IMPROVED POWER QUALITY BASED AC-DC CONVERTER

2022-2023

A Dissertation submitted to
Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)
Towards the Partial Fulfillment of Requirements for Awarding the Degree
of
Bachelor of Technology (B.Tech)) in Electrical Engineering

Supervised by:
Dr. Shailendra Kumar Sharma
Professor
Department of Electrical Engineering

Submitted By:
Anurag Pawar
Ameya Subhedar
Sachin Das
Arpita Alave
Kiran Gurjar

Department of Electrical Engineering
Shri G.S. Institute of Technology and Science,
Indore-452003 (M.P.) -India

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Indore-452003 (M.P.) -India
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RECOMMENDATION

We are pleased to recommend that the dissertation work entitled **Improved Power Quality based AC-DC Converter** carried out by **Anurag Pawar**, **Ameya Subhedar**, **Sachin Das**, **Arpita Alave**, **Kiran Gurjar** in partial fulfillment for degree of Bachelor of Technology (B.Tech)) in Electrical Engineeringof Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)during the year 2022-2023. The project report has been approved as it satisfies the academic requirement in respect of project work prescribed for the Bachelor of Engineering degree.

Supervisor	**Prof. & Head**
Dr. Shailendra Kumar Sharma	**E.E.D, S.G.S.I.T.S, Indore**
E.E.D, S.G.S.I.T.S, Indore	**.**

Dean (Academics)
S.G.S.I.T.S, Indore

Shri G.S. Institute of Technology and Science,

Indore-452003 (M.P.) -India

Department of Electrical Engineering

2022-2023

CERTIFICATE

We are pleased to certify that the dissertation work entitled **Improved Power Quality based AC-DC Converter** carried out by **Anurag Pawar**, **Ameya Subhedar**, **Sachin Das**, **Arpita Alave**, **Kiran Gurjar** is accepted in partial fulfillment for the award of the degree of Bachelor of Engineering in Electrical Engineering of **Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)** during the year **2022-2023**

Internal Examiner	**External Examiner**
Date:	**Date:**

Shri G.S. Institute of Technology and Science,
Indore-452003 (M.P.) -India
Department of Electrical Engineering

2022-2023

DECLARATION

We **Anurag Pawar**, **Ameya Subhedar**, **Sachin Das**, **Arpita Alave**, **Kiran Gurjar**, , students of Bachelor of Technology (B.Tech)) in Electrical Engineering, hereby declare that We have worked on project with title **Improved Power Quality based AC-DC Converter** under the supervision of **Dr. Shailendra Kumar Sharma, Professor,Department of Electrical Engineering** and all the material used in the report are properly referenced and all references are taken into account to the best of our belief.

Anurag Pawar **0801EE191013**	**Ameya Subhedar** **0801EE191008**	**Sachin Das** **0801EE203D07**
Arpita Alave **0801EE203D01**	**Kiran Gurjar** **0801EE203D04**	

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Anurag Pawar
Ameya Subhedar
Sachin Das
Arpita Alave
Kiran Gurjar

Abstract

After the Industrial revolution humans have seen an exponential growth in infrastructure and technological sectors. To maintain this growth, we need an enormous energy generation and because of that our resources are getting depleted which is causing harmful effects on earth and its bio diversity. So, for our survival we need an efficient energy generation and transfer of power. Efficient generation of power at present is crucial as wastage of power is a global concern. Power factor measures a system's power efficiency and is an important aspect in improving the quality of supply. In most power systems, a poor power factor resulting from increasing use of inductive loads is often overlooked. A power factor correction unit would allow the system to restore its power factor close to unity for economical operation. The advantages of correcting power factors include reduced power system losses, increased load-carrying capabilities, improved voltages, and much more

AC-DC power factor correction (PFC) single-stage converters are attractive because of their cost and their simplicity. In these converters, both PFC and power conversion are done at the same time using a single converter that regulates the output. Since they have only a single controller, these converters operate with an intermediate transformer primary-side DC bus voltage that is unregulated and is dependent on the converters' operating conditions and component values. This means that the DC bus voltage can vary significantly as line and load conditions are changed. Such a variable DC bus voltage makes it difficult to optimally design the converter transformer as well as the DC bus capacitor. We propose a methodology to achieve this optimum performance.

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Chapter 1

Introduction

We are using more energy as a result of technological advancement. For a very long time, people have looked for ways to use more energy for the least amount of money. Everything from little household appliances to massive industrial gear demonstrates how humans have been drawn to electrical energy. Its demand is increasing tremendously.

In the scenario mentioned earlier, humans are not only interested in obtaining power. Other aspects including power quality, cost, and whether or not it contributes to pollution are also taken into account. The power factor is one of the important aspects that must be considered when consuming power. Consuming less power, which is more expensive, serves no purpose. For instance, our home's fans use a lot of electricity. By increasing an appliance's power factor, we may use it to its fullest potential and ensure that it uses all of the energy that is supplied to it without wasting any of it.

Another crucial factor that needs to be strongly emphasised is ”power cost”. Usually, it is expected that appliances will utilise less expensive energy. Nobody wants to spend more money on power in today's fast-paced society; instead, we all want to use it as efficiently as possible. How many people would be interested in an appliance if, for instance, using it resulted in an increase in our power bill and a strain on our finances?

Therefore, we must always operate our equipment and appliances at the greatest power factor in order to consume the least amount of energy feasible. The goal of this project is to identify and analyse the factors that affect ”power consumption” and ”power cost,” as well as to optimise these parameters even when the most demanding power application is running.

1.1 Motivation

The desire for dependable, high-quality energy in today’s contemporary environment is the driving force behind the creation of a superior power quality-based AC-DC converter. With the development of complex electronic devices and sensitive machinery that require precise and consistent power input to operate, the requirement for a clean and stable power source has become more important than ever.

Power quality problems like voltage sags, harmonics, and flickers can adversely damage electronic machinery and equipment and result in costly downtime and repairs. Furthermore, because of a rise in greenhouse gas emissions, poor power quality can lead to energy waste, increased electricity prices, and environmental problems.

A more effective power quality-based AC-DC converter has a variety of advantages over conventional converters, including increased efficiency, increased dependability, and lower harmonic distortion. Additionally, it can improve the efficiency of machinery and electronic equipment by delivering a constant output voltage and frequency and minimising voltage sags and flickers.

An improved power quality-based AC-DC converter can also contribute to lowering energy consumption and environmental impact by minimising energy losses and minimising the need for expensive filtering equipment.

In conclusion, the goal of creating a better power quality-based AC-DC converter is to meet the growing demand for a supply of power that is high-quality, dependable, and efficient while minimising energy waste and environmental effect. This technology can contribute to a more sustainable future by enhancing the performance and dependability of electronic equipment and machines through the improvement of power quality.

1.2 Previous work

We have gone through the concepts of AC-DC converters of various types. We also have a basic understanding of switching devices like solid state devices diodes and energy storing elements like inductors and capacitors and passive elements like resistors. We have an idea of the Power Factor and a discussion about power quality and its improvement. Our work will be related to analyzing the efficient AC-DC converters. We have an idea of Single-Phase Full Converters with different types of loads R, RL, RC, and RLC. Last time we used SCR as a switching device, but this time MOSFET will be used. In recent times a lot of research has been done to improve the power quality and minimize losses. To do analysis Inductor was designed with specifications. The analysis part would require concepts of power electronics, power quality and electrical machines and the basics of network theory. We have basic training in MATLAB Simulink and the use of Simscape simulations for software purposes.

1.3 Organization of thesis

Described briefly in Chapter 1 is the goal we hope to accomplish with this study. The areas in which we would be seeking for this project are also clarified in this chapter. Some theories about the power factor and its economics are presented in Chapter 2. The Prototype system, Improved Power Quality based AC-DC converter, design, and circuit schematic are all covered in Chapter 3. In Chapter 4, the MATLAB Simulink model of the circuit is first given with wave forms and results before hardware is discussed using components. Chapter 5 concludes with recommendations for the respective projects' future work and a summary of the relevant areas.

Chapter 2

Literature Survey

A valuable amount of research has been carried out on this topic. Broadly, I can classify all the literature reviews into 3 categories:

2.1 Power Electronics

Electrical engineering's field of power electronics deals with transforming a power source's available energy into the form that a load needs. To accomplish this power conversion, a power converter uses semiconductor components including diodes, MOSFETs, and IGBTs. MOSFETs and IGBTs are controlled switches that can be turned on or off by a switching signal at their gate (i.e. a high gating pulse is the turn-on command and a low or zero gating pulses is the turn-off command). Diodes are uncontrolled switches that turn on and conduct current when forward-biased and turn off when reverse-biased. Depending on the application, a power converter may be an AC/DC converter, DC/DC converter, DC/AC inverter, or AC/AC converter. These converters can be powered by a wide range of energy sources, including batteries, solar panels, electric generators, AC single-phase, AC three-phase, and DC sources. Low-power single-phase AC/DC converters (25 W) will be the main topic of this thesis.

The applications of power electronics are vast and varied, ranging from simple battery chargers to complex motor drives, renewable energy systems, power grids, and transportation systems. Power electronics technology is used to efficiently control the flow of electrical power and to convert electrical energy from one form to another, such as from AC to DC, DC to AC, or DC to DC.[1]

The field of power electronics has grown rapidly in recent years, fueled by the demand for energy-efficient and cost-effective power conversion solutions. Power electronics technology plays a vital role in addressing the challenges faced by the modern world in terms of energy conservation, environmental sustainability, and the efficient use of resources.

For an AC/DC converter's output voltage to be maintained, some type of control technique is required for the necessary DC voltage by regulation. A sensing circuit in a closed-loop power converter is responsible for sending output voltage values (samples) to a controller circuit so that the power converter can be adjusted; typically, this entails adjusting the duty cycle of the converter. The Duty-cycle (D) is a unit of measurement that refers to the ratio of on-time to the switch's period T. It is stated as a percentage, with 100

2.2 Power Factor

Power factor, a measurement of how efficiently the load draws real power. The power factor should ideally be 1. Power Factor is the ratio of the fundamental wave's active power (measured in watts) to perceived power (measured in volt-amperes).[2]

$$PowerFactor = \frac{P}{S} = \frac{P}{VI\cos\phi} \tag{2.1}$$

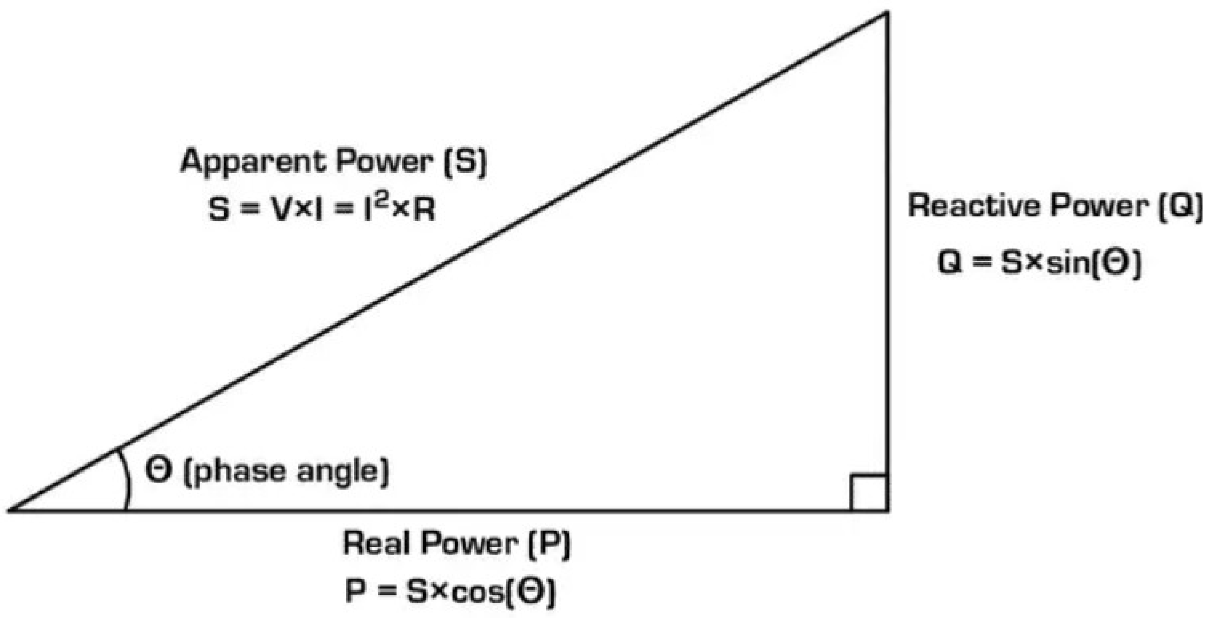

Figure 2.1: Power Triangle

The power factor ranges from 0 to 1, can be of types lagging leading and unity. When the phase difference between current and voltage is zero power factor is 1. The purpose of making power factor unity is to make circuit look purely resistive.The apparent power is equal to the flowing real power in system. [3]

The apparent power is equal to the flowing real power in the system. If the current is not sinusoidal but the voltage is sinusoidal, the power factor consists of two factors:

- displacement factor related to phase angle
- distortion factor related to a wave shape.

The three standard quantities associated with power are as follows:

- Active Power: Average rate of delivery of power.
- Apparent Power: Product of circuit voltage and current. It is measured in Volt-Ampere

- Reactive Power: Imaginary power that is out of phase, with active power

The function of the power factor correction circuit is to minimize the input current distortion and make the current in phase with the voltage of the system

2.3 Power Factor Charges

Utility providers charge consumers with low power factors in their electrical networks power factor fees. A low power factor implies that part of the power supplied by the utility is being lost owing to reactive power. Power factor is a measure of the efficiency with which electrical power is being utilised.

As the utility company must deliver more current than the client is really using to make up for the reactive power when a customer has a low power factor, the distribution network experiences higher losses. The distribution system is strained and has less capacity as a result of the higher current, which might result in voltage dips and other power quality problems.

Utility companies frequently charge customers with low power factors power factor fees in an effort to motivate them to raise their power factor and prevent energy waste. These fees are often calculated based on the discrepancy between the customer's actual power factor and the utility provider's predetermined target power factor.

Reactive power, which is the difference between visible power and active power for the customer, may be used to compute the power factor charges. The fees may alternatively be computed using the kVA demand, which represents the entire amount of power that the utility supplies to the client while accounting for both active and reactive power components. Customers can lower their power factor charges and total energy expenditures by increasing their power factor. Power factor may be increased in a number of ways, including by adding power factor correction capacitors, employing more energy-efficient tools, or improving the way electrical systems are built.

In a nutshell power factor charges are costs that utility companies charge consumers who have electrical systems with low power factors. These fees are meant to motivate users to decrease energy waste and increase power factor, which can cut total energy expenditures and enhance power quality.

2.4 Chapter Summery

In this chapter, we have gone through power electronics applications and its vast scope. We refreshed some basic definitions related to power and its equations. At last, we learned about the Power Factor Charges and learned about the Economics of the Power Converter and the importance of Power Quality. .

Chapter 3

Prototype System

3.1 Boost type power factor converter

To increase the power factor of AC power systems, a boost-type power factor correction (PFC) converter is a kind of power electronic circuit. The power factor is a gauge of how effectively the load is utilizing the available electricity. Reactive power, or power that does not contribute to the work actually being done, makes up a large portion of the power factor, which can lead to problems like increased current draw and decreased efficiency.

Using a rectifier circuit, a boost-type PFC converter transforms the AC input voltage into a DC voltage. The boost converter raises the voltage level and enhances the power factor by modifying the current waveform after the DC voltage has been passed through it. The output voltage and current of the boost converter are controlled by an inductor and a switching component (often a MOSFET or IGBT).

The inductor current never hits zero when the boost converter is running in continuous mode. As a result, the circuit may regulate the input current to be in phase with the input voltage and maintain a steady output voltage, producing a high power factor. A capacitor is then used to filter the boost converter's output before supplying a smooth DC voltage to the load.

A feedback loop that monitors the output voltage and modifies the switching device's duty cycle to maintain a constant output voltage is commonly used to regulate a boost-type PFC converter. In order to stabilize the circuit and guarantee appropriate performance under a variety of load and input voltage situations, a compensator is also included in the control loop.[4]

In general, a boost-type PFC converter is a well-liked and efficient approach for improving the power factor of AC power systems and reduce reactive power problems.

3.2 Working Principle of Improved Power Quality based AC-DC Converter

Improoved-quality electricity based Electronic devices called AC-DC converters efficiently and more effectively change alternating current (AC) into direct current (DC). The following phases make up the operating principle of these converters:

- Rectification: The AC voltage is first rectified to produce a pulsating DC waveform using a diode bridge rectifier. This stage is essential to convert AC voltage to DC voltage, which is needed to power many electronic devices.
- Filtering: The pulsating DC waveform is then filtered to remove the AC components and produce a smoother DC waveform. This stage typically involves a capacitor, which acts as a low-pass filter, and an inductor, which further smoothes the waveform.

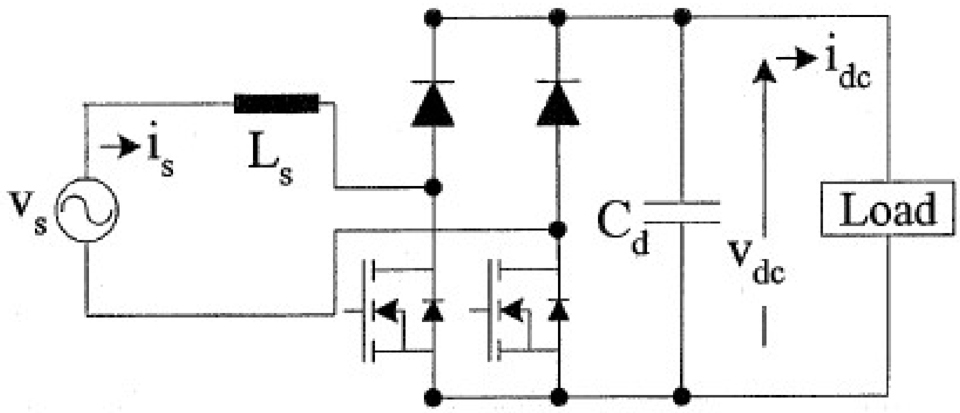

Figure 3.1: Symmetrical two-device unidirectional boost converter

- The power factor of the input AC signal, which is normally less than unity due to the non-linear nature of the rectifier, is corrected by the power factor correction (PFC) stage. A boost converter is often used to implement the PFC stage, to assure the input current waveform complements the input voltage waveform.

- DC-DC conversion: A DC-DC converter is used to scale the DC voltage down or up to the desired voltage level for the load. This step is necessary to provide a DC output voltage that is steady and controlled, regardless of changes in the input voltage or load circumstances.

3.3 Circuit Diagram

The usage of this converter results in significantly decreased weight and volume, improved compactness, and improved power quality at both the ac mains and dc output.In principle, it is a combination of diode bridge rectifier and step-up dc chopper with filtering and energy storage elements. In order to provide immediate response and high degree of power quality at input ac mains and dc output, these converters use wide-bandwidth closed-loop controllers in the outer voltage loop and high-frequency PWM and hysteresis current control techniques in the control of the inner current loop dc output .These converters are extensively used in electronic ballasts, power supplies, variable-speed ac motor drives in compressors, refrigerators, pumps, fans, etc. [5]

3.4 Designing a boost-type power factor correction (PFC) converter

- Establish the requirements: Start by determining the required input and output voltage, current, and desired power factor. This will direct both the overall design and the choice of components.

- Select the switching frequency since it will affect the inductor and capacitor sizes needed for the PFC circuit. Although fewer components can be used at higher frequencies, switching losses may also increase.

- The most popular architecture for PFC circuits is the boost converter, therefore choose that one. Based on the parameters and the selected switching frequency, determine the component values and ratings.

- Choose the elements: Depending on their reviews, availability, and price, choose the components. This contains the output capacitor, diode, inductor, and power semiconductor devices (MOSFET or IGBT).

- Determine the duty cycle: The duty cycle, which is dependent on both the input and output voltage requirements, determines the ratio between the input and output voltages.

- Develop the control loop: The PFC converter needs a feedback control loop to maintain a high power factor and manage the output voltage. Voltage reference, error amplifier, and compensation make up the control loop.

- Use a simulation programme to test the design and make sure it adheres to standards. Simulate the PFC circuit design. Worst-case circumstances such input voltage changes, load variations, and component tolerances should be taken into account throughout the simulation.

- Build the prototype, then test it under various operating situations to make sure it satisfies the standards and needs. Once the design has been validated.

- Design optimization If required, alter the component values, switching frequency, or control loop settings to enhance performance or cut costs.

All things considered, creating a boost-type PFC converter involves a solid grasp of power electronics and circuit design, as well as meticulous component selection, extensive testing, and verification of the final design.

3.5 Boost type power factor converter control circuit

One of the most important parts of the boost-type power factor correction (PFC) converter is the circuit that is in charge of maintaining a high power factor and managing the output voltage. The control circuit modifies the duty cycle of the switching device by monitoring the output voltage through a feedback loop in order to keep the output voltage constant.

- Error Amplifier: The control circuit's core is the error amplifier. It computes an error signal that reflects the difference between the output voltage and a reference value.

In order to stabilise the control loop, the error signal is subsequently amplified and fed via a compensator.

- Voltage Reference: As a reference for the output voltage, the voltage reference offers a consistent and precise voltage. Typically, a precise voltage reference IC is used for generating it.

- Compensator: The control loop is stabilised and properly operated under a variety of load and input voltage situations thanks to the compensator, a filter. The boost converter's phase lag must be made up for by a phase shift that the compensator is intended to supply.

- Pulse Width Modulator (PWM): The boost converter's switching device, often a MOSFET or IGBT, is driven by a control signal produced by a pulse width modulator (PWM). The error signal is compared to a triangle waveform with a set frequency to produce the PWM signal. A consistent output voltage is achieved by adjusting the PWM signal's duty cycle.

- Current Sensing: A current sensing circuit that monitors the input current and makes sure it is in phase with the input voltage is also a part of the control circuit. A current transformer or shunt resistor are frequently used in the current detecting circuit.

- Overcurrent Protection: An overcurrent protection circuit is built into the control circuit to safeguard it against overcurrent situations. A current limit circuit that shuts off the circuit if the current exceeds a set limit is typically part of the overcurrent protection circuit.

The control circuit of a boost-type PFC converter needs to be carefully developed and tested to ensure proper operation under a variety of load and input voltage conditions.

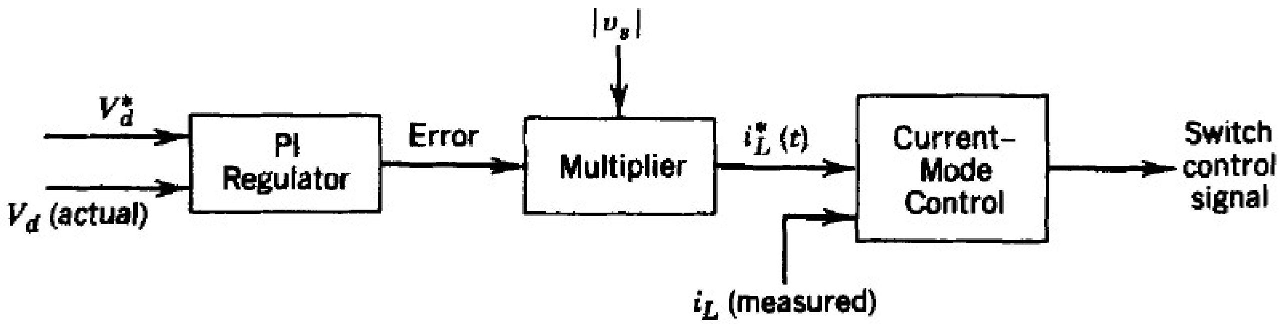

Figure 3.2: Control Block

Reactive power issues may be reduced and the power factor of AC power systems can be improved with a well-designed control circuit. [6]

3.6 Chapter Summery

In this chapter first we discussed Boost-type power factor converters, what are their requirements. Then working principle of an Improved Power Quality based AC-DC converter is discussed in detail with circuit diagram. Then how to design boost type PFC converter is described.

Chapter 4

Prototype Device

In this chapter theoretical knowledge will be practically implemented by us to obtain desired results

4.1 Prototype Specification

Input voltage: 12V

Output Voltage: 25V

Load Power: 25W

Ripple Inductance: 1%

Voltage Ripple:2%

Load Current

$$LoadCurrent = \frac{Power}{OutputVoltage} \tag{4.1}$$

Load Current=1 A

By taking minimum Power Factor=85%

$$Pin = \frac{Po}{\eta \cos \phi} \tag{4.2}$$

$$Pin = 30V \tag{4.3}$$

$$In = \frac{30}{12} \tag{4.4}$$

$$= 2.5A \tag{4.5}$$

To calculate the value of inductance,

$$L = \frac{Vo}{8fsw\Delta Ip} \tag{4.6}$$

$$L = \frac{25}{8 * 10^4 * 0.01 * 1.414 * 2.5}$$

$$= 8.8mH$$

We have taken capacitor of 220uF.

At load, we needed 25Ω resistance which we obtained by 4 100Ω resistors in parallel

4.2 Component Details

4.2.1 MOSFET :- IRF840

Features:-

- Dynamic dV/dt rating
- Repetitive avalanche rated
- Fast switching
- Ease of paralleling
- Simple drive requirements

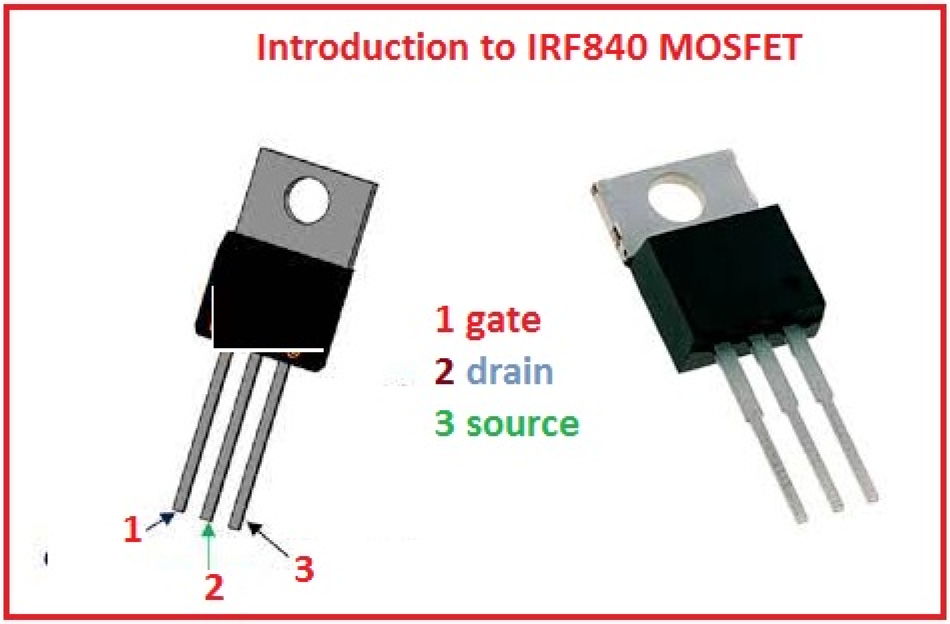

Figure 4.1: IRF840-MOSFET

Type Designator:-

- Type of Transistor: MOSFET
- Type of Control Channel: N -Channel
- Maximum Power Dissipation (Pd): 125 W
- Maximum Drain-Source Voltage |Vds|: 500 V
- Maximum Gate-Source Voltage |Vgs|: 20 V
- Maximum Gate-Threshold Voltage |Vgs(th)|: 4 V
- Maximum Drain Current |Id|: 8 A
- Maximum Junction Temperature (Tj): 150 °C
- Total Gate Charge (Qg): 63(max) nC

- Rise Time (tr): 23 nS
- Drain-Source Capacitance (Cd): 310 pF
- Maximum Drain-Source On-State Resistance (Rds): 0.85 Ohm

4.2.2 Transformer :- 12-0V, 3A

Features details :-

- Input voltage: 230V AC
- Output voltage: OV or ground and 12V
- Output current: 3A
- MAX. FREQUENCY RANGE 50HZ TO 60HZ
- Act as a step-down transformer reducing 230V AC to 12V AC
- It gives the output of 0V or ground and 12V.
- Single-phase step-down transformer.
- Type: Vertical Mount Type.

4.2.3 Diode :- IN5408

Features :-

- 3.0 ampere operation at TA = 75°C with no thermal runaway.
- High current capability.
- Low leakage

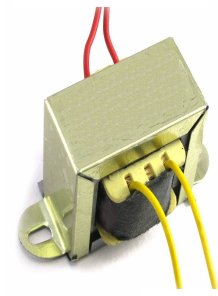

Figure 4.2: 12V 3A step down Transformer

Figure 4.3: IN5408

- Peak Repetitive Reverse Voltage, VRRM= 1000V
- Diffused Junction
- Low Forward Voltage Drop
- Surge Overload Rating to 200A Peak
- Low Reverse Leakage Current
- Lead Free Finish, RoHS Compliant

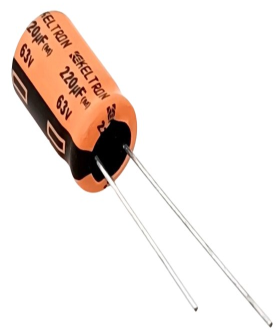

Figure 4.4: 220uF-63V capacitor

4.2.4 220uf 63V capacitor

- Capacitance: 220µF
- Voltage(DC): 63V
- Capacitance Tolerance: ± 20
- Capacitor Terminals: Axial Leaded
- Polarity: Polar
- Capacitor Case / Package: Axial Leaded
- Product Diameter: 12.5mm
- Product Length: 30mm
- Ripple Current: 550mA
- Operating Temperature Min: -55°C
- Operating Temperature Max: 125°C

4.2.5 Inductor

The toroidal inductor has been designed by us in our power electronics under guide observation using 19AWG wire.

4.2.6 Resistance - 100Ω 10 watts 5% wire wound

In order to achieve 25Ω, 4 resistors of 100Ω in parallel are utilised by us.

Features:-

- High Power 100 ohm 10 Watt Resistor ±5% Tolerance
- Excellent Heat and Humidity Withstand Performance, Long Life
- RoHS Compliant
- Resistance: 100ohm
- Power Rating: 10W
- Resistance Tolerance: ± 5%
- Resistor Case / Package: Axial Leaded
- Resistor Technology: Wire wound
- Temperature Coefficient: ± 350ppm/°C
- Resistor Type: General Purpose
- Product Length, Width: 49mm,10mm
- Operating Temperature Min, Max: -55°C,155°C

Figure 4.5: 100 Ohm 10W Resistor

4.2.7 Arduino Uno R3

Arduino Uno is a microcontroller board based on the AT mega328P, an 8-bit microcontroller with 32KB of Flash memory and 2KB of RAM. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Features:-

- Micro-controller: AT-mega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA

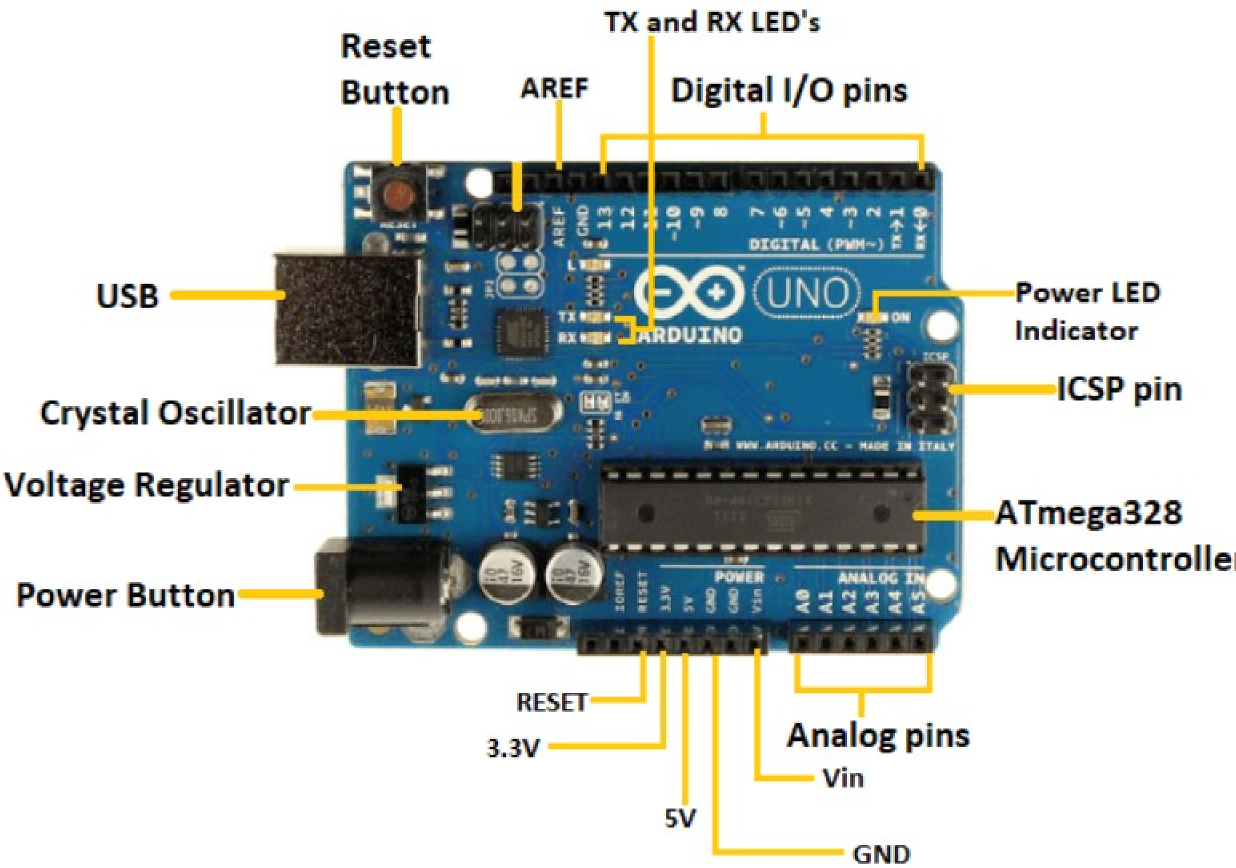

Figure 4.6: Arduino Uno R3

- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (AT-mega328) of which 0.5 KB used bootloader
- Clock Speed: 16 MHz
- Memory: AVR CPU at up to 16 MHz 32KB Flash
- Length: 68.6 mm
- Micro-controller: AT-mega328P Operating voltage: 5v
- USB: 14
- Digital I/O Pins: 6
- Analogue Input Pins: 6 • Flash Memory: 32 KB
- SRAM: 2 K
- EEPROM: 1K

4.3 Prototype

Prototype has been developed by us for Improved Power Quality based AC-DC Converter using boost topology. The required components are assembled by us. On the 1x1 board, we fixed the component according to the respective circuit. In our prototype, first take domestic Ac power of 230V, which is then stepped down to 12V by a transformer of 230/12V 3A current rating. The bridge circuit has two diodes (D1,D2) of IN5408 and two MOSFET(T1, T2) IRF840. Pair of the diode and MOSFET(D1, T2) is connected in parallel with another pair of the diode and MOSFET(D1, T2) is connected in parallel with another pair of the diode and MOSFET(D2, T1). And finally, the bridge circuit is in

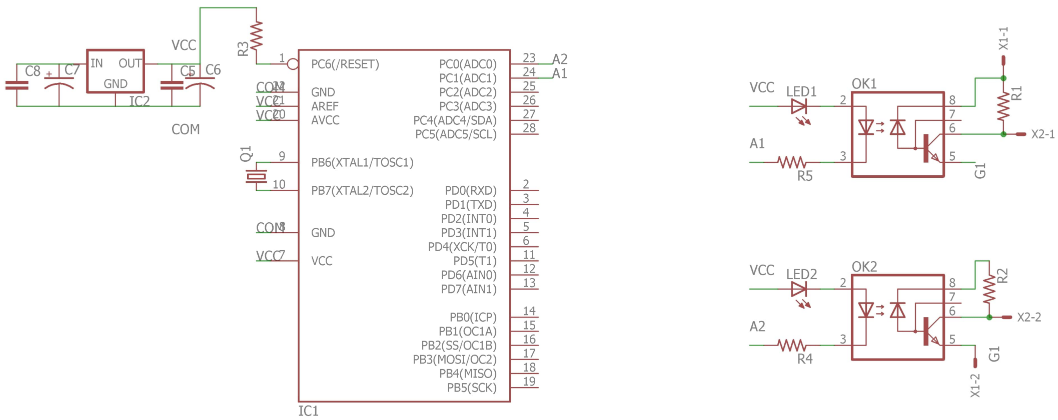

Figure 4.7: Gate drive circuit design

parallel connection with a capacitor of 220uF which is connected with a resistive load of 25Ω in parallel.

For controlling MOSFET we have used Arduino Uno as Microcontroller. A square wave signal is produced on the output by a pair of MOSFETs under the control of Arduino code by single Pulse Width Modulation.

4.4 Driver Circuit

The driver circuit is designed on PCB using EasyDA software. We used microcontroller pin in pcb. The driver circuit is taking 5V DC supply for which we used another power supply. It uses

4.4.1 6N136 Optocoupler:-

Description:-

The 6N136 are optocouplers with a GaAIAs infrared emitting diode, optically coupled with

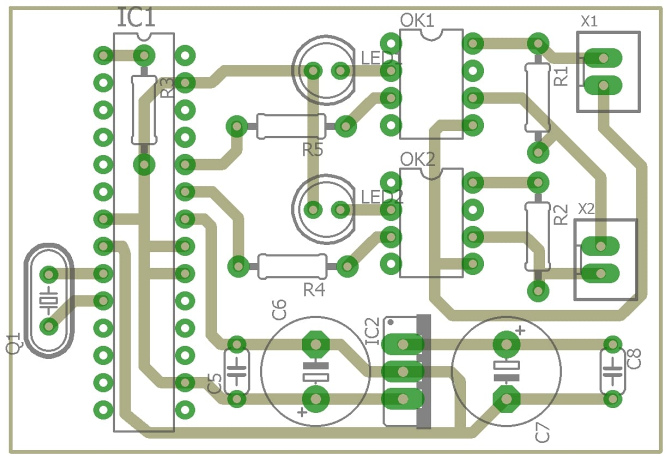

Figure 4.8: PCB Design

an integrated photo detector which consists of a photo diode and a high-speed transistor in a DIP-8 plastic package. Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled should not exceed the maximum permissible reference voltages.

Features :-

- Isolation test voltages: 5300 VRMS
- TTL compatible
- High bit rates: 1 Mbit/s
- High common-mode interference immunity
- Bandwidth 2 MHz
- Open-collector output
- External base wiring possible

4.4.2 Voltage Regulator 7805

Features:-

- 5V Positive Voltage Regulator
- Minimum Input Voltage is 7V
- Maximum Input Voltage is 25V
- Operating current(IQ) is 5mA
- Internal Thermal Overload and Short circuit current limiting protection is available.
- Junction Temperature maximum 125 degree Celsius

Description :-

Electronic circuits frequently use voltage regulators. In exchange for a variable input voltage, they offer a consistent output voltage. In our situation, the 7805 IC is a well-known regulator IC that is used in most projects. The letters ”78” and ”05” in the name 7805 stand for a positive voltage regulator and a device that outputs 5 volts, respectively. So, a +5V output voltage will be provided by our 7805. Most electronics projects employ the 7805 Voltage Regulator IC, which is a widely used voltage regulator. For a supply with the changeable input voltage, it offers a constant +5V output voltage. This IC's output current is up to 1.5A. However, the IC loses a lot of heat, thus projects that need higher current are advised to include a heat sink. For instance, if you are using 1A and the input voltage is 12V, then (12-5) * 1 = 7W. Heat will be produced from this 7 Watts.

4.4.3 Crystal Oscillator :- 16MHz

Specifications:

- Resonance Resistance 40ohms (max)
- Oscillation mode: Fundamental mode
- Shunt Capacitance less than 7pF
- Drive Level less than 100µW
- Operating Temperature Range: -20 to + 70°C
- Operable Temperature Range: -25 to + 85°C
- Storage Temperature Range: -55 to + 125°C

Description:-

The Crystal Oscillator is an electronic oscillator circuit that produces an electrical signal with a precise frequency using the mechanical resonance of a piezoelectric crystal that is vibrating. Additionally, it has automated amplitude control, and temperature-related frequency drift is very minimal. The only applications for crystal oscillators are high-frequency ones. According to the inverse piezoelectric effect, which governs how crystal oscillators operate, an applied electrical field will cause a mechanical distortion in a given piece of material. As a result, it makes use of the mechanical resonance of the vibrating crystal, which is created by the use of a piezoelectric material, to produce an electrical signal with a specific frequency. When you want to use a different clock speed in the microcontroller itself, almost all of them feature an external oscillator. Crystal oscillators feature two leads and can be connected in any direction because there is no polarity for crystals.

4.4.4 capicitor:-1000uF

This 1000uF 50V capacitor is a high-quality electrolytic radial polarised capacitor. Power supplies, DC-DC converters, and switched-mode power supply all frequently employ electrolytic capacitors. This capacitor offers a large operating range, a long life, and little leakage current.
Features of 1000uF 50V Electrolytic Capacitor :-

- Capacitance: 1000uF
- Maximum Voltage: 50 Volts
- Tolerance: ± 15
- Capacitor Type: Radial Through Hole Electrolytic
- Polarization: Yes. Line with '-' denotes negative lead
- Max Temperature: +85°C

4.5 100Ω Resistance

Description :-
These can handle up to 1/4W of electricity at voltages up to 350V and are of the carbon film axial leaded through hole kind. The most popular size for breadboarding is 1/4W resistors. Because they have easy-to-read color-coding on a tan (5With a 0.55 mm diameter and is made of steel wire with tin and copper plating, the leads are also quite robust and hold up well to repeated insertions into solderless breadboards. The resistor leads no longer need to be inserted into the breadboard using needle nose pliers. The larger leads also fit

into the contacts with improved grip. These resistors might be helpful for sky-wiring a project because of the sturdy leads.

Features :-

- Power Rating :- 1W
- Resistance Tolerance :- ± 1
- Resistor Case / Package :- Axial Leaded
- Voltage Rating :- 500V
- Resistor Technology :- Metal Film
- Temperature Coefficientt :- ± 100ppm/K
- Resistor Type :- Flame Proof
- Product Diameter :- 3.53mm
- Product Length :- 10.16mm
- Operating Temperature Min :- -65°C
- Operating Temperature Max :- 165°C

4.6 Matlab Simulation

4.6.1 Structures of driver circuits

In circuit we have taken voltage 325 as V maximum as our input voltage with frequency 50 hz, connected to the inductor in Series, then we bridge type boost converter having

2 diodes on same side and solid-state devices on other side parallel to the capacitor. At the capacitor which is connected in parallel to the load we want a voltage drop of 400V. The load can be of different types R, RL RLC etc. We have taken a solid-state device as MOSFET as it is feasible at very high frequency and do not require anti-parallel diodes. MOSFET is injected with gate current.

4.6.2 Control Methodology

First, we take the ratio of input sinusoidal voltage with maximum voltage, we get a unit template ranging from 1 to -1. We compare the output voltage to the reference voltage 400V and generate an error signal which is the difference between the reference voltage and output voltage. The error signal is passed to the PI controller to amplify and reduce the steady-state error. the PI controller can achieve a fast response and steady-state accuracy with minimal overshoot. The result is multiplied by a unit template that we calculated earlier. The result is then subtracted from Il current flowing through the inductor as current sensing and feedback. The following resulted in wave is compared with a triangular wave of a fixed frequency 10Khz. This is the PWM technique, the duty cycle of the PWM signal is adjusted to maintain a constant output voltage and thus we get our required gate pulse.

4.6.3 Specifications

Vs=325 V

L=0.00446601 H

R=100 Ω

F=50hz

C=0.001F

Ts=$10^{-}5$

$P = 0.1$

$I = 0.01$

$M = 1.73913$

4.6.4 Simulink blocks used

We have made a simulation model on MATLAB Simulink using Sims cape accessories These are as follows:

- AC voltage source
- inductor
- capacitor
- Two MOSFET
- Two diodes
- Resistor as load
- Summer
- PI controller
- Triangular wave
- Relational Operator as Comparator

We simulated it in Discrete power GUI and observed results on scope.

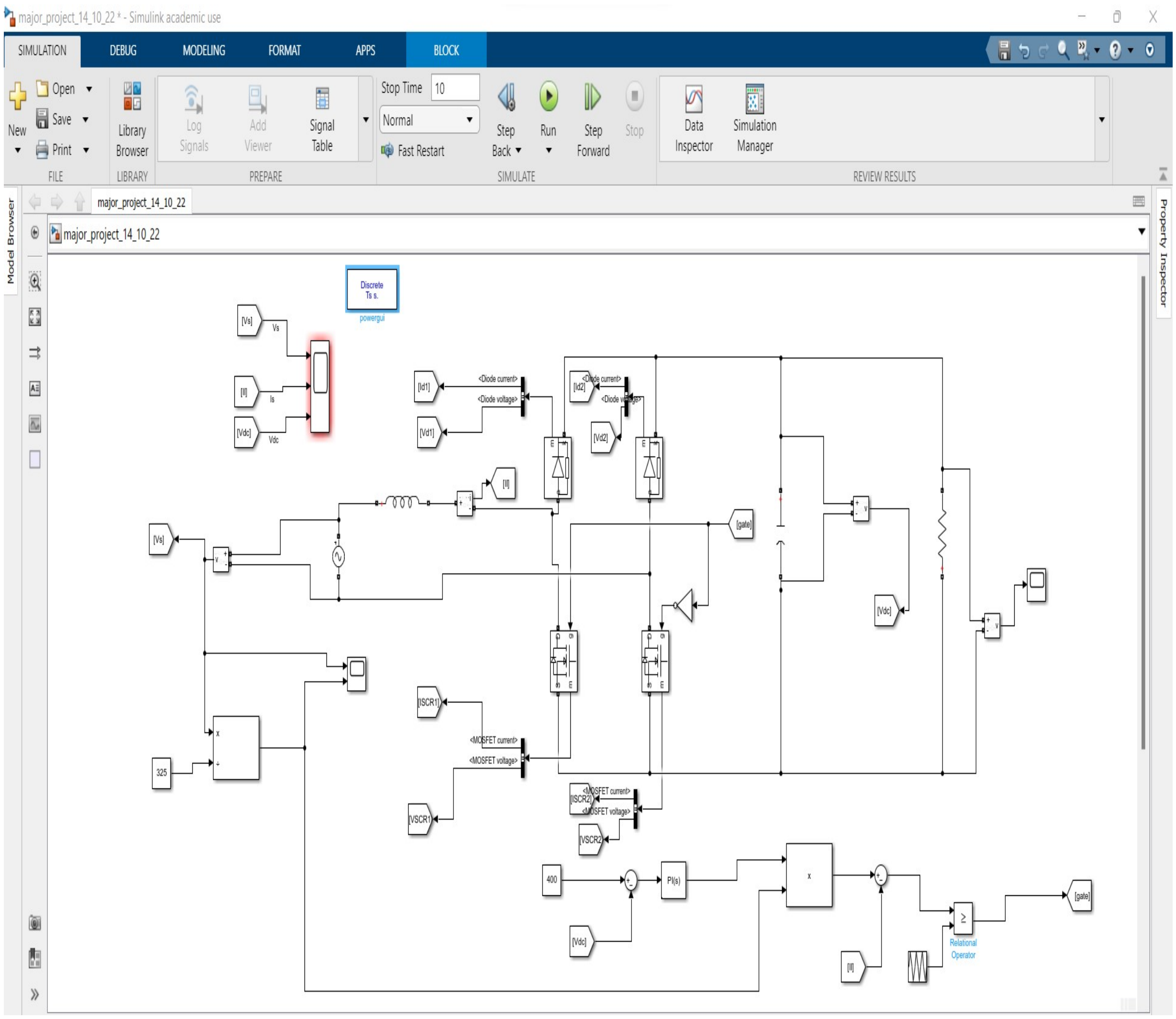

Figure 4.9: PFC Circuit in Simulink

4.6.5 MATLAB simulation of boost type PFC converter

4.6.6 Waveforms and Results

The outcomes of the simulation are shown in scope, where Il is sinusoidal and in phase with the source voltage with current flowing through an inductor at a rate of 8 A. We may observe some current noise that is caused by the MOSFET and diode switching devices. A signal that can be reduced by using the right inductor value

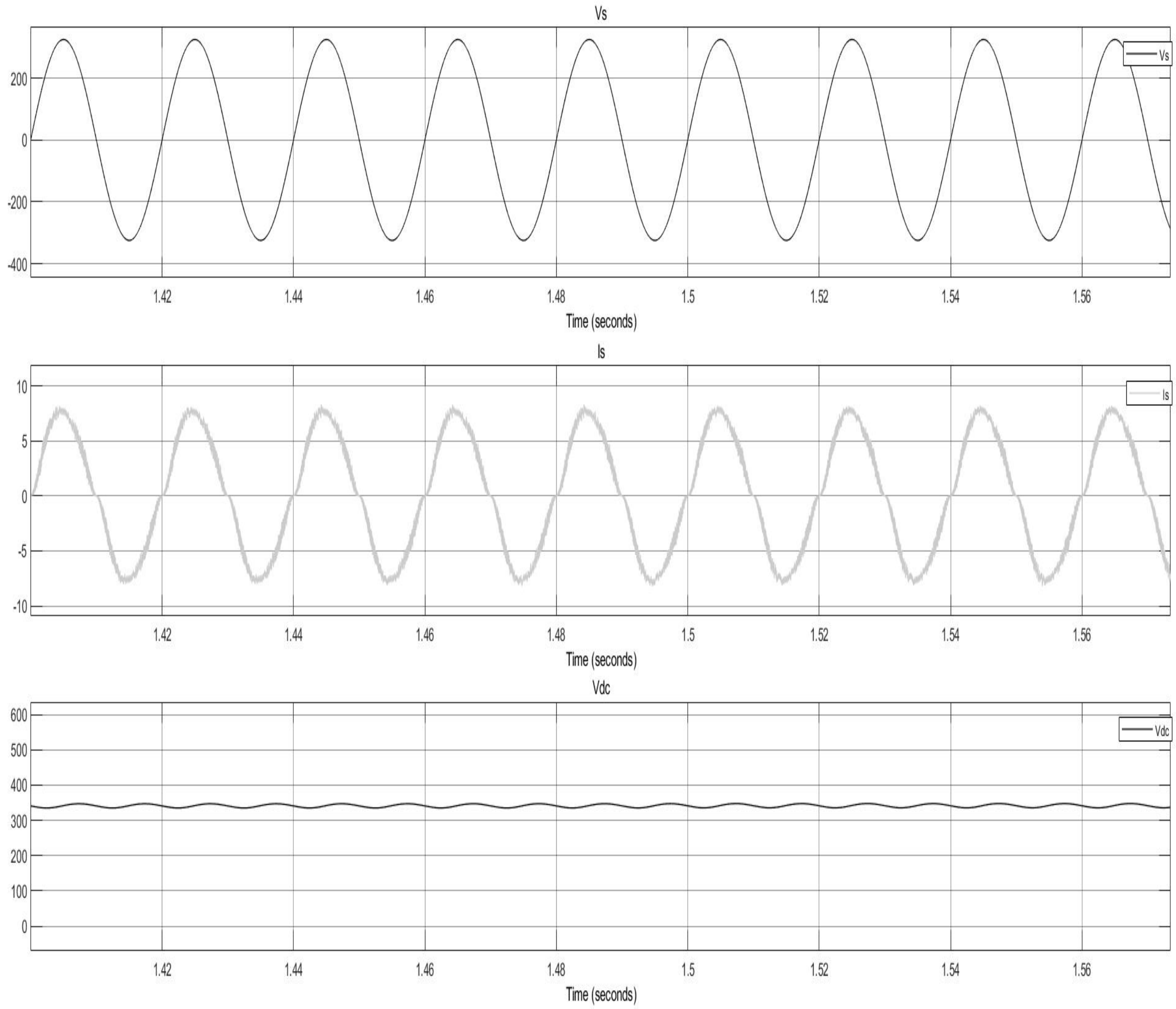

Figure 4.10: wave-forms of Input voltage, inductor current, output voltage

345V of voltage is present across the capacitor, which is a little fluctuating but positive and a DC voltage as it is not negative for any instance.

According to the description of the load current's behavior, there is a transient reaction before a steady-state response.

The first surge in load current up to 5.7A shows that there was an abrupt jump in the load's need for electricity. This can be the result of a MOSFET switching. Following this

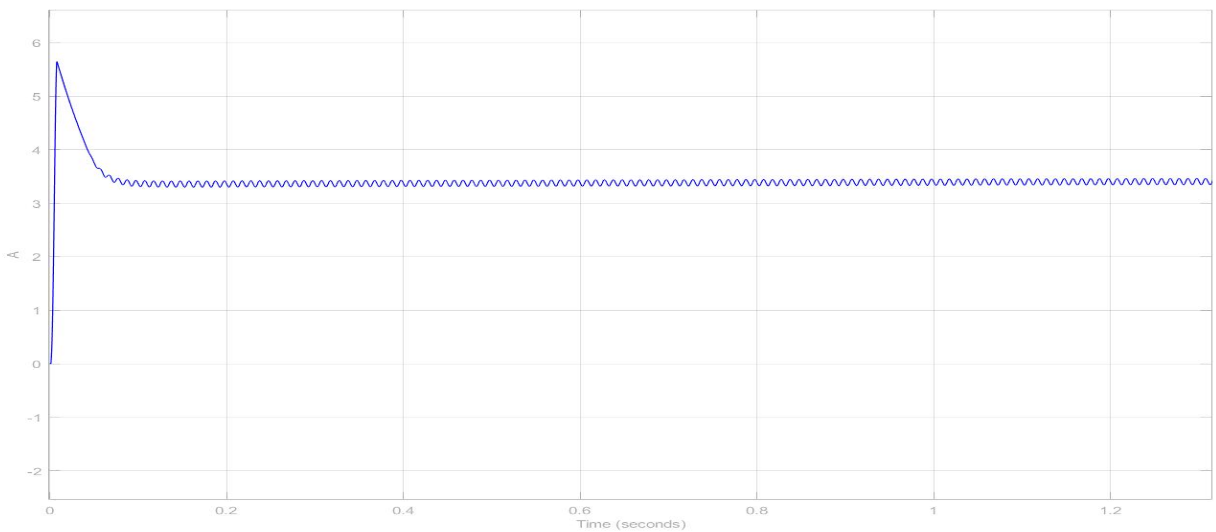

Figure 4.11: load current

first transient reaction, the load current decreases sinusoidally and varies between 3.2A and 3.4A. This shows that the load is settling down and is consuming the same amount of electricity.

4.7 Chapter Summery

In this chapter first discussion is about prototype specification then details of components used in our hardware including MOSFET, diode, transformer, and IC resistors. Later, Matlab Simulation is described with waveforms and analysis of results.

Chapter 5

Conclusions and Future Work

5.1 Conclusions

In conclusion, An inventive solution to the power quality problems seen in power electronics applications is the Enhanced power quality based AC-DC converter. In comparison to conventional AC-DC converters, the suggested converter has a better power factor, less harmonic distortion, and better efficiency.

The design of the AC-DC converter based on improved power quality has important ramifications for the power electronics sector, where power quality is a key factor. To increase power factor and decrease harmonic distortion, the suggested converter may be employed in a variety of applications, including electric vehicles, data centres, and renewable energy systems. This will lower energy consumption and increase system efficiency.

These converters might be viewed as a better alternative to conventional power quality improvement techniques because of their smaller overall converter size, higher efficiency, lower cost, and enhanced reliability. These converters provide superior power quality at both the dc output and the ac mains input for a better overall design of the equipment.[5]

5.2 Future Work

There are a few directions that future research on the AC-DC converter based on improved power quality may go. A few of the potential future projects include:

- To assess the converter's resilience and efficiency under various operating situations, performance under various loads, such as R, RL, RLC, and input voltages, is being examined.

- The converter's implementation in a real-world system and assessment of its performance there are necessary to verify simulation results and gauge the converter's performance under realistic operating circumstances.To increase the converter's effectiveness and dependability, its cooling system will be examined and optimised.

- Soft-switching methods to minimise switching losses in IPQCs even at high switching frequencies to improve the dynamic reaction and to minimise the size of the energy storage components (high-frequency transformers, input and output filters). quality control technology has been transformed through sensor reduction to save costs and increase reliability. Widespread use of dedicated ASICs for converters control is emerging in the new applications. Modern multilevel converter techniques provide great efficiency, reduced device stress, and reduce high-frequency noise.

- The continued advancement of solid-state device technology in terms of low conduction losses, higher permissible switching frequencies, ease of gating process, and new devices especially with low voltage drop and reduced switching losses will give IPQCs in low-voltage dc power applications necessary for high-frequency products a real boost.

- These areas of future research could significantly contribute to the development of more efficient and reliable power electronics systems, which can enhance the overall performance of various applications and contribute to a more sustainable energy future.[5]

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Appendix A

Codes used in the thesis

1. **Code for Arduino Uno Micro-controller board**

```
int mos_1 = 8;
int mos_2 = 9;
int Squre_Wave = 7;

void setup() {
  // put your setup code here, to run once:
  pinMode(mos_1,OUTPUT);
  pinMode(mos_2,OUTPUT);
  pinMode(Squre_Wave,INPUT);

  digitalWrite(mos_1,LOW);
  digitalWrite(mos_2,LOW);



}
```

```
void loop() {
  // put your main code here, to run repeatedly:
  Squre_Wave = digitalRead(7);  //For Square Wave Switching
  if (Squre_Wave == 1) {

    digitalWrite(mos_1, HIGH);
    digitalWrite(mos_2, LOW);

    delayMicroseconds(50);



    digitalWrite(mos_1, LOW);
    digitalWrite(mos_2, HIGH);

    delayMicroseconds(50);



  }
  }
```

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