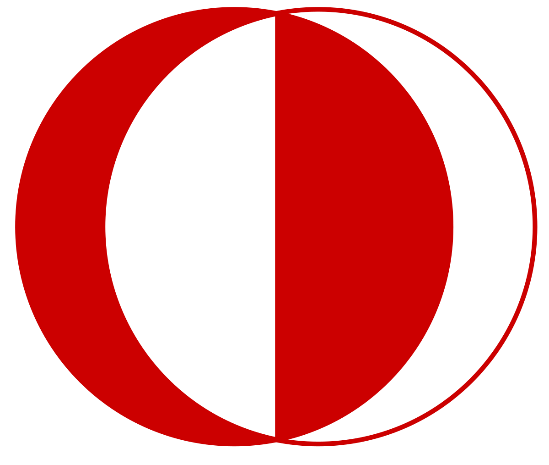
# **EE463 STATIC POWER CONVERSION-I**

# **TERM PROJECT SIMULATION REPORT**



Musa Ulusoy 2305555

Muhammet Samet Yakut 2305647

Berna Corak 2304392

Table of Contents

[**EE463 STATIC POWER CONVERSION-I** 1](#_Toc91525592)

[**TERM PROJECT SIMULATION REPORT** 1](#_Toc91525593)

[**Introduction** 3](#_Toc91525594)

[**Topology Selection** 3](#_Toc91525595)

[**Analytical Calculations** 4](#_Toc91525596)

[**Thermal Calculations** 5](#_Toc91525597)

[**Switching Losses and Conduction Losses:** 5](#_Toc91525598)

[**Capacitor and Inductor Losses:** 6](#_Toc91525599)

# **Introduction**

In our term project we are required to build a motor driver circuitry which will run a DC motor via AC grid. In this report, the topology we have chosen and the reason behind it will be discussed. Necessary analytical calculations will be given. Simulation of the circuitry will be talked upon and component selection will be presented. Next, thermal calculations and the implementation we have done so far will be provided.

# **Topology Selection**

Specifications of the project can be found in the GitHub repository: <https://github.com/odtu/ee463/tree/master/Term%20Project>. For this project, basic topologies that we considered are as follows:

* *Center-tap transformer:* This topology turned out to be way expensive compared to others (~300 TL), therefore it is automatically eliminated. Besides this, in the small scale it has only one tap at the secondary, decreasing the flexibility of the output voltage, if used as a single component.
* *Single phase full bridge diode rectifier with buck converter:* This topology is comparably cheaper compared to others. However maximum output voltage that a single phase diode rectifier can provide is 207 V, when variac is at 100%. That means for a maximum operational output of 180 V, duty cycle (DC) of the buck converter should be around 90%, which is not desired since as DC gets closer to the edges, its output becomes instable and non-reliable.
* *Single phase thyristor rectifier:* Similarly with the previous topology, maximum output this can provide is 207 V. For 180 V output, 30° of firing angle is required, which is reasonable. However, compared to the next topology especially, two gate driver circuitry is needed, complicating the matters. Even though price-wise being comparable with the three phase full bridge diode rectifier with buck converter, this topology is found to be more error-prone due to this multiple gate driver requirement and hence is not chosen.
* *Three phase full bridge diode rectifier with buck converter:* This topology is decided upon at the end, due to it being cheap and its ease of implementation. Since the motor acts like a capacitive load in addition with its series parasitic inductance, two components of the buck converter is not necessary, decreasing the cost even further and simplifying the circuitry. Only a gate driver is basically needed, which is fairly doable.
* *Three phase thyristor rectifier:* Compared with the single phase case, cost and complexity is tripled, thus this topology is, too, eliminated.

# **Analytical Calculations**

Average output voltage of a three phase full bridge diode rectifier, ignoring the commutation:

For our purposes, reaching this high is not necessary, thus variac can be arranged such that DC does not go beyond 80%.

In other words, by setting the variac around 42-50%, we can operate the buck converter below 80% DC.

# **Thermal Calculations**

## **Switching Losses and Conduction Losses:**

Our design consists of 7 diodes and 1 IGBT as semiconductors. 6 of the diodes is in the three-phase rectifier module, 1 of them is used as a freewheeling diode buck converter and also, IGBT is used as a switch in the buck converter.

**-Switching Loss formula (Reverse Recovery Loss):**

**-Conduction Loss Formula**

Three-phase rectifier module VUO36-16NO8 [1] consist of 6 diodes. For these diodes, let’s do the loss calculations:

(Maximum voltage that rectifier diodes will block) (buck converterin duty cycle’I edge’lere yakin olmamasi icin line-line voltage boyle olmali)

(In our case, reverse current will be smaller since Vreverse = 135 V)

(Operation Frequency)

(Not written in the datasheet)

Hence, for these diodes, switching losses can be ignored.

(Maximum current that passes through a diode in our design)

For the freewheeling diode, we are planning to implement DSEP30-06B [2] to the buck converter. For this diode, let’s do the loss calculations:

(Maximum voltage of the motor that diode will block)

(In our case, reverse current will be smaller since Vreverse = 180 V)

(Operation Frequency)

(Written in the datasheet)

We can say that switching loss is very low.

(Maximum current that passes through this diode in our design)

The IGBT used as a switch in the buck converter is IXGH24N60C4D1 [3]. For this IGBT, let’s do the loss calculations:

(Switch on energy of the IGBT)

(Switch off energy of the IGBT)

(Collector-Emitter voltage in saturation)

(Current passes through this IGBT when it is conducting)

## **Capacitor and Inductor Losses:**

The remaining losses comes from the parasitic resistances of the inductor. We are not planning to use capacitor neither in the rectifier side nor in the buck converter side. Also, controller unit is working for logical operations hence, it does not consume significant amount of power. So, inductors cable resistance is enough for the loss calculation.

(Armature winding resistance)

13.6W

# **Implementation**

So far, we have set 3 lab meeting to try some parts of the project. The tested parts are

* A close loop feedback topology
* Three-phase rectifier module.

For the close loop feedback topology, we worked on a topology which consist lots of LM741 op-amps. We initially tested the square wave generator part of the topology. The duty cycle of the square wave can be adjusted with a potentiometer. We have done it successfully, but afterwards, we decided that keeping all the op-amps in the linear region is hard to achieve. Hence, it is decided to search for another feedback topologies. After that, we decided to implement TL494 voltage reference chip into our circuit controller. It is thought that output voltage will be sampled by this chip, and it compares the sampled voltage with the reference voltage. Then, TL494 will arrange the duty cycle of the square wave and IGBT of the buck converter will switch accordingly.

For the three-phase rectifier module, we have bought one from the Konya Street. However, when we tested it, we realized that one of the diodes were not working. Hence, we go to Konya Street again and bought another one. This was working well. With this module, it can be said that rectification will be done successfully.

Of course, there are some challenges for us in this project. However, our biggest challenge is closed-loop controller design. We are not familiar with the TL494 chip and testing procedure of this chip is not easy for uninformed ones. By doing some research, it was found a test circuit for the TL494. However, after the implementation of this circuit was hard and we could not observe any expected results. It would be nice to adding some photos of the circuit or the results but taking photos did not come to our minds. Another problem is temperature of the IGBT. There will be losses in the IGBT, and this energy will pop up as heat. Hence, heatsink must be used to prevent heating problems.