

Middle East Technical University

Electrical & Electronics Engineering Department

EE463 – Static Power Conversion I

Hardware Project

Complete Simulation Report

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# **Introduction**

# **Problem Definition**

# **Possible Topologies for Solution**

## **Single Phase Thyristor Rectifier**

## **Three Phase Thyristor Rectifier**

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*Figure x. Three phase thyristor rectifier schematic****.***

Six thyristors are employed in the three phase thyristor rectifier. Thyristors are activated using gate signal generators to regulate output voltage. Theoretical output voltage calculation is as follows,

**Advantages**

* Without using an extra converter, the output voltage can be managed with a three phase thyristor rectifier.
* Output voltage ripple of this topology is lower than the single phase thyristor rectifier topology.
* THD of this topology is lower. Since, the third harmonic of the input current is not observed.
* Back-to-back three phase thyristor rectifiers can be used to achieve four quadrant operation.

**Disadvantages**

* Thyristors are more expensive than regular diodes as component, and six thyristors make up this topology. This topology is therefore more expensive than other alternatives.
* Three phase thyristor rectifier topology requires the usage of six separate gate signals. In order to do this, gate drivers and additional components are needed. It raises the price and makes the structure more difficult.
* It is challenging to synchronize gate drivers. Since it should be taken into account, the zero crossing issue.

## **Three Phase Diode Rectifier and Buck Converter**

There are two sections of this topology. Three phase ac grid voltage is rectified in the first section to low ripple dc voltage. In the second section, we use a buck converter to adjust the output voltage using the switch's duty cycle.



*Figure x. Three phase diode rectifier schematic****.***

There is no control of average output voltage for three phase diode rectifier. Calculation of the output voltage is as follows,

In order to control the output voltage, a buck converter must be used after the rectifier circuit.



*Figure x. Buck converter schematic****.***

The input dc voltage is step-down to the desired level by the buck converter. A MOSFET that is driven by a gate signal is used to regulate output voltage. Outpur voltage of a buck converter simply calculated as,

As we connect the rectifier and the buck converter, the output voltage becomes,

**Advantages**

* This topology has low voltage ripple in output.
* Only one gate signal is needed for this topology, and it will be supplied to operate the buck converter. In comparison to other topologies, this system is hence simpler. Additionally, syncing the signals is not needed in this topology.
* The cost of this system is lower than that of thyristor rectifiers.

**Disadvantages**

* Four quadrant operation is not supported by this topology. There is no method to obtain four quadrants because a diode rectifier can only operate in one quadrant.
* As a result of using an external diode in the buck converter, the predicted efficiency is lower than topologies with thyristors.

# **Topology Selection and Reasoning**

We gave information about 3 different alternative topologies that can be used within the scope of the project. We also listed the advantages and disadvantages of each topology. When we compared the advantages of each topology, we decided that three phsae diode rectifiers with buck converter would be the most suitable topology for us.

The most effective factor in the selection of three phase diode rectifier topology with buck converter was simplisity. In other rectifier topologies using thyristor, it would be necessary to generate multiple gate signals and perform zero crossing detection to control the system. However, in a topology with a diode rectifier, only the gate signal will be needed for the buck converter that we will add to the system. In addition, its cheapness and low output voltage were also effective in our decision.

# **Simulations of Selected Topology**

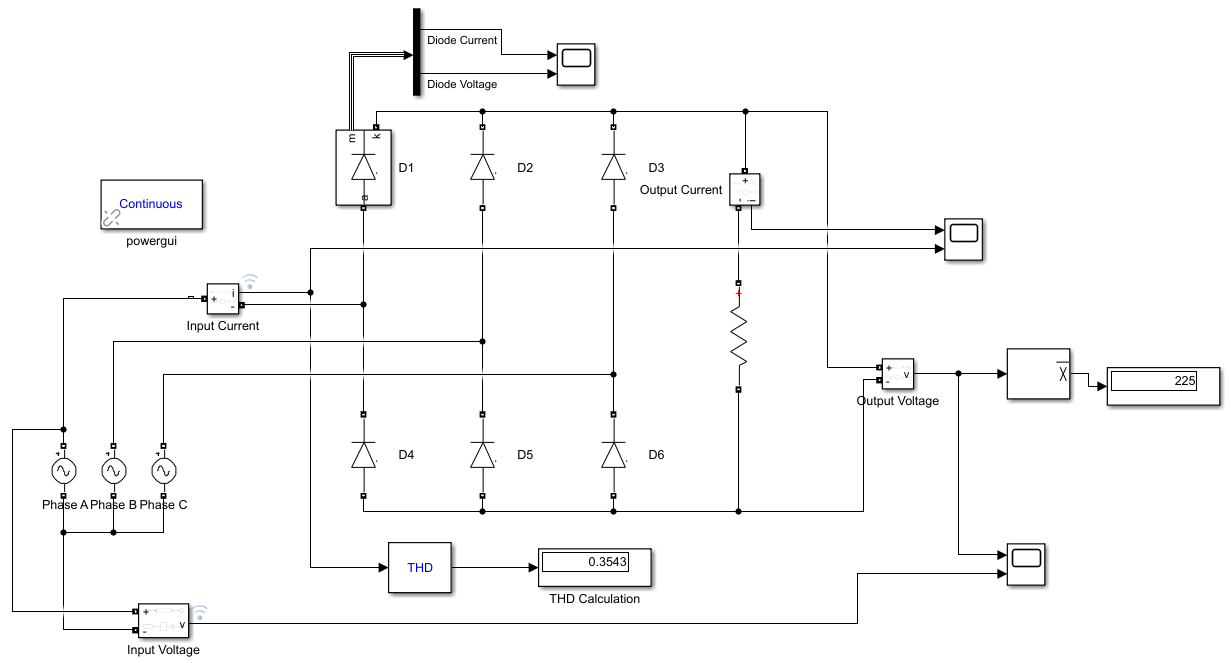
In this section, the simulation tests of the topology we have chosen are part by part.

## **Three Phase Diode Rectifier Simulation**

Within the scope of the project, we were asked to drive the motor with a maximum of 180V DC. Therefore, the output voltage that we will see at the output of our entire system at the maximum duty cycle value that we will determine for the buck converter should be 180Vrms DC. When we consider the output that the buck converter will provide, we know that the output voltage of buck converters varies in direct proportion according to the duty cycle percentage of the switch used in the converter. However, since high duty cycle values cannot be achieved in practice, we have determined the maximum duty cycle value of the gate signal that we will use for the switching process as 80%. In order for us to see 180Vrms in the buck converter output with 80% duty cycle, our input phase voltage should be calculated as follows,

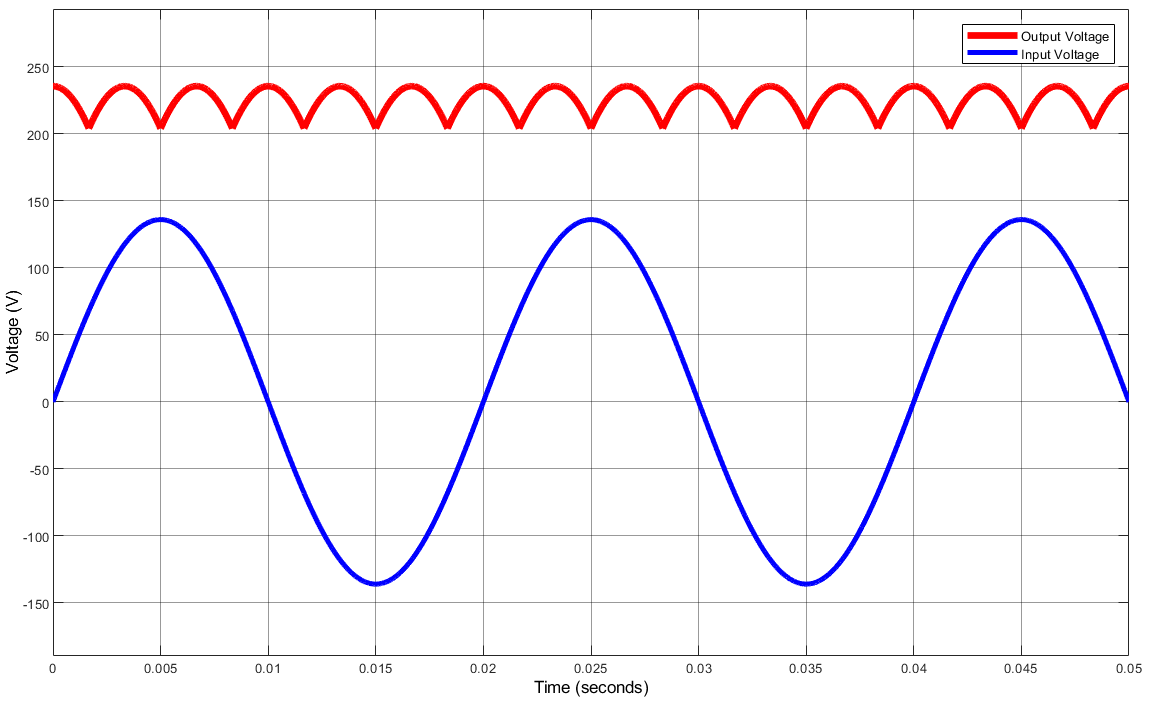
Since the ideal case will be considered in our simulation, the value of 96.2Vrms is used as the input pahse voltage. However, due to the voltage drop due to commutation and other nonidealities, the amount of input voltage will need to increase a little more.

The circuit schematic used for the simulation of the three phase diode rectifier is as in figure x.



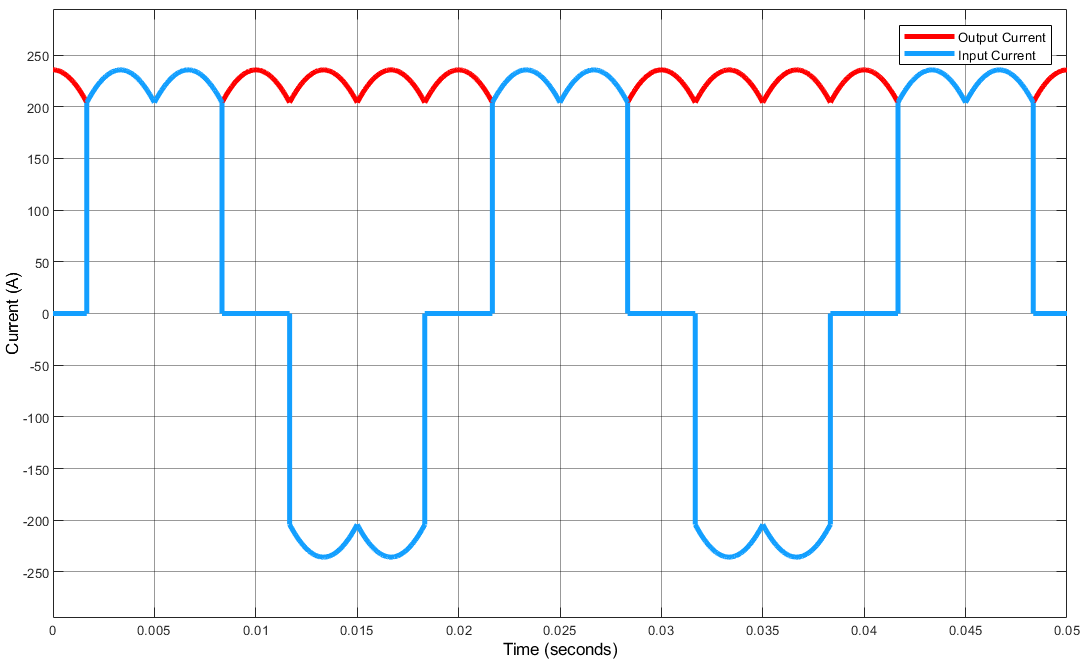
*Figure x. Circuit schematic for simulation of three phase diode rectifier.*

Simulation results of input and output voltage waveform are included in figure x.



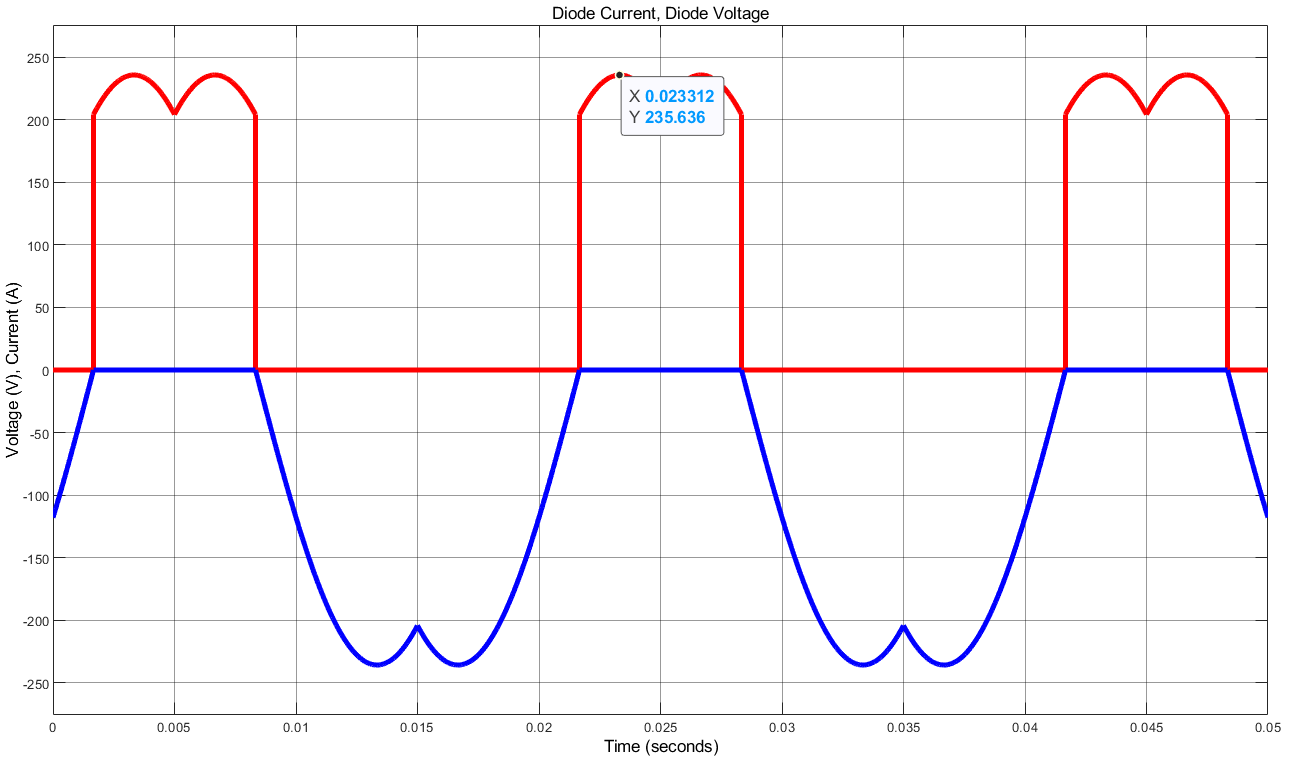
*Figure x. Input and output voltage waveforms of three phase diode rectifier.*

The simulation results of the input and output current waveform are given in figure x.



*Figure x. Input and output current waveforms of three phase diode rectifier.*

The waveform showing the voltage and current flowing through one of the diodes used in the rectifier is as in figure x*.*

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*Figure x. Diode current and voltage waveforms for thre phase diode rectifier.*

Only 1ohm resistor was used as load in the simulation model. Since no capacitor is used as a load, the observed ripple voltage is higher than a capacitor rectifier. When we examined the simulation plots obtained, it was observed that the waveforms were according to the ideal case without line inductance and resistances as expected*.*

Since the resistance value used in the load is 1ohm and our diode is considered ideal, the maximum voltage value on the resistor and the maximum current that will pass through it are equal and 235.6V and 235.6A. The maximum current rating varies according to the resistance at the load.

## **Buck Converter Simulation**

## **Three Phase Diode Rectifier and Buck Converter Simulation**

# **Simulation of Controller**

# **Component Selection**

# **Thermal Analysis**

# **Conclusion**

# **References**