POWER ELECTRONIC INTERFACE

(To obtain constant DC output voltage from varying AC input)

A PROJECT REPORT

submitted towards the

J component for the subject

DISTRIBUTED GENERATION and MICROGRID

EEE 4004

by

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ABSTRACT

This project aims to design and implement a power electronics-based system for obtaining a constant DC voltage from a varying AC input voltage. A 3-phase diode bridge rectifier is used to convert the AC input into a pulsating DC waveform. The pulsating DC waveform is then fed to a DC buck-boost converter, which regulates the output voltage to a constant level. The project utilizes the principles of power electronics, including the use of semiconductor devices such as diodes and thyristors, to achieve the desired output voltage. The system is designed and implemented using MATLAB SIMULINK. The results demonstrate that the system can effectively obtain a constant DC voltage from a varying AC input and generate a 400v DC voltage for power supply purposes. This project has potential applications in renewable energy systems, electric vehicle charging systems, and other power electronics-based applications.

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CHAPTER I

1. INTRODUCTION

1.1 INTRODUCTION

In this project will be obtaining a constant DC voltage as output from a varying AC input. Using a 3 phase diode bridge rectifier and a DC-DC buck-Boost converter with closed loop control.

1.1.1 Motivation

In this era of evolving technology, Electric Vehicles are in great demand. This fuels the research on EV. Increasing number of EVs also means increasing queues at the charging stations. Charging infrastructure is not able to expand in comparison to increase in number of EVs. Increasing range of EVs can help reduce the crowd on charging stations . We intent to create range extension system for EVs which can recharge the EV in running condition .In this project we will be Tackling the power converter part for this concept.

1.1.2 Objectives

To design a 2 Stage Power Converter for obtaining a constant DC-output from varying AC input.

1.1.3 Scope of the Work

Produce a constant DC voltage at across a resistive load taking a 3 phase variable ac voltage source as input.

1.2 ORGANIZATION OF THESIS

A three-phase uncontrolled diode rectifier with a DC link capacitor, combined with a buck-boost converter and a PI controller, can be used to obtain a constant DC output voltage from a variable AC input voltage. The uncontrolled diode rectifier converts the three-phase AC input into a pulsating DC voltage, which is smoothed by the DC link capacitor.

Table 1: Design Specifications

Sr. No	Element	Value
1	AC Input	600V AC
2	DC Link Capacitor(C1)	50mF
3	Inductor (L)	12mH
4	Capacitor (C2)	4.4emF
5	Min Load (R)	23ohm
6	Ki	0.21
7	Kp	0.004

CHAPTER II

2. PROJECT DESCRIPTION

2.1 OVERVIEW OF PROJECT

When an AC input is taken from a generator, the voltage generated can vary as the speed of the vehicle changes. Use this converter to charge the battery of the vehicle, which requires a constant DC voltage.

2.2. MODULES OF THE PROJECT

2.2.1 Three-phase uncontrolled diode bridge rectifier with a DC link capacitor

The uncontrolled diode rectifier converts the three-phase AC input into a pulsating DC voltage, which is smoothed by the DC link capacitor.

2.2.2 Buck-boost converter and a PI controller

The buck-boost converter, which is a DC-DC converter, is used to regulate the DC voltage to a constant level. The PI controller is a feedback control system that continuously monitors the output voltage and adjusts the duty cycle of the converter to maintain the desired voltage level.

2.3 TASKS AND MILESTONES

2.3.1 Block Diagram

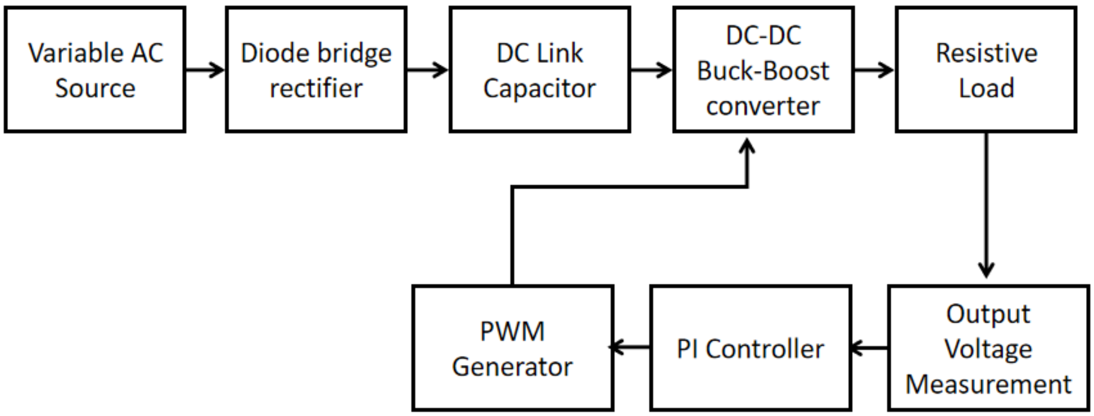

Fig.1 I Block Diagram

A combination of a three-phase uncontrolled diode rectifier with a DC link capacitor, a buck-boost converter, and a PI controller can be utilized to maintain a stable DC output voltage despite variations in the input AC voltage. The uncontrolled diode rectifier changes the AC input to a pulsating DC voltage, which is then smoothed by the DC link capacitor. The buck-boost converter, a type of DC-DC converter, is responsible for regulating the DC voltage to a constant level. The PI controller is a feedback control system that continuously monitors the output voltage and adjusts the converter's duty cycle to maintain the desired voltage level. This combination of components can be used to charge a vehicle battery by taking AC input from a generator, which may experience voltage variations due to changes in the vehicle's speed.

CHAPTER III

3. BUCK – BOOST CONVERTER WITH PI CONTROLLER

3.1 DESIGN APPROACH

3.1.1 Codes and Standards

Considering following standards and input for the DC-DC converter

Table 2: Input Parameters and Design Specification

Sr. No	Element	Value
1	Source Voltage	841.2 V
2	Output Voltage	400 V
3	Ripple Voltage	1 %
4	Ripple Current	10%
5	Min Load (R)	23ohm
6	Maximum current	17.5 A
7	Switching Frequency	25 KHz

3.1.2 Alternatives and Trade-offs

Certainly, instead of using a PI controller for controlling the output voltage of a buck-boost converter, we can employ various other control techniques. For instance, we can use a proportional-integral-derivative (PID) controller, a sliding mode controller, or a model predictive controller, depending on the requirements of the application.
Moreover, we can also consider using other types of converters, such as the Cuk converter, which may offer higher efficiency and better performance in certain scenarios. The Cuk converter is a type of DC-DC converter that can provide a non-inverting buck-boost voltage conversion with continuous input and output currents, low input ripple current, and high efficiency. It can also handle a wide range of input and output voltages, making it a versatile option for many applications.

3.2 DESIGN SPECIFICATIONS

3.2.2. Parameter Specification

Sr. No	Element	Value
1	AC Input	600V AC
2	DC Link Capacitor(C1)	50mF
3	Inductor (L)	12mH
4	Capacitor (C2)	4.4emF
5	Min Load (R)	23ohm
6	Ki	0.21
7	Kp	0.004

CHAPTER IV

4. PROJECT DEMONSTRATION

4.1 INTRODUCTION

Converter was designed using above specifications and calculations in MATLAB/SIMULINK and Results were obtained and verified.

4.2 CALCULATION

DC link voltage, Vdc = 841.2 V
Output Voltage, Vo = 400 V
Voltage Ripple, dVl = 1%
Current Ripple, dIl = 10%
Load Resistance = 23 ohm
Maximum Current, Imax = 17.5 A
Switching Frequency,Fsw = 25 kHz

=> Vo = (D*Vs)/(1-D)
=> Vo/Vs = D/(1-D)
=> 400/841.2 = D/(1-D)
=> D = 0.322
Minimum Inductor Value, Imin = $R(1-D)^2/2Fsw$
=> $23x(1-0.322)^2/(2x25x10^3)$
=> Lmin = 0.2114 mH

Minimum Capacitor Value, Cmin = D*Vo/(R*Fsw*dVo)
=> Cmin = $0.322*400/(23*25*10^4)$
=> Cmin = 56 uF

Calculating the Proportional and Integral gains for PI Controller.

For Finding the values proportional gain (Kp) of the PI Controller, Ziegler-Nichols method is implemented and it is calculated as follows:

Step-1:

Initialy values of Kp and Ki are kept 0, then value the of Kp is slowly increased until the damping of the system is reduced, after certain value of Kp we get desired voltage that value is known as Kcr(Critical proportional constant).Now using Ziegler Nichols method we can calculate the value of Kp and Ki:

Kp=0.45*Kcr

Ki=0.8*Kp/Pcr

Hence using these formulas we calculate desired value of Kp and Ki.

4.3 SIMULATION RESULTS

4.3.1. Source Variation

The system is designed considering 600 V, 3 phase AC voltage as standard input voltage. For testing system's response at varying input voltages, the system was simulated in MATLAB SIMULINK with voltage amplitude changing at 1, 3 and 5 seconds to 150%, 100% and 70% respectively. At zero second, input voltage is at standard value. Following results were obtained as a result

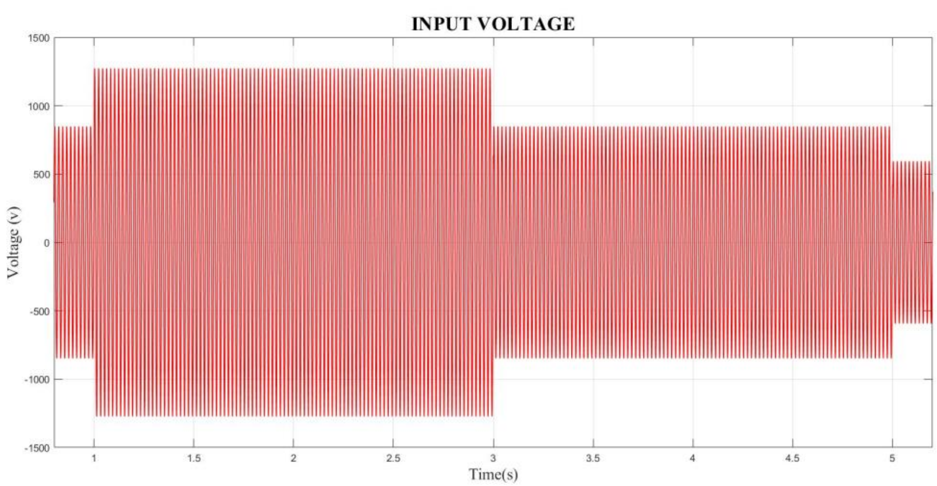

Fig.2 Input Voltage

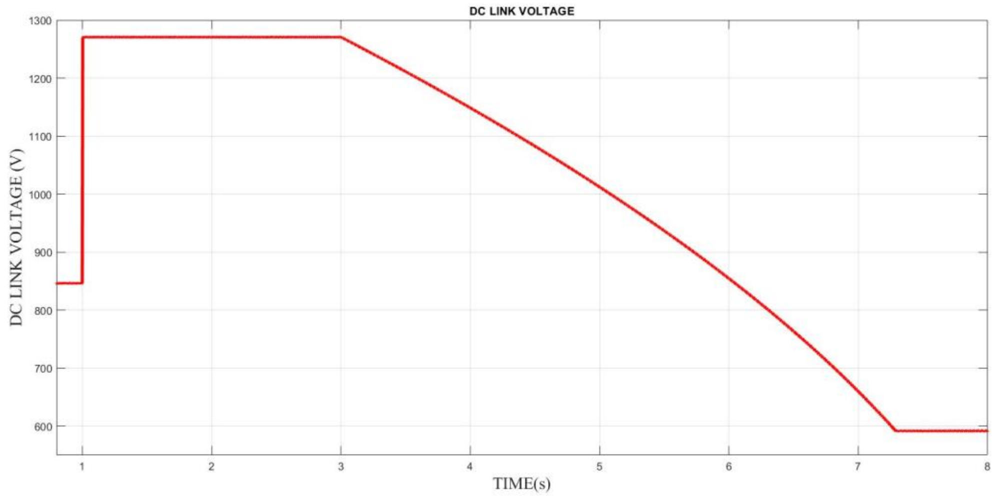

Fig.3 DC Link Voltage

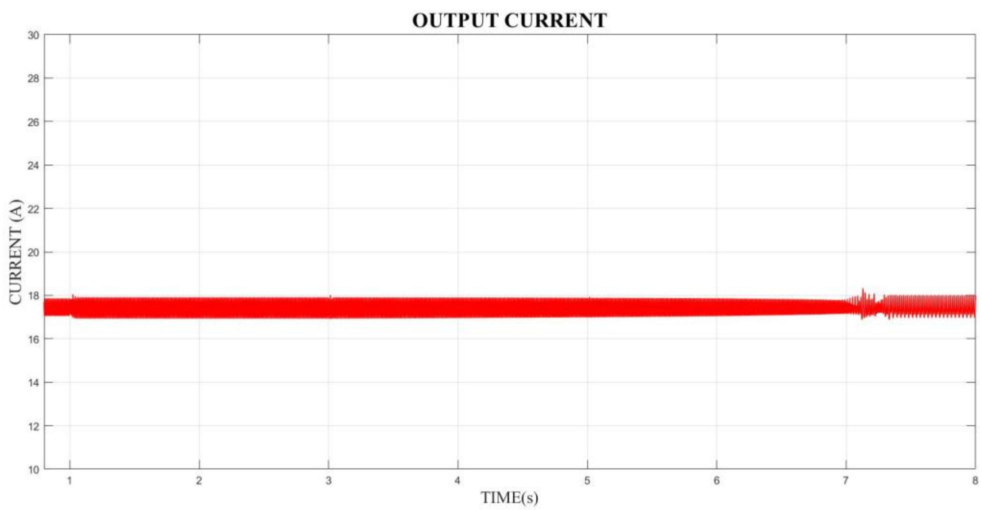

Fig.4 Output Current

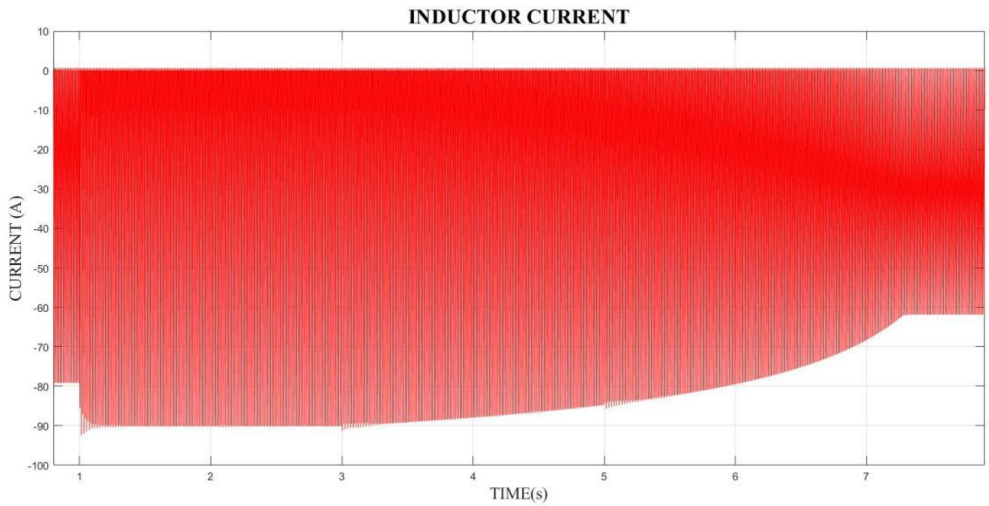

Fig.5 Inductor Current

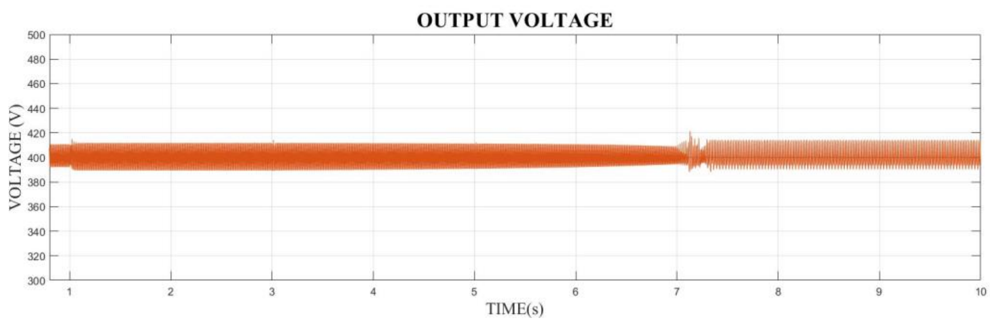

Fig.6 Output Voltage

4.3.2. Load Variation

The system was also tested for variation in load resistance at standard specified input voltage. Minimum load resistance is taken to be 23ohm. At 1 second the resistance is increased to 46ohm and then again at 2 second the resistance is reduced to 23ohm. Following results were obtained as a result.

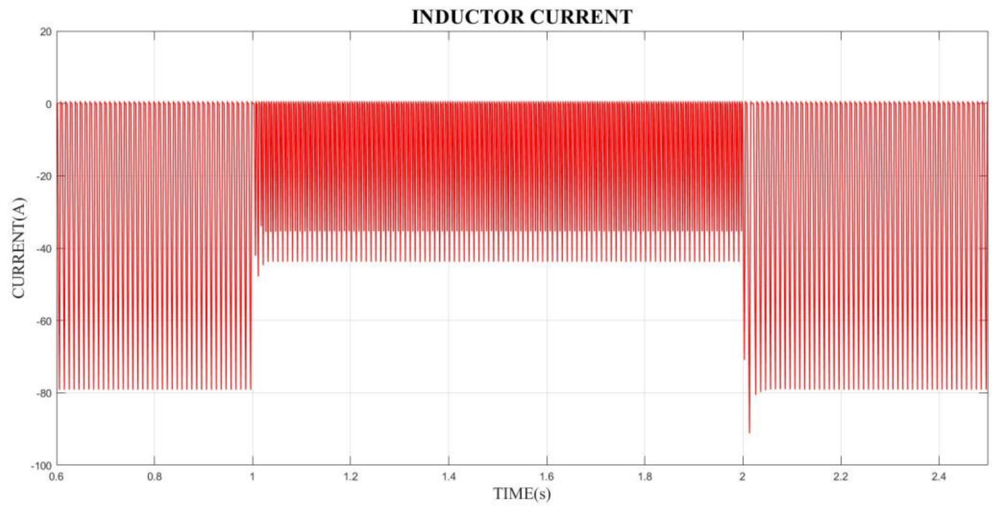

Fig.7 Inductor Current (for varying load)

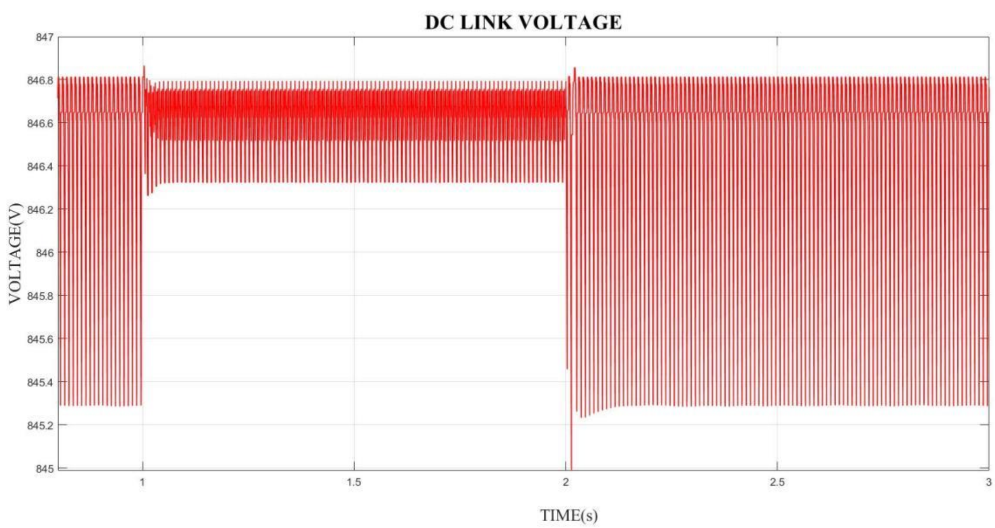

Fig.8 DC Link Voltage (for varying load)

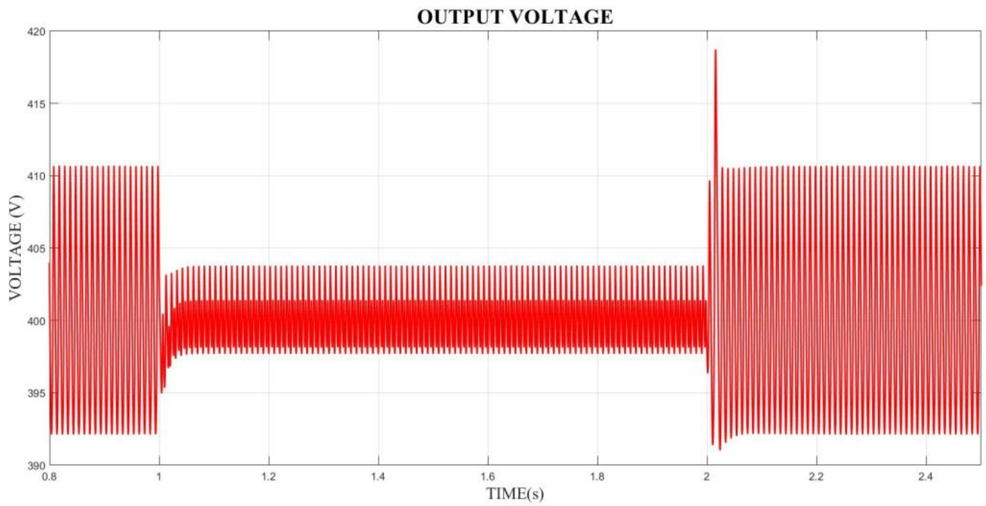

Fig.9 Output Voltage (for varying load)

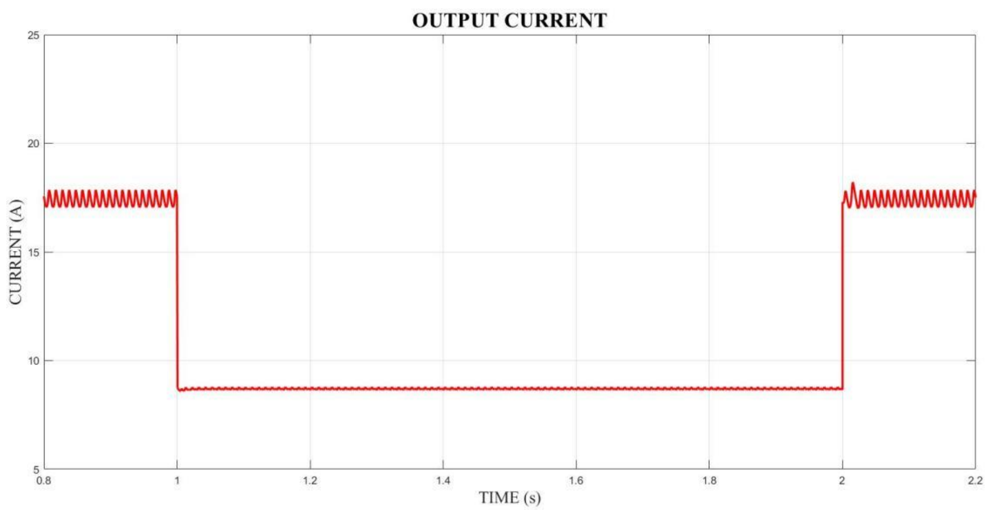

Fig.10 Output Current (for varying load)

CHAPTER V

5. CONCLUSION

5.1 SCOPE OF WORK

- To improve the system's performance while transitioning from buck operation to boost operation and vice-verca.
- To implement the system with a battery as a load instead of resistor.
- To implement the system in it's intended usage in Electric Vehicles.

5.2 SUMMARY

In conclusion, this project successfully designed and implemented a power converter for a range extension system for Electric Vehicles. Through the use of simulation tools such as MATLAB SIMULINK, the power converter was optimized to achieve high efficiency and effectiveness. The successful implementation of the power converter for a range extension system has the potential to significantly improve the efficiency and effectiveness of EV, making them more practical and convenient for daily use.

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