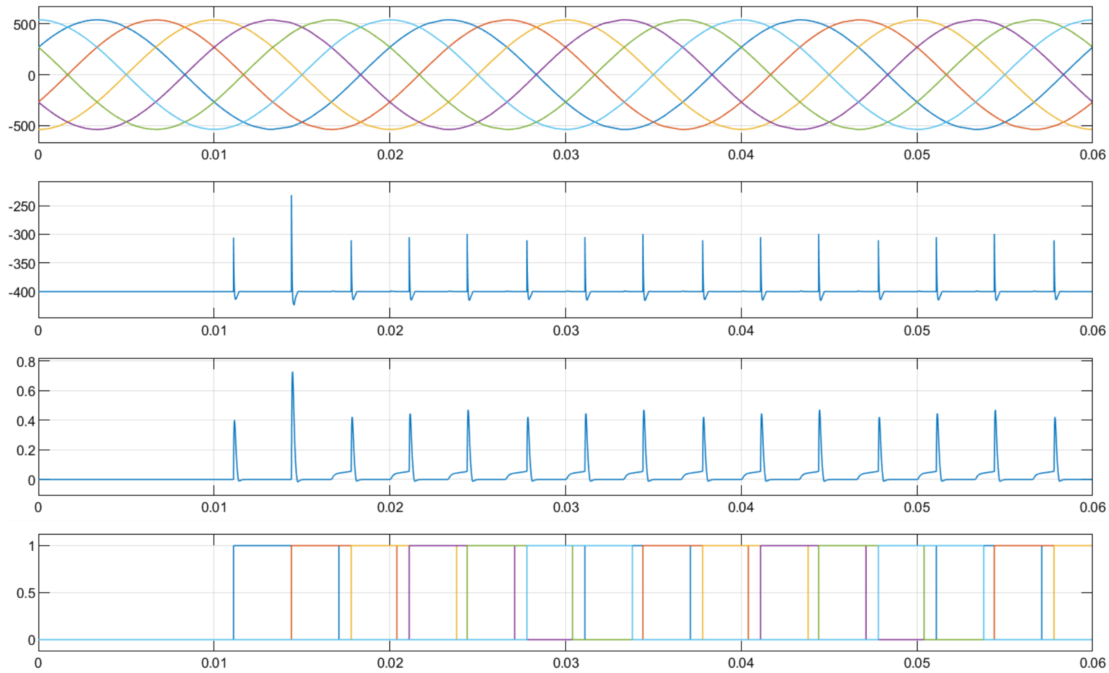


Figure 7: waveforms of phase to phase voltage, Ud, Id, and pulse voltage with back EMF (**α_2=170°**)

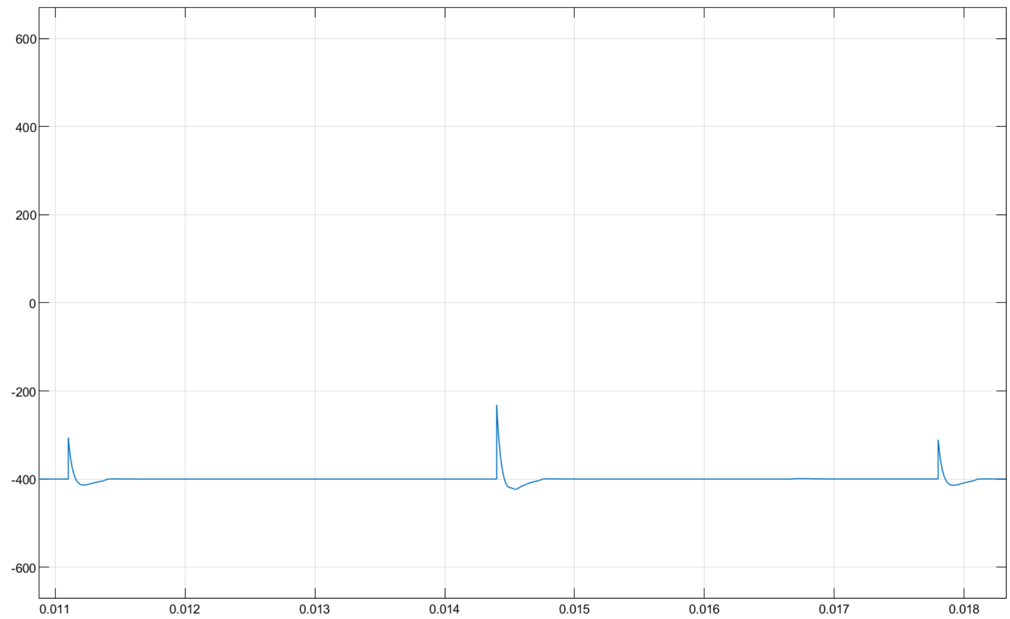


Figure 8: waveform of Ud

5. Analysis of the Results

3.1 (theoretical calculation of model 1)

theoretical calculations of rectification mode

$$U_d = 2.34U_2 \cos\alpha = 44.87V$$

$$I_d = \frac{U_d}{R} = \frac{44.87}{1}A = 44.87A$$

theoretical calculations of inversion mode

$$U_d = -2.34U_2 \cos\beta = -506.98V$$

$$I_d = \frac{U_d - E_M}{R_\Sigma} = \frac{-506.98 + 400}{1}A = -106.98A$$

$$I_2 = \sqrt{\frac{2}{3}} I_d = \sqrt{\frac{2}{3}} \times 44.87A = 36.64A \qquad I_2 = \sqrt{\frac{2}{3}} I_d = -\sqrt{\frac{2}{3}} \times 106.98A = -87.39A$$

$$I_{VT} = \sqrt{\frac{1}{3}} I_d = \sqrt{\frac{1}{3}} \times 44.87A = 25.91A \qquad I_{VT} = \sqrt{\frac{1}{3}} I_d = -\sqrt{\frac{1}{3}} \times 106.98A = -61.76A$$

3.1 (result of model 1)

	Rectification Mode			Active Inversion Mode		
	theoretical results	simulation results	error	theoretical results	simulation results	error
U_d	44.87V	42.31V	5.71%	-506.98V	-400V	
I_d	44.87A	40.87A	8.91%	-106.98A	0.03187A	
I_2	36.64A	33.92A	7.42%	-87.39A	0.07383A	
I_{VT}	25.91A	28.46A	9.84%	-61.76A	0.07439A	

3.1 (analysis of part 1)

According to the data in the table, we find the simulation statistics of rectification mode is similar to the theoretical results. However, the simulation statistics of active inversion mode is quite different from the theoretical results. Therefore, we did some further research to look up into this question.

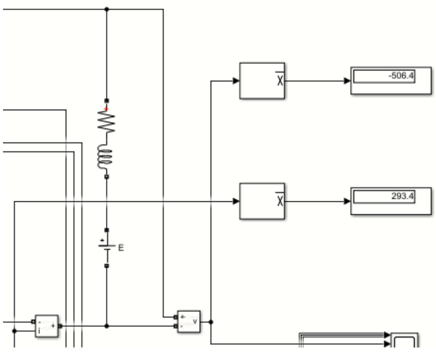


Figure 9: simulation results of U_d and I_d

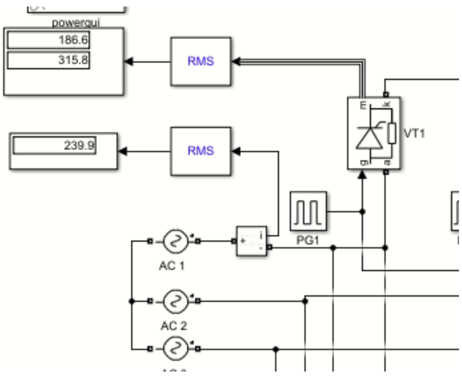


Figure 10: simulation results of I_{VT} and I_2

We find that the absolute value of *E* is less than the absolute value of U_d when calculated according to the given data, and the calculated current is negative. From the conduction characteristics of thyristor, it is impossible to happen in practice. When we change *E* to -800V, the simulation results are in good agreement with the theoretical value. This is because when the absolute value of E is less than the absolute value of U_D, *E* is not enough to send electric energy from DC side to AC side.

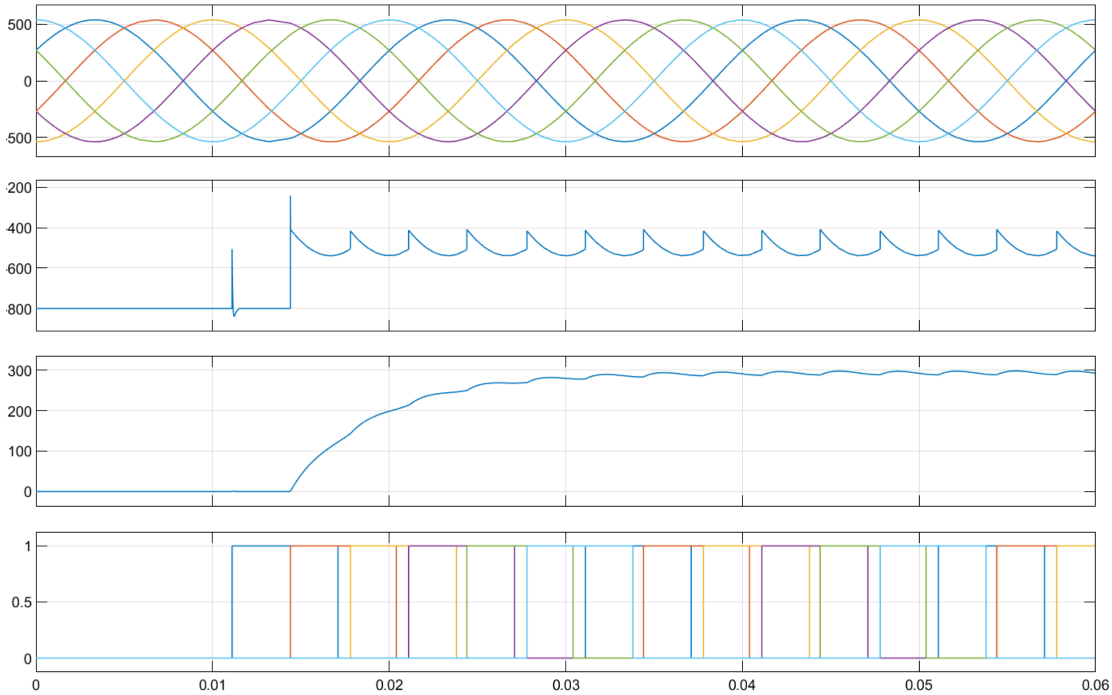


Figure 10: waveforms of phase to phase voltage, Ud, Id, and pulse voltage with back EMF (E=-800V)

Part 2:

1. Topic

Three-Phase Full Bridge Rectifier (power diode version)

2. Simulation Model

There is onr model established to simulate three-phase full bridge rectifier (power diode version)

2.1 (Simulation model)

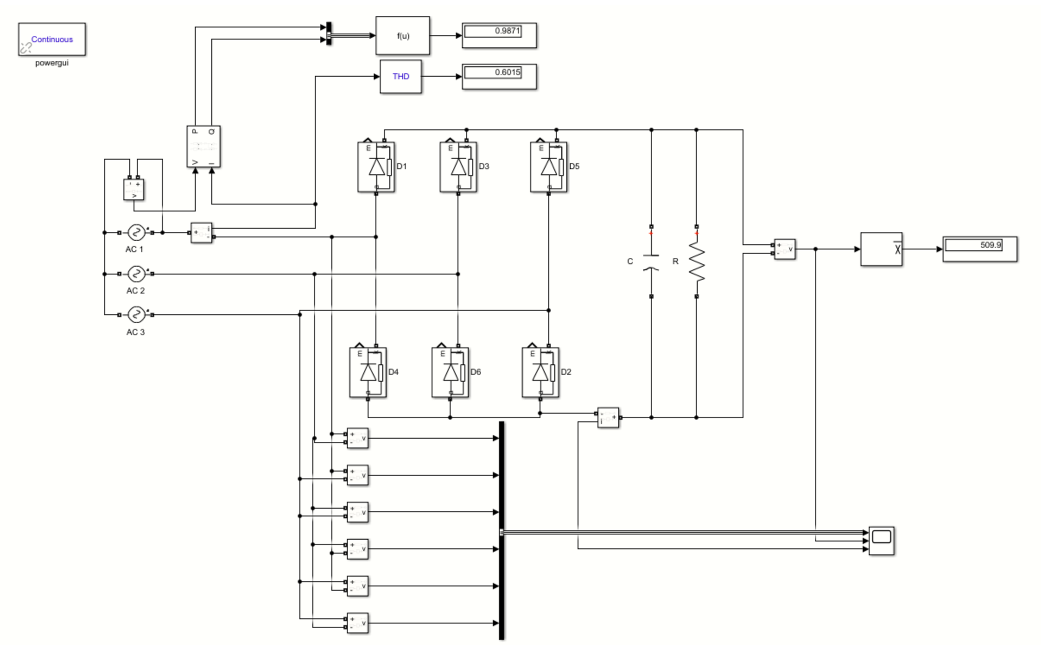
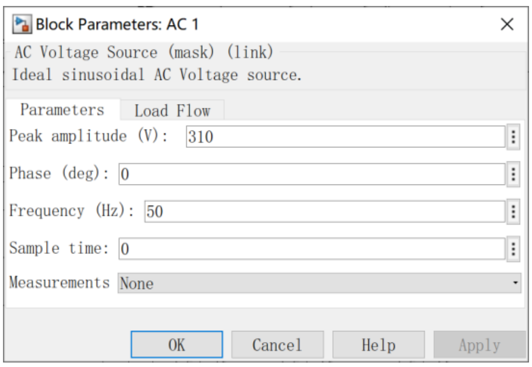


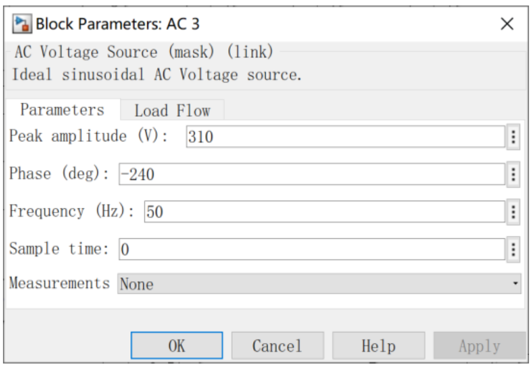
Figure 1: Simulation model 3

This model is established to simulate three-phase full bridge rectifier (power diode version). It includes three AC sources, six power diodes, a resistor and a capacitor. In order to observe the waveforms of U_d, I_d, phase to phase voltage, there are also some voltage measurements, current measurements, power measurements, bus creators and scopes. And we also use some RMS blocks, mean blocks, THD blocks, function blocks, and displayers to display simulation results .

3. Parameter Setup

3.1 (AC source parameters)





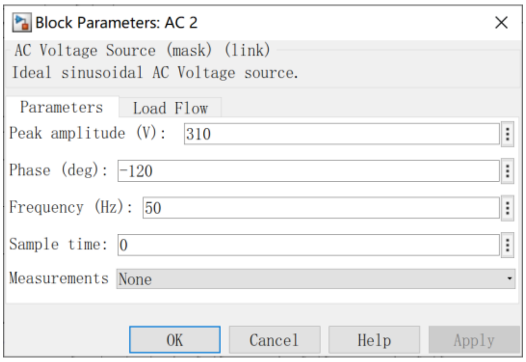


Figure 2: AC1 source parameters

3.1 (Other parameters)

C	5.5mF

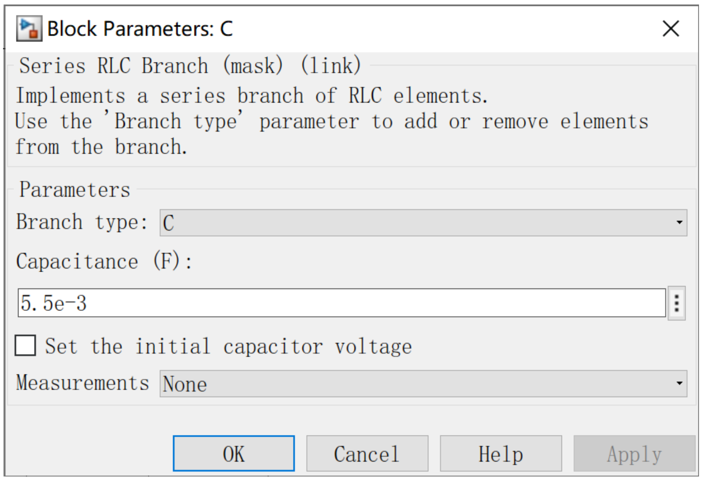


Figure 3: capacitor parameters

4. Simulation Results

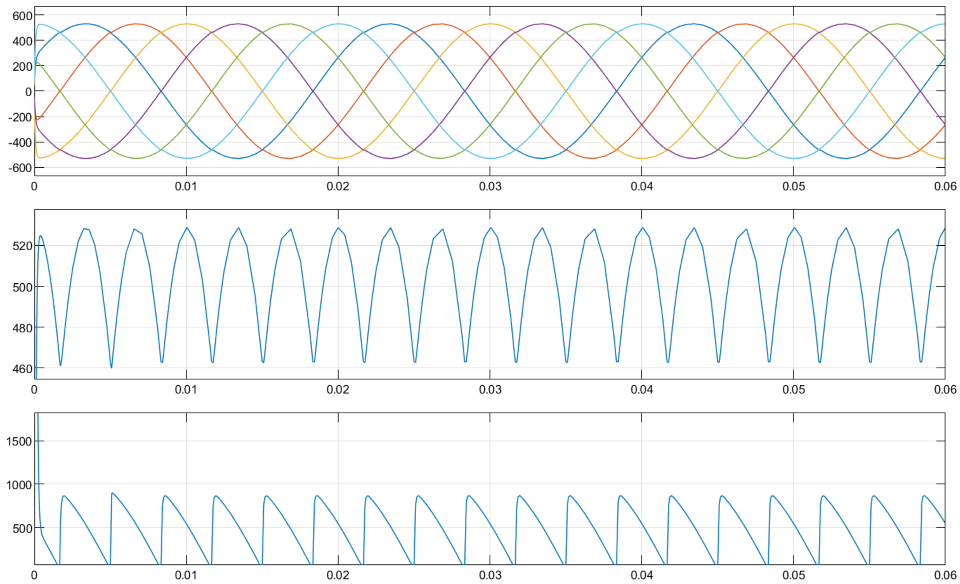


Figure 4: waveforms of phase to phase voltage, Ud and Id

5. Analysis of the Results

The results of part2 are:

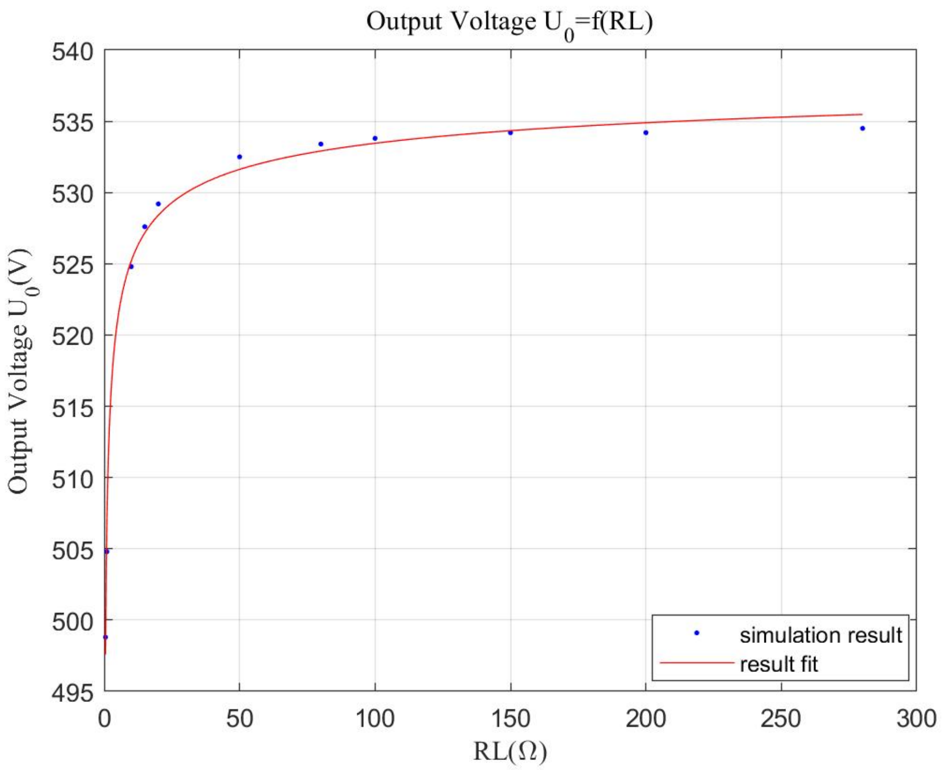


Figure 5 Uo = f(RL)

We test 10 points of RL, from 1 ohm to 280 ohm. The result shows that the output voltage increases with the resistance increasing, starting from 550V to around 535V. And when the resistance is about 30 ohm, the increasing rate is getting slow down.

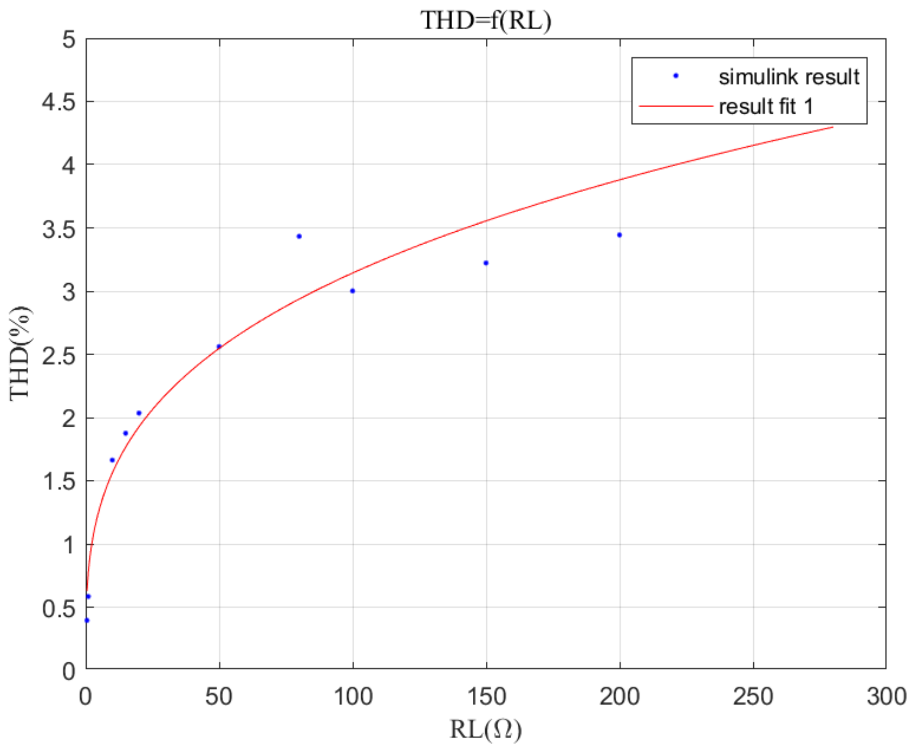


Figure 6 THD = f(RL)

The THD increases with the resistance increasing, starting from 0.5 to around 4.5.

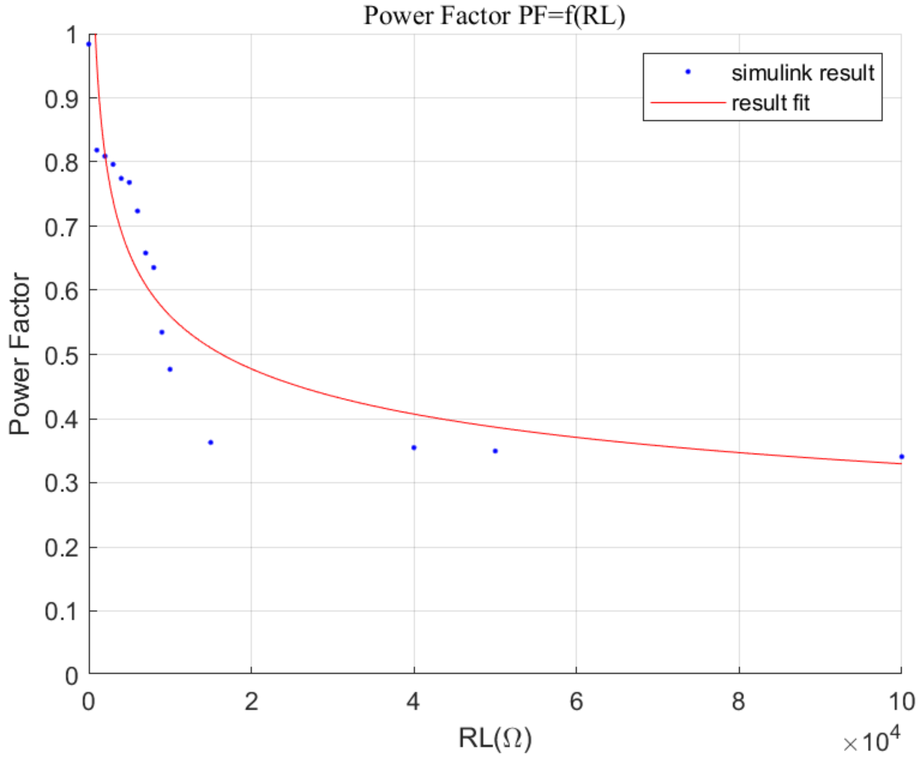


Figure 7 PF = f(RL)

The power factor decreases with the resistance increasing, starting from about 1 to around 0.35. And when the resistance is about 1000 ohm, the increasing rate is getting slow down.

As we know, the critical condition $\omega RC=\sqrt{3}$ is the intermittent and continuity of the waveform of current i_d. When the resistance is large, the curve of current i_d is continuous. Meanwhile, when the load is small, the curve of current i_d isn't continuous. The bellowing might be the reason why the inflection point turns out.

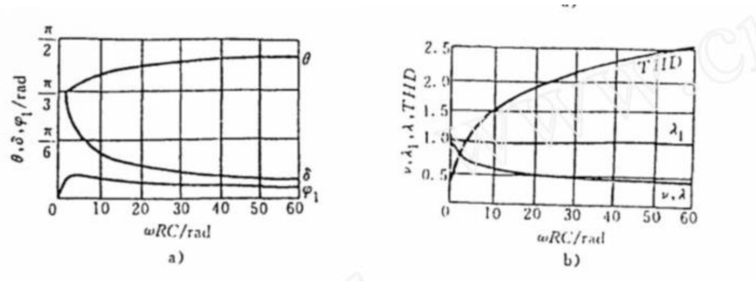


Figure 8 results from literature

This is a figure that we found in a paper about the three-phase full bridge rectifier with capacitor impedance. It is very similar to the results we got in the Simulink.