Middle East Technical University

Electrical and Electronics Engineering Department

EE 463 - STATIC POWER CONVERSION I

DESIGN&MANUFACTURING PLAN OF HARDWARE PROJECT (KARA SIMSEKLER GROUP)

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1.INTRODUCTION:

Driving a DC motor is a very fundamental and important role for a Power Electronics engineer. Therefore, that project is a great chance for students. It is divided into parts, and for the first part, a topology is chosen to drive the motor in a proper way, and according to chosen topology, some simulations are made.

The Project includes 2 basic problems. One of them is the AC to DC conversion and other one is speed control of DC motor. AC to DC conversion is made by using rectifier circuits such as thyristor and diode rectifier. In addition, speed is directly controlled by input voltages or it is controlled by using PWM control. Also, the DC motor can be connected as series, shunt or separately excited. The connection method changes the characteristic of the motor and controlling systems.

In this report, some topologies which can be useful for driving a motor are investigated in a detailed way. Advantages and disadvantages of them are listed. The reasons why that topology is chosen, and simulation results of chosen topology are added. Moreover, some discussions are made about how a better DC output can be obtained from the motor driver. Lastly, proper components are selected with their values.

2. DESIGN OF THE PROJECT PARTS

2.1 AC to DC Conversion

AC to DC conversion are made by using rectifier circuit. There are some rectifier topologies such as diode and thyristor rectifiers. Diode rectifiers are used for uncontrolled rectification. Thus, the output voltage is not controlled externally. Thyristor rectifiers are controlled by firing angle and output voltage level can be adjusted. In our cases, we wanted that rectifier gives the uncontrolled, constant DC voltage. Hence, a diode rectifier circuits were used at this project.

In addition, it is supposed that output of rectifier circuit has low voltage ripple. Thus, the 3 phase diode rectifiers were used. Moreover, advantages of 3-phase rectification over 1 phase rectification are:

1) The output current in the load contain very less AC component.
2) Ripple factor is lower and therefore high filtering is not required to give steady DC output.
3) The power output and, rectification efficiency is quite high.
4) Transformer Utilization Factor (TUF) is high.
5) Higher DC output voltage and higher DC output power.

Therefore, it is obvious that choosing a 3-phase rectifier is more logical.

The three-phase diode bridge with DC link capacitor are illustrated at Figure 1. The DC link capacitor is used for minimizing voltage ripple at output of the rectifier.

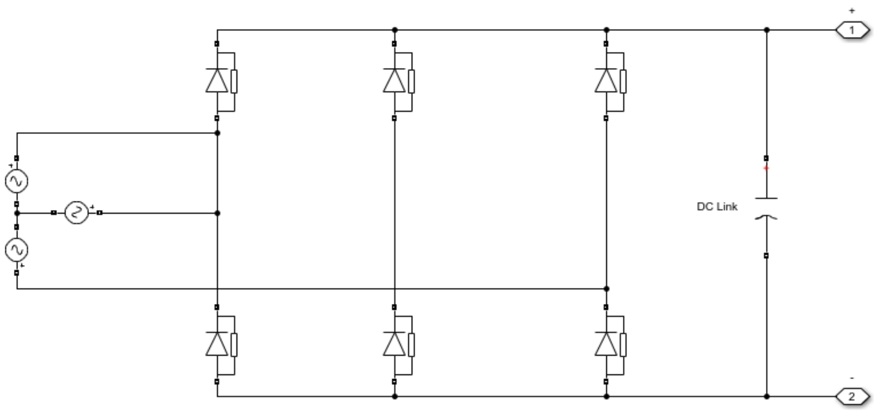

Figure 1- The three-phase diode bridge with DC link capacitor

For the Figure 1, the output voltage is (Line-to-Line Voltage) and the ripple without capacitor is 300 Hz. The capacitor is used for destroying this voltage ripple. The capacitor is range of hundred micro farad and it is called DC link capacitor.

2.2 SPEED CONTROL

At AC to DC conversion, 3 phase diode rectifiers were used and the output of the rectifier were constant. The speed of the motor can be controlled by voltage level changing using buck converter at armature terminal of the motor. Thus, the voltage level is adjusted by using PWM control. Physical meaning of the PWM is switching device that led the current flow at specific time in periodic way. The switching device is called as transistor. When the transistor is off, the other switch led load current flow over. The other switch is diode that is called Free-Wheeling Diode. It is obligatory because of the motor; inductive load and it does not lead the current change immediately. Buck converter which is composed of the switching transistor and free-wheeling diode are illustrated at Figure 2.

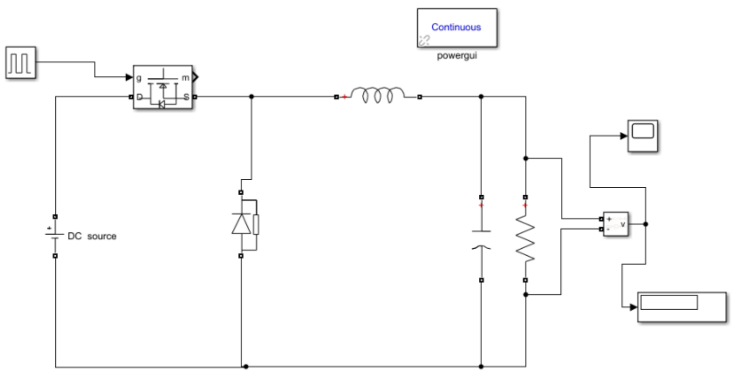

Figure 2- Buck Converter Topology

Duty level determines the armature voltage of the DC motor and it adjust the speed and torque of the DC motor.

Also, the transistor is controlled by the gate driver. The gate driver switches the transistor and it controls the duty cycle and so armature voltage.

For controlling the duty, the controller must be used. The controller can be analog or digital. Also, the controller signal is isolated with transistors due to avoiding the ground loop.

3) OVERALL DESİGN

The overall design is merged form of two parts. One of them AC to DC converter, and other one is voltage level regulator. The Figure 3 is illustrated the overall circuit schematic. Gate Driver has two basic unit which are controller and electrical insulator.

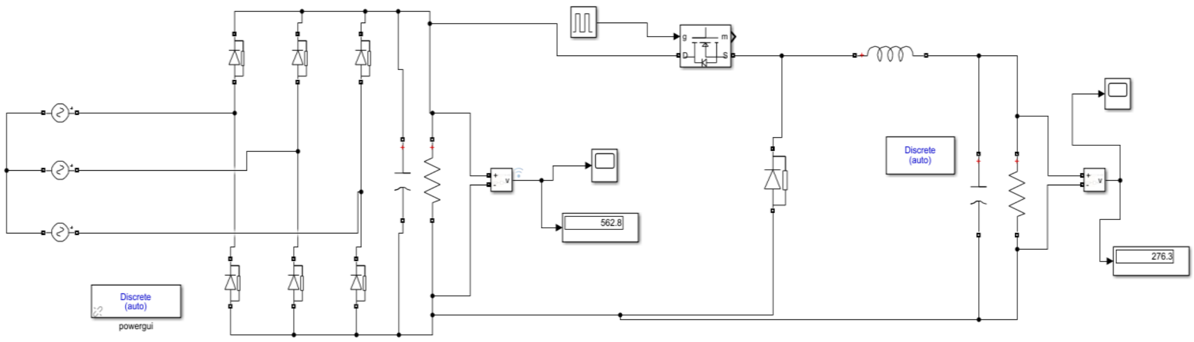

Figure 3 – Overall Design of 3 Phase converter and Buck converter

4) PLAN FOR MANUFACTURING

First, we will simulate our design as much as possible and while simulating we will try to simulate with non-ideal components to get more realistic results. During these simulations, we will try to get better results by changing some design parameters or adding new components. Moreover, while we are simulating our design, we aim to set up configuration in real part by part to observe the difference between simulation and reality. After we achieve our goal, we will try to improve our design for bonus parts of project (robustness, neatness etc.).

5) SIMULATION RESULTS

3 phase Diode Rectifier + Buck Converter was chosen as a DC motor driver .Simulation was made to know our motor driver.Results are given.

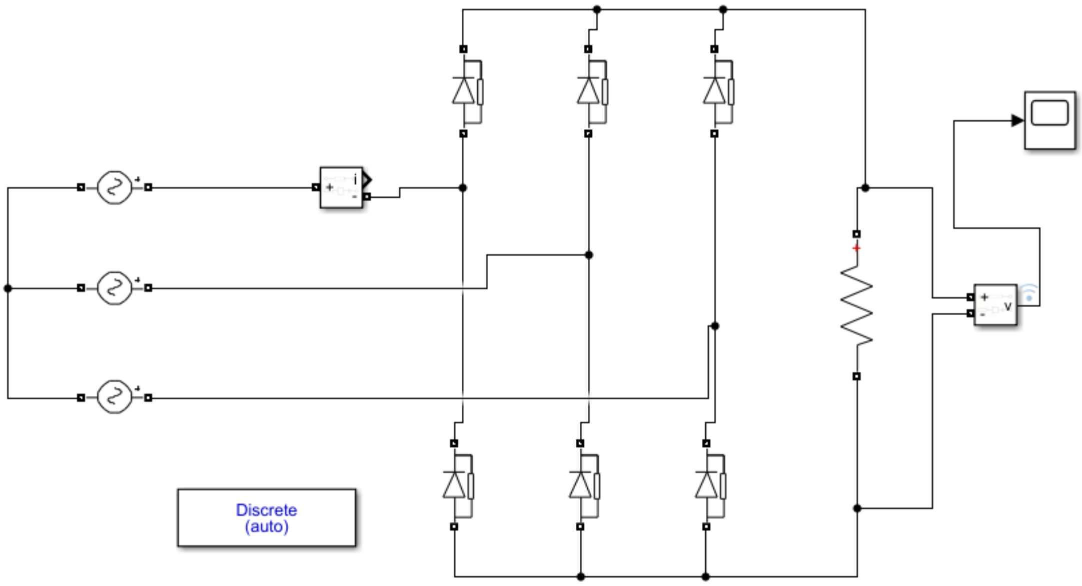

Figure x. 3 Phase diode rectifier without capacitor.

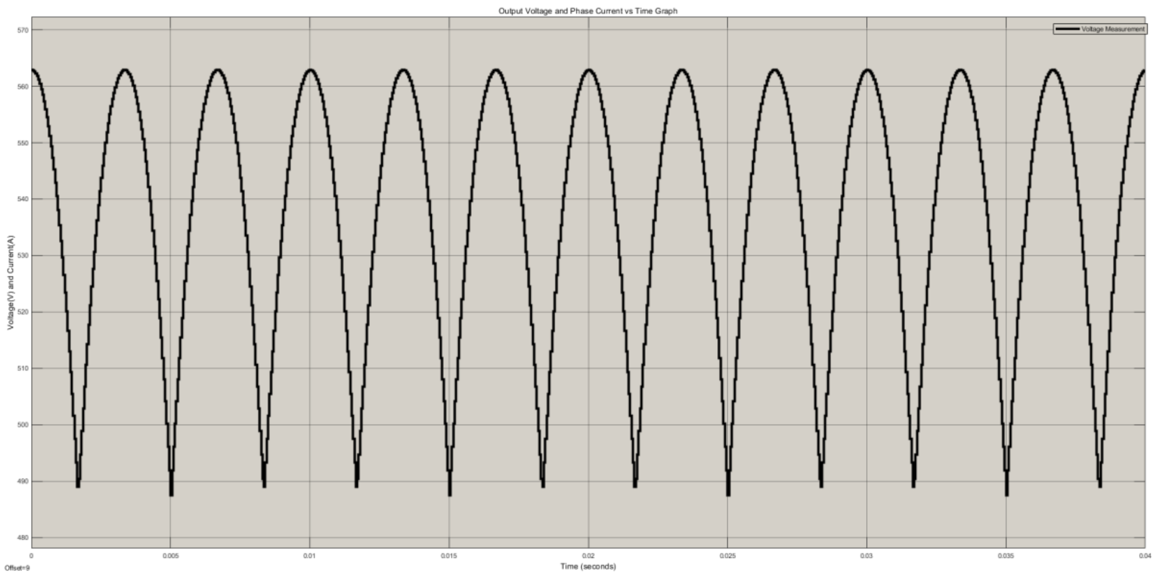

Figure 4 . Output voltage waveform of 3 phase rectifier without capacitor

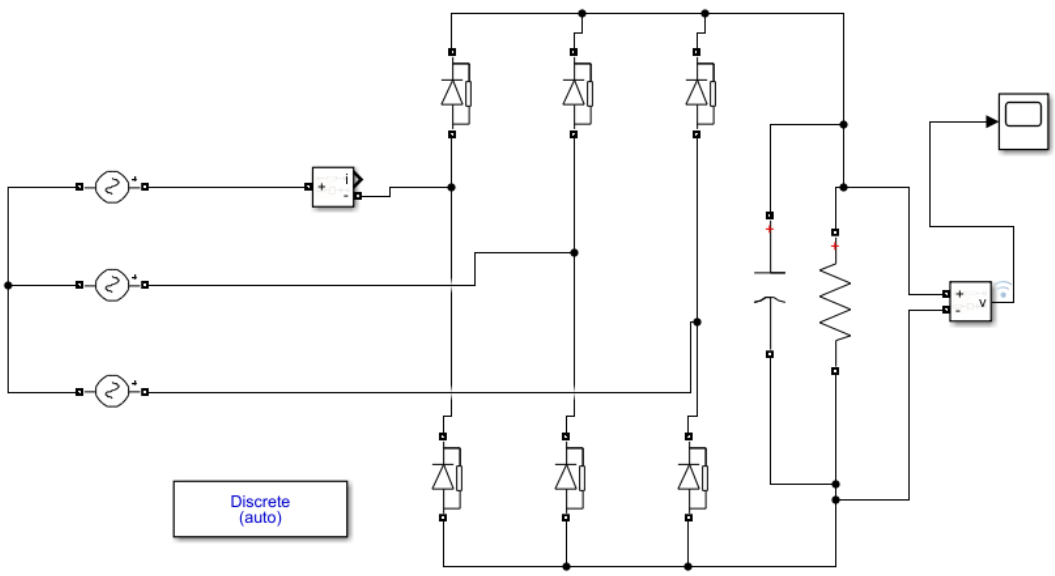

Figure 5. 3 Phase diode rectifier

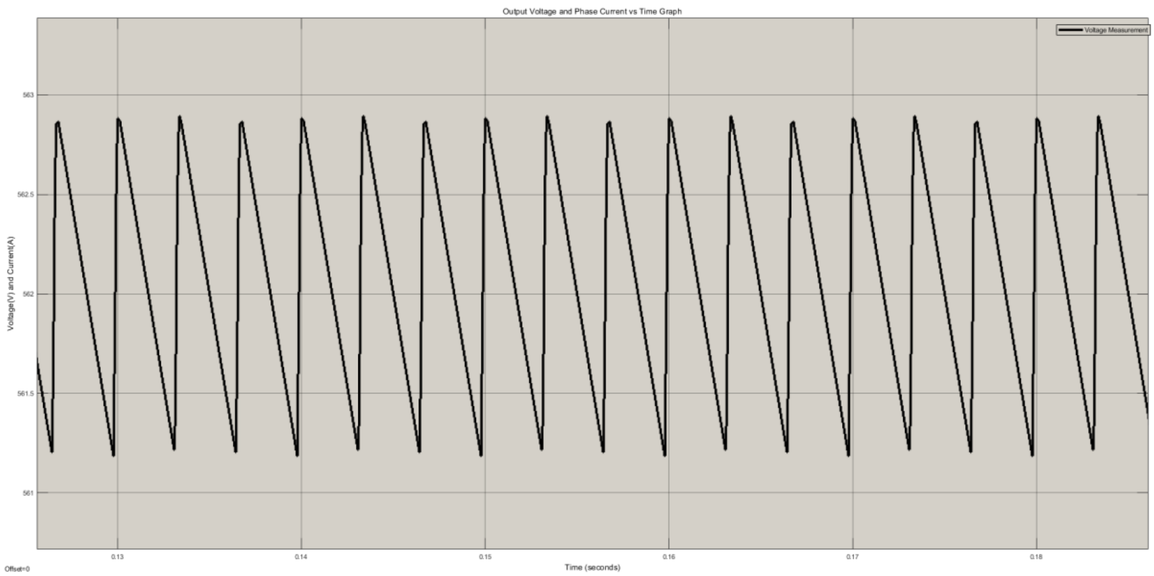

Figure 6 . Output waveform by using 10 mF capacitor

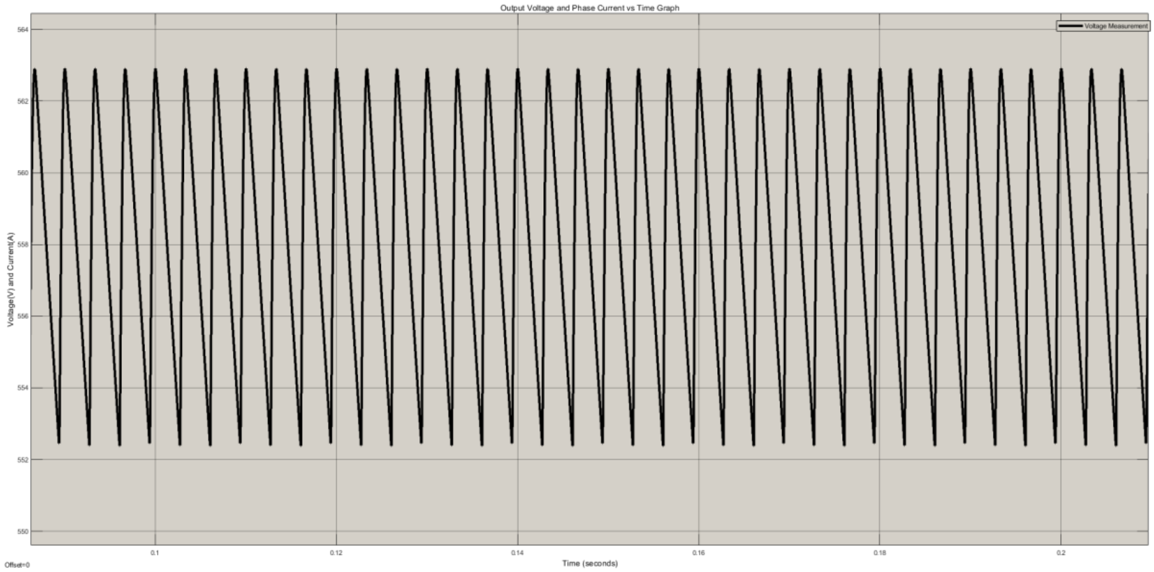

Figure 7 . Output waveform by using 1.4 mF capacitor

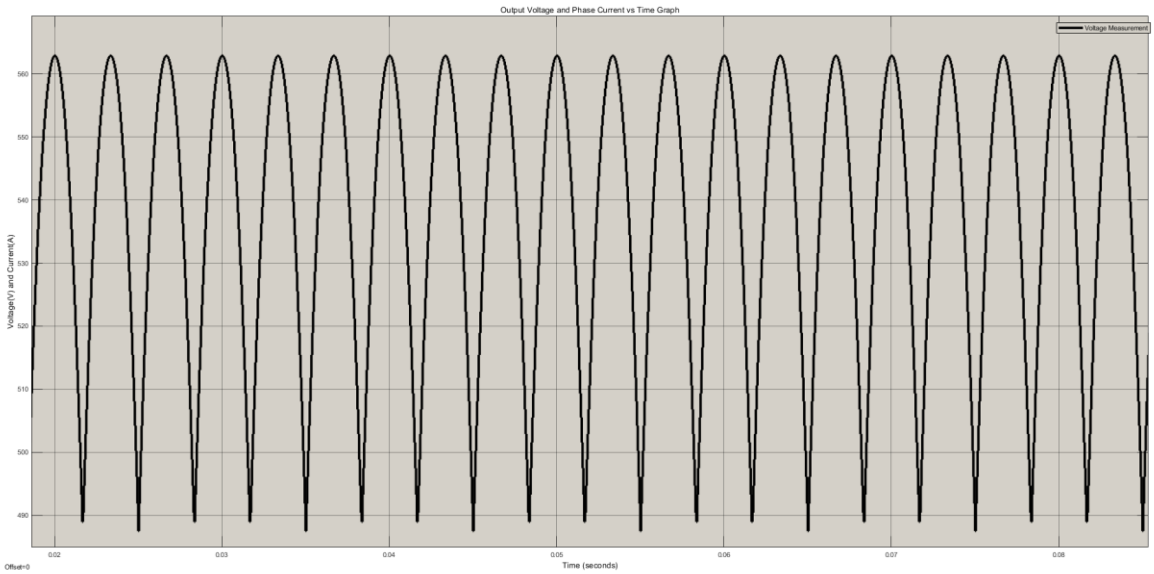

Figure 8 . Output waveform by using 0.01 mF capacitor

10mF Capacitor was chosen because the peak to peak voltage differences is very low.It is closer to DC voltage.We need to step down our output voltage because we need maximum 180 Voltage DC to drive our DC motor.Buck converter system was simulated to step down our output voltage.We need a duty cycle generator. Thanks to duty cycle generator we can control our DC output voltage. Simulation of buck converter is given.

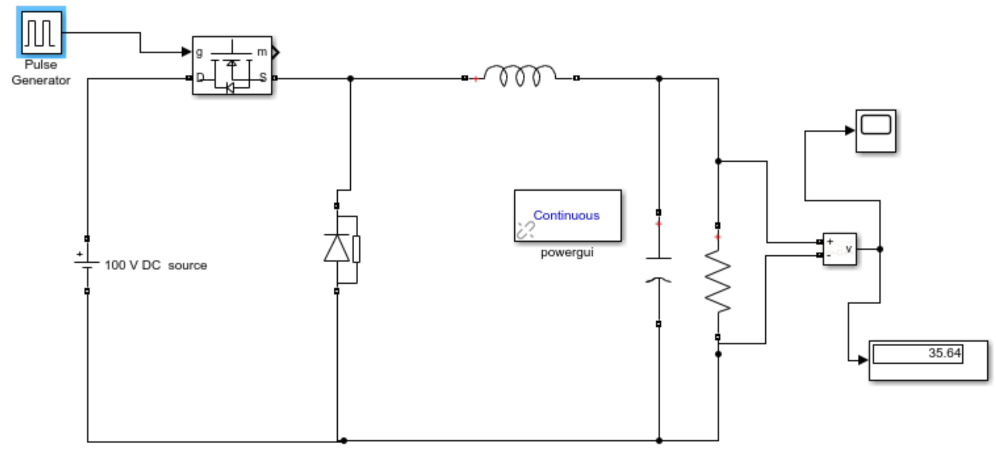

Figure 9. Schematic of Buck Converter

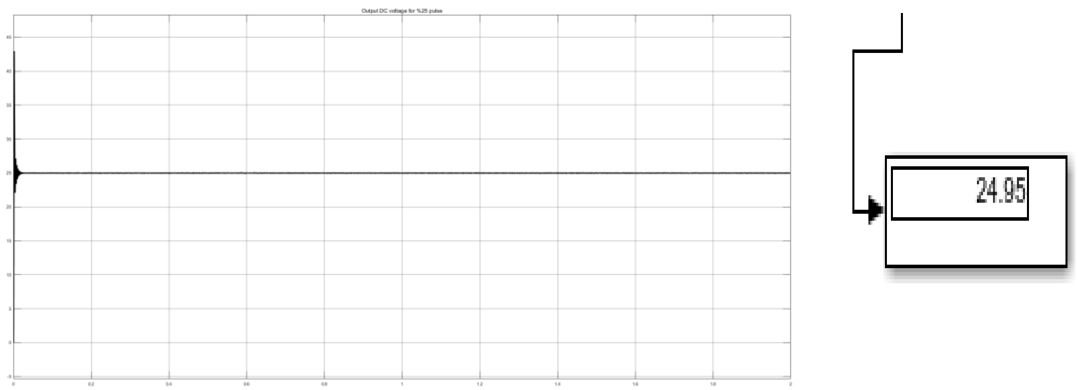

Figure 10. Output voltage form of %25 Buck Converter.(Display screen)

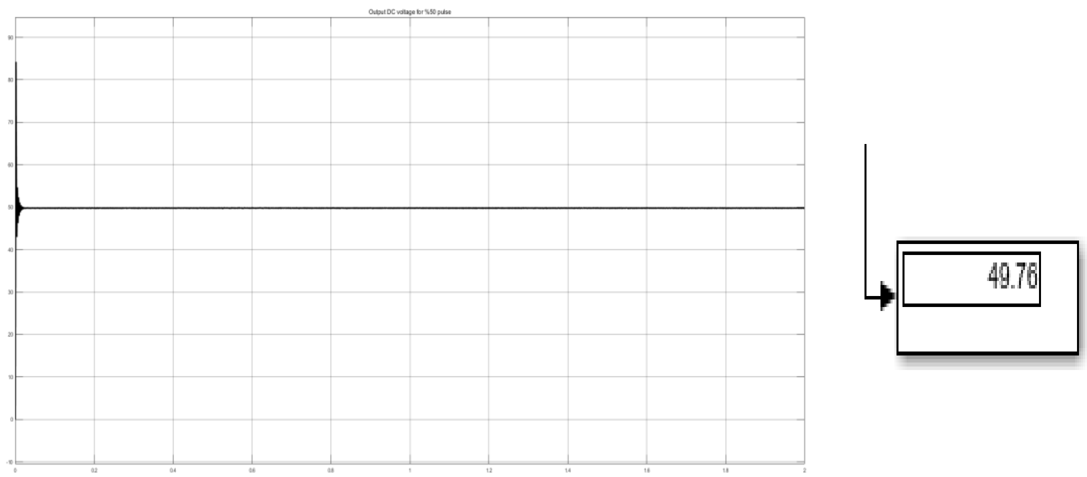

Figure 11. Output voltage form of %50 Buck Converter.(Display screen)

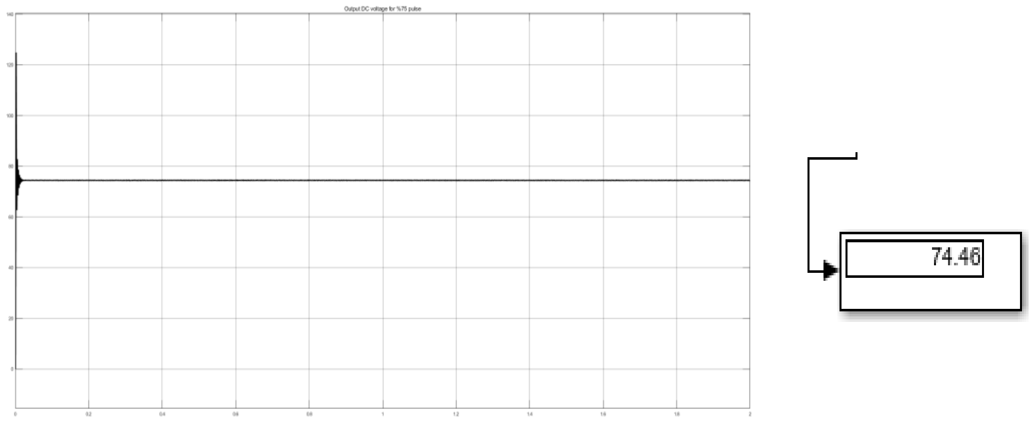

Figure 12. Output voltage form of %75 Buck Converter.(Display screen)

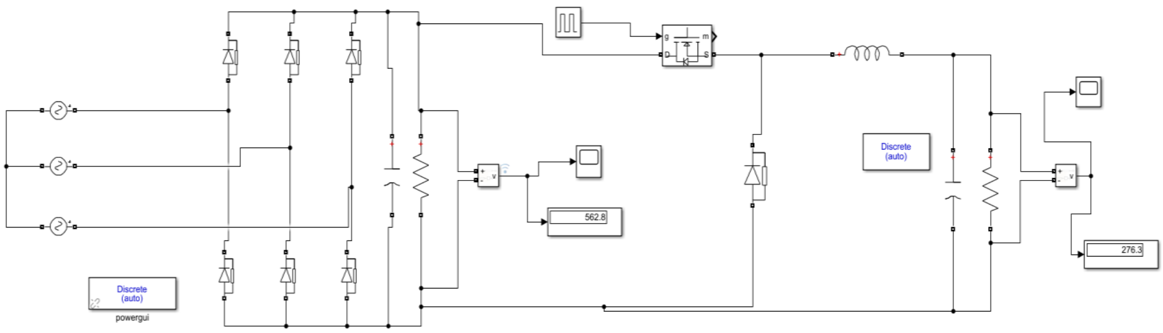

Figure 13. Overall design with %50 Buck Converter

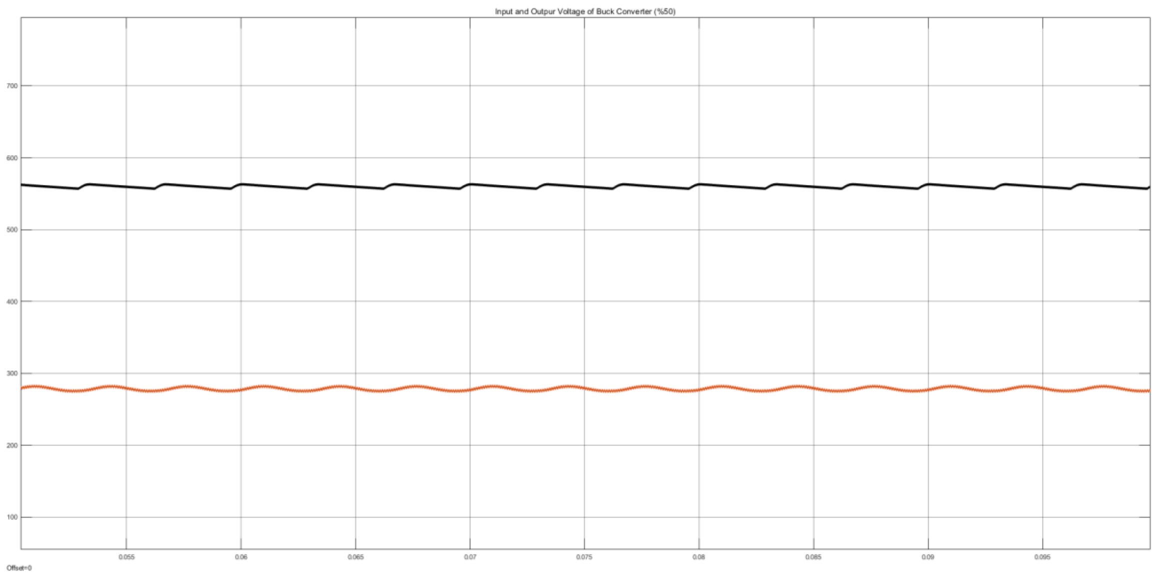

Figure 14. Input and Output voltage waveform of Buck Converter (%50) (Overall system)

6)DUTY CYCLE GENERATOR

We need a duty cycle generator to control to buck converter circuit. We can control output voltage of the buck converter circuit by changing duty cycle parameters.

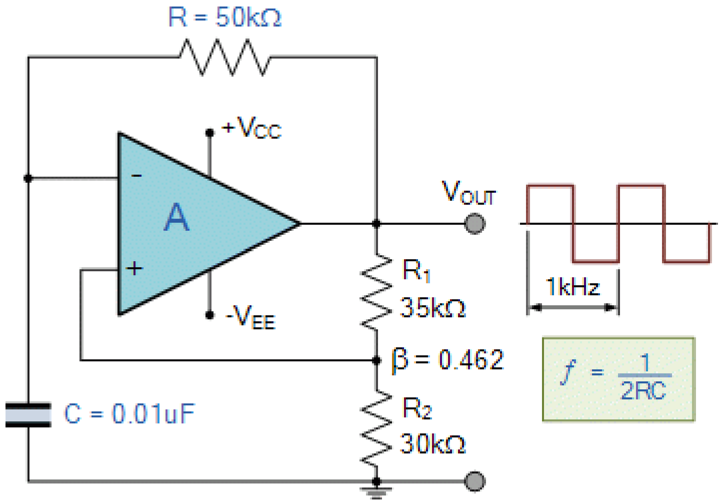

Figure 15. Schematic of the duty cycle generator

7)COMPONENTS

7 x Diode

3 x 100 ohm resistor

1 Mosfet

220 uF Capacitor

10 mF Capacitor

For Duty Cycle Generator

Op-Amp

1 k POT