ACTIVE-CLAMP FLYBACK CONVERTER AS FUZZY LOGIC CONTROLLED ACTIVE POWER SUPPLY CHARGING SYSTEM FOR EV APPLICATIONS

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ABSTRACT

Electric Vehicle (EV) charging systems require high efficiency reduced switching stress, and a stable power supply for reliable operation. Conventional flyback converters face issues such as high switching losses, spike voltages, harmonics, low efficiency, and limited power handling capability. To overcome these drawbacks, this project proposes an Active-Clamp Flyback Converter (ACFC) based charging system with improved power conversion performance. The active-clamp technique suppresses voltage spikes caused by transformer leakage inductance and recycles the leakage energy, resulting in reduced switching losses and enhanced efficiency. To ensure regulated output voltage and better dynamic response, a Fuzzy Logic Controller (FLC) is implemented and compared with a conventional PI-controlled system. The system is designed and simulated in MATLAB/Simulink and analyzed for performance parameters such as ripple voltage, efficiency, device stress, and power transfer capability. The simulation results demonstrate that the FLC-based Active-Clamp Flyback Converter offers improved voltage regulation, reduced ripple and switching stress, and higher overall efficiency, making it highly suitable for battery-operated Electric Vehicle charging and other DC applications.

CHAPTER-1

INTRODUCTION

1.1 GENERAL

In modern power electronic systems, the demand for high-efficiency energy conversion is rapidly increasing due to the global shift toward renewable energy integration and electrification of transportation. Among various applications, Electric Vehicles (EVs) play a major role in reducing carbon emissions and dependence on fossil fuels. However, the performance and lifespan of EVs greatly depend on the design of efficient and intelligent power supply systems used for charging and power management.

An Active Power Supply (APS) is a power electronic system capable of providing controlled, stable, and efficient DC power to a load. It performs active regulation of voltage and current through feedback control techniques to achieve minimal ripple, fast transient response, and high efficiency. In EV charging systems, the APS ensures the precise control of power flow from the grid or renewable sources to the battery, thereby maintaining safety, stability, and charging speed.

At the core of such power supplies lies the DC–DC converter, which converts unregulated DC input voltage into a regulated output voltage suitable for the load or battery. Among various DC–DC topologies, the Flyback converter is a widely used isolated converter due to its simplicity, low cost, and ability to provide electrical isolation between input and output. However, conventional Flyback converters suffer from several drawbacks such as high switching losses, voltage spikes due to leakage inductance, and low energy efficiency at higher power levels.

To overcome these issues, researchers have developed advanced converter topologies such as the Active-Clamp Flyback (ACF) Converter. The ACF converter introduces an auxiliary switch and a clamping capacitor, which recycle the leakage energy from the transformer and achieve Zero Voltage Switching (ZVS) operation. This not only reduces switching losses and voltage stress but also significantly enhances the overall efficiency of the system.

For intelligent and dynamic control, the Fuzzy Logic Controller (FLC) is implemented as part of the feedback system. Unlike conventional linear controllers (such as PI or PID), FLC does not require a precise mathematical model and can adapt effectively to parameter variations and load disturbances. It provides a smoother output voltage with faster response and minimal steady-state error, making it ideal for Active Power Supply (APS) systems.

Therefore, the Active-Clamp Flyback Converter with Fuzzy Logic Controlled APS presents an optimal solution for modern EV charging systems. It combines soft-switching techniques, intelligent control, and energy recovery to achieve higher efficiency, lower power losses, and improved reliability. This project focuses on the design, modeling, and simulation of such a converter using MATLAB/Simulink and compares its performance with conventional control techniques to demonstrate its effectiveness for Electric Vehicle (EV) power supply applications.

1.2 PROBLEM DEFINITION

Electric vehicle (EV) charging systems require efficient and compact power converters to handle high voltage levels while maintaining safety and reliability. The conventional flyback converter, though simple, suffers from high switching losses, voltage spikes due to transformer leakage inductance, and reduced overall efficiency. These limitations make it unsuitable for modern high-performance EV applications. Hence, there is a need for a modified topology that can minimize switching losses, recover energy from leakage inductance, and maintain soft-switching operation. The Active-Clamp Flyback Converter (ACFC) offers these improvements and, when combined with an intelligent control strategy such as Fuzzy Logic Control (FLC), can significantly enhance converter performance and efficiency for EV charging systems.

1.3 MOTIVATION

With the increasing demand for sustainable transportation, electric vehicles are rapidly gaining popularity. However, the performance and lifespan of EVs depend heavily on the efficiency of their charging systems. Conventional converters experience poor voltage regulation and energy losses during fast charging. Active-clamp techniques, which allow soft switching, have proven effective in minimizing switching stress and improving energy efficiency. Incorporating fuzzy logic control adds intelligence to the converter's response, enabling adaptive operation under varying load and input conditions. This motivates the study and simulation of an Active-Clamp Flyback Converter with Fuzzy Logic Control for EV charging applications.

1.4 OBJECTIVES

The main objectives of this project are:

1. To design and simulate an Active-Clamp Flyback Converter (ACFC) suitable for electric-vehicle charging applications, ensuring high efficiency and reduced switching losses.

   - To simulate conventional flyback converter based half-bridge rectifier with C-Filter system.
   - To simulate proposed PV with flyback converter based Full-bridge rectifier with π-Filter system.
   - To simulate closed loop flyback converter based Full-bridge rectifier With PI controlled ssystem.
   - To simulate closed loop flyback converter based Full-bridge rectifier With Fuzzy Logic controlled ssystem.

2. To analyse the electrical behaviour of the conventional Flyback converter and identify its limitations in terms of voltage stress, efficiency, and ripple.

3. To implement a Fuzzy Logic Controller (FLC) for closed-loop voltage regulation and compare its performance with the conventional Proportional–Integral (PI) controller.

4. To derive and validate mathematical equations for voltage gain, current flow, and transformer design parameters of the ACFC.

5. To evaluate performance parameters such as rise time, peak time, settling time, steady-state error, and ripple reduction using MATLAB/Simulink simulation.

6. To develop hardware and test it for Flyback converter.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is essential for understanding the development and improvements in Flyback converter topologies and control strategies. This chapter presents a comprehensive review of existing works on DC–DC converters, Active-Clamp techniques, and intelligent control systems used in electric vehicle (EV) power supplies. It highlights the progress made by researchers and identifies the gaps that led to the development of the proposed system.

2.2 REVIEW OF FLYBACK CONVERTER TOPOLOGIES

The Flyback converter is a simple isolated DC–DC converter widely used in low- and medium-power applications such as battery chargers, LED drivers, and auxiliary power supplies.

Watson et al. (1996) [9] first introduced the concept of using an Active-Clamp circuit in the Flyback topology to recycle leakage energy and achieve soft-switching operation. This approach significantly reduced voltage stress on the MOSFET and improved converter efficiency.

Alou et al. (2002) [16] demonstrated that the Active-Clamp Flyback Converter (ACFC) is well suited for low-power and wide input voltage applications. Their research showed that active-clamp circuits minimize energy loss and electromagnetic interference (EMI) compared to conventional RCD snubbers.

Lin et al. (2005) [13] presented an analysis and design of an Active-Clamp Flyback Converter operating under Zero-Voltage Switching (ZVS) conditions. The study revealed improvements in power density and thermal performance, which are crucial for compact EV chargers.

Huang et al. (2016) [10] explored MHz-frequency ACFCs using Gallium Nitride (GaN) switches, demonstrating ultra-high efficiency and compact design suitable for adapter-level power supplies. This innovation marked a transition from silicon-based devices to wide bandgap semiconductors for high-efficiency converter design.

Perrin et al. (2016) [19] investigated resonant-mode operation of GaN-based Active-Clamp Flyback Converters under high-temperature conditions, confirming their robustness and reliability in automotive and EV environments.

2.3 REVIEW OF CONTROL STRATEGIES IN FLYBACK CONVERTERS

The control of Flyback converters plays a vital role in achieving stable and accurate output voltage. Conventional methods such as Voltage Mode Control (VMC) and Current Mode Control (CMC) provide good regulation but often fail under non-linear or dynamic conditions.

Liu et al. (2018) [15] analyzed control methods for Active-Clamp Flyback converters with nonlinear junction capacitance, emphasizing the importance of precise timing in achieving ZVS. However, these conventional controllers often suffer from poor adaptability and slow dynamic response.

Zaman and Radic (2020) [12] proposed a design methodology for adapter power supplies using all-silicon Active-Clamp Flyback converters. Their study highlighted the need for improved control algorithms capable of handling variable loads and maintaining stable operation under disturbances.

With the evolution of intelligent control systems, Fuzzy Logic Control (FLC) emerged as an effective method for nonlinear systems. Unlike PI controllers that require accurate mathematical models, FLC uses linguistic rules to make control decisions. It is robust, adaptable, and ideal for systems with parameter variations such as power converters operating under dynamic loads.

2.4 FUZZY LOGIC CONTROL IN POWER ELECTRONICS

The concept of fuzzy logic was first introduced by Lotfi Zadeh in 1965. In power electronics, FLCs are used to improve voltage regulation, reduce overshoot, and minimize settling time without the need for an exact system model.

Zhang et al. (2010) demonstrated that integrating Fuzzy Logic Controllers in DC–DC converters provide better transient performance compared to conventional linear controllers. The fuzzy rules mimic human decision-making and adaptively adjust the duty cycle to maintain stable output.

In 2018, Xue and Zhang implemented a secondary-resonant Active-Clamp Flyback Converter with improved soft-switching and high efficiency. Their study proved that intelligent control methods combined with active-clamp topology could achieve better energy utilization and reliability.

2.5 APPLICATIONS IN ELECTRIC VEHICLE (EV) POWER SYSTEMS

Electric vehicles require compact, efficient, and reliable power converters for on-board chargers and auxiliary systems. The Active-Clamp Flyback Converter is ideal for such applications due to its galvanic isolation, high efficiency, and reduced EMI.

Weir and Cathell (2008) [1] emphasized the need for smart power supplies capable of handling variable load conditions in renewable and EV systems. Zhou et al. (2008) [2] introduced a quasi-active PFC circuit suitable for LED and EV applications, contributing to energy-efficient design.

Recent developments by Ben-Yaakov (2018) and BRUSA Elektronik AG (2022) have integrated Active-Clamp Flyback Converters into wireless inductive charging systems, showcasing their adaptability in high-voltage, three-phase EV chargers.

2.6 SUMMARY OF LITERATURE REVIEW

From the above studies, it is evident that:

- Conventional Flyback converters suffer from switching losses, voltage spikes, and poor dynamic response.
- Active-Clamp techniques provide soft switching, energy recovery, and higher efficiency.
- The use of wide bandgap devices (GaN, SiC) further enhances performance in high-frequency applications.
- Fuzzy Logic Control offers robustness, adaptability, and improved response compared to traditional PI control.
- Integration of Active-Clamp Flyback topology with FLC makes it a strong candidate for next-generation EV charging systems.

The review establishes the research gap: while Active-Clamp converters are proven efficient, limited studies have combined them with intelligent fuzzy logic control for EV charging systems. This project addresses that gap through detailed simulation and analysis.

CHAPTER-3

EXISTING SYSTEM

3.1 INTRODUCTION

The Flyback converter is one of the most widely used isolated DC–DC converters for low and medium power applications such as switch-mode power supplies (SMPS), LED drivers, and battery chargers. It’s simple structure, cost-effectiveness, and inherent isolation capability make it suitable for various industrial and consumer electronic systems. However, when applied to electric vehicle (EV) charging, the conventional Flyback converter suffers from several drawbacks, including high switching losses, high voltage stress across components, and reduced efficiency.

3.2 FLYBACK CONVERTER

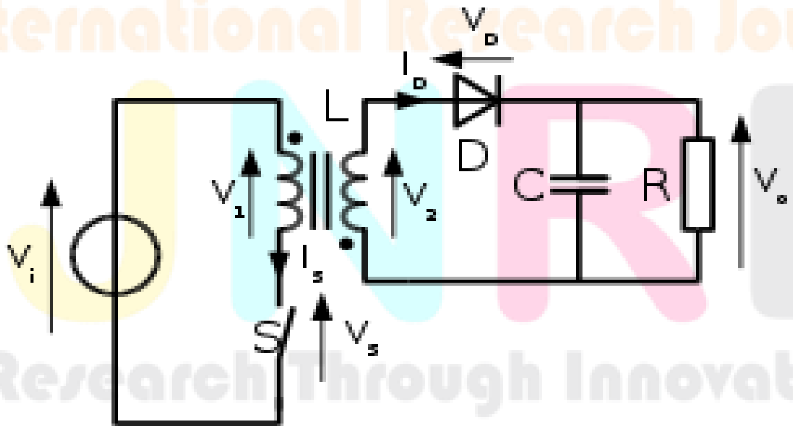

Fig 3.1 Schematic of a flyback converter

Schematic of a flyback converter is shown in Fig 3.1 The flyback converter is used in both AC/DC and DC/DC conversion with galvanic isolation between the input and any outputs. More precisely, the flyback converter is a boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the boost converter is left out and the device is called a flyback transformer.

3.2.1 Structure and principle

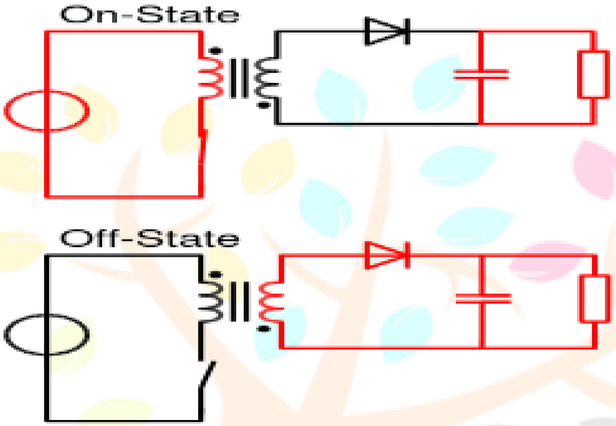

Fig 3.2 The two configurations of a flyback converter operation

Fig. 3.2 shows the two configurations of a flyback converter in operation: In the on-state, the energy is transferred from the input voltage source to the transformer (the output capacitor supplies energy to the output load). In the off-state, the energy is transferred from the transformer to the output load (and the output capacitor).

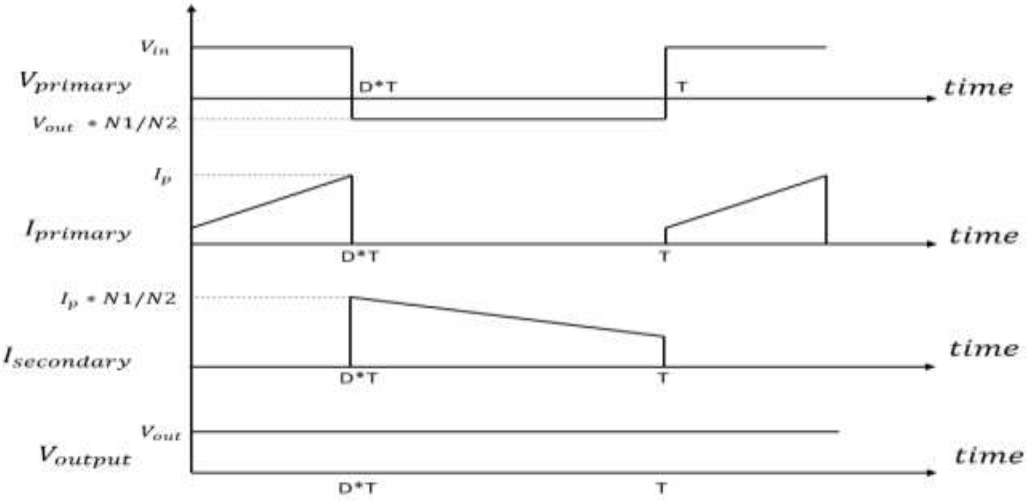

Fig. 3.3 Waveform - using primary side sensing techniques - showing the 'knee point'.

The schematic of a flyback converter can be seen in Fig. 3.3. It is equivalent to that of a boost converter, with the inductor split to form a transformer. Therefore, the operating principle of both converters is very close:

- When the switch is closed (top of Fig. 3.2), the primary of the transformer is directly connected to the input voltage source. The primary current and magnetic flux in the transformer increases, storing energy in the transformer. The voltage induced in the secondary winding is negative, so the diode is reverse-biased (i.e., blocked). The output capacitor supplies energy to the output load.
- When the switch is opened (bottom of Fig. 3.2), the primary current and magnetic flux drops. The secondary voltage is positive, forward-biasing the diode, allowing current to flow from the transformer. The energy from the transformer core recharges the capacitor and supplies the load.

The operation of storing energy in the transformer before transferring to the output of the converter allows the topology to easily generate multiple outputs with little additional circuitry, although the output voltages have to be able to match each other through the turns ratio. Also there is a need for a controlling rail which has to be loaded before load is applied to the uncontrolled rails, this is to allow the PWM to open up and supply enough energy to the transformer.

3.2.2 Operation

The flyback converter is an isolated power converter; therefore, the isolation of the control circuit is also needed. The two prevailing control schemes are voltage mode control and current mode control (in the majority of cases current mode control needs to be dominant for stability during operation). Both require a signal related to the output voltage. There are two common ways to generate this voltage. The first is to use an optocoupler on the secondary circuitry to send a signal to the controller. The second is to wind a separate winding on the coil and rely on the cross regulation of the design.

The first technique involving an optocoupler has been used to obtain tight voltage and current regulation; whereas the alternative approach was developed for cost-sensitive applications where the output did not need to be as tightly controlled but up to 11 components including the optocoupler could be eliminated from the overall design. Also, in applications where reliability is critical, optocouplers can be detrimental to the MTBF (Mean Time between Failures) calculations.

Recent developments in primary-side sensing technology, where the output voltage and current are regulated by monitoring the waveforms in the auxiliary winding used to power the control IC itself, have improved the accuracy of both voltage and current regulation.

Previously, a measurement was taken across the whole of the flyback waveform which led to error, but it was realized that measurements at the so-called *knee point* (when the secondary current is zero, Fig. 3.4) allow for a much more accurate measurement of what is happening on the secondary side. This topology is now replacing ringing choke converters (RCCs) in applications such as mobile phone chargers.

3.3. BLOCK DIAGRAM

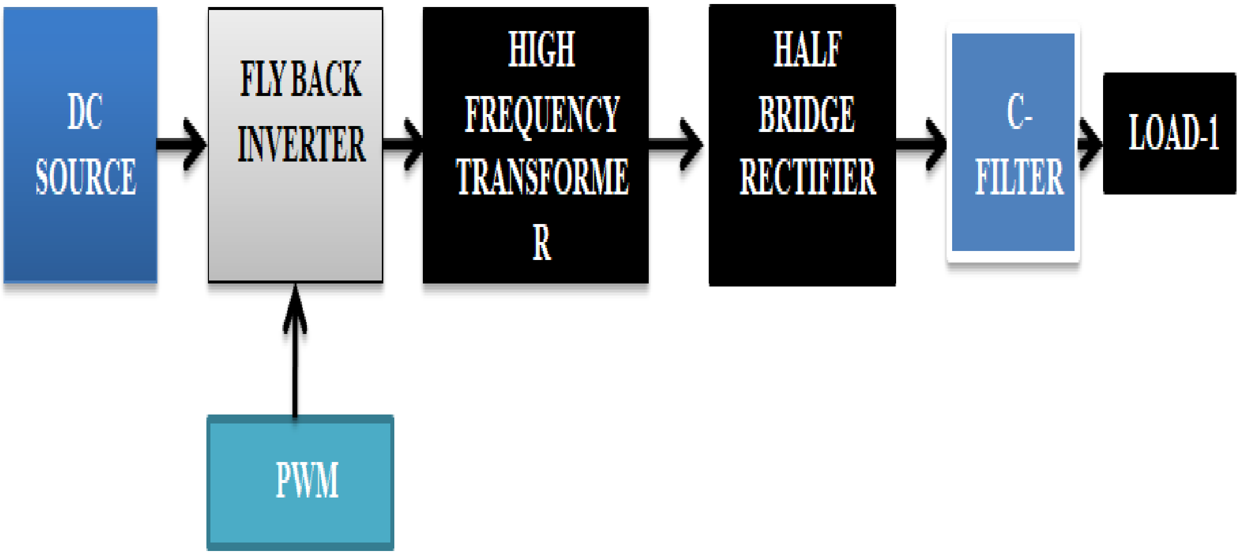

Fig.3.4. Existing Block Diagram of Flyback Converter Based Half-Bridge Rectifier with C-filter

The Fig 3.4 shows the Existing Block Diagram of Flyback Converter Based Half-Bridge Rectifier with C-filter.

3.4. CONVENTIONAL CIRCUIT DIAGRAM

The Existing Circuit Diagram of Flyback Converter Based Half-Bridge Rectifier with C-filter is shown in Fig 3.5.

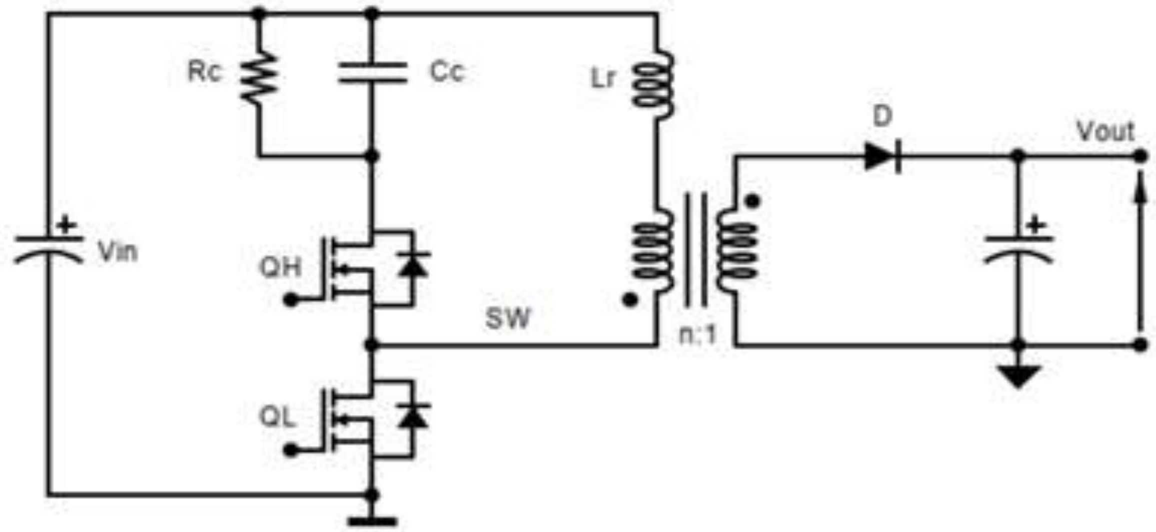

Fig.3.5. Existing Circuit Diagram of Flyback Converter Based Half-Bridge Rectifier with C-filter

3.5 CONVENTIONAL CIRCUIT DRAWBACKS

- More Switching Losses
- High spike voltages
- Low efficiency
- More harmonics
- Low power rating

CHAPTER-4

PROPOSED SYSTEM

ACTIVE CLAMP FLYBACK CONVERTER

4.1 INTRODUCTION

To overcome the drawbacks of the conventional Flyback converter such as high switching losses, voltage stress, and poor efficiency, a modified topology known as the Active-Clamp Flyback Converter (ACFC) is proposed.

The ACFC utilizes an auxiliary switch and clamping capacitor to recycle the energy stored in the transformer's leakage inductance. This design achieves soft switching, minimizes switching stress, and improves the overall efficiency of the converter.

Furthermore, a Fuzzy Logic Controller (FLC) is implemented in the closed-loop control system to enhance voltage regulation, reduce transient errors, and improve system stability under varying load and input conditions.

The combination of Active-Clamp technology and Fuzzy Logic Control results in a high-efficiency, low-loss, and adaptive converter suitable for Electric Vehicle (EV) charging applications.

4.2 PRINCIPLE OF OPERATION

The Active-Clamp Flyback Converter operates similarly to the conventional Flyback converter, but includes an additional clamping switch (QH) and clamping capacitor (Cc) connected in parallel with the primary switch.

The purpose of this network is to recover the leakage energy and enable Zero-Voltage Switching (ZVS) during turn-on, thus reducing switching losses and electromagnetic interference (EMI).

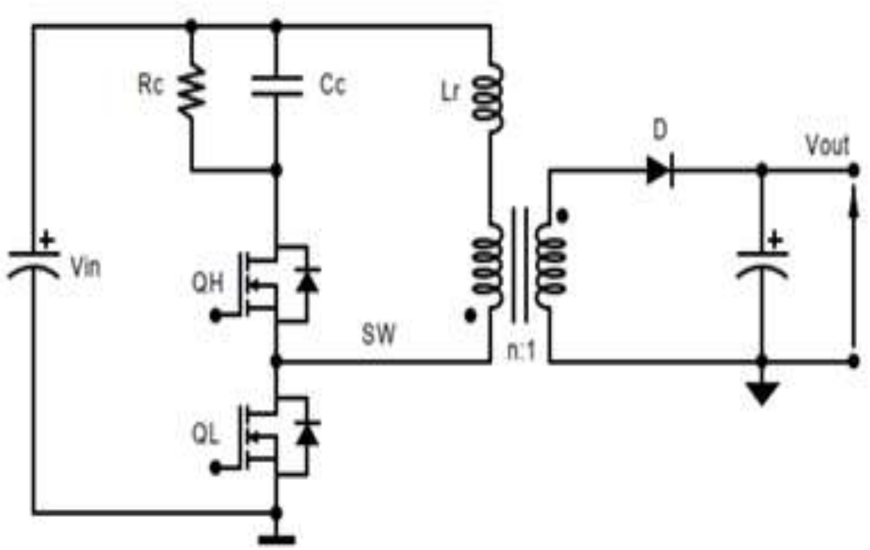

Fig 4.1 The ACF generic schematic.

The ACF generic schematic is shown in Fig. 4.1. In it Vin is voltage of input supply-capacitor (i.e. dc link), QH and QL are high- and low-side switches, respectively; Lr comprises external inductor and leakage inductance, Cc is clamping capacitor, Lm magnetizing inductance, n transformer turns ratio, D output diode, and Vout is the output voltage.

The ACF is different than conventional flyback converter in sense that QH is used instead of the clamping diode (which is used in a standard passive RCD snubber). The QH is actively controlled in order to improve efficiency by recycling energy stored in the leakage inductance.

In HDCIV applications one has to use external inductor in order to achieve zero voltage switching (ZVS) of the QL. The general advantages and disadvantages of an ACF in single-phase applications, compared to conventional flyback are listed.

However, it is found that for three-phase input (i.e. HDCIV) application, with the high dc voltage-conversion-ratio (>80), the efficiency is comparable or even lower than the conventional flyback dc-dc converter and that usage of (external) inductor is mandatory.

Additional drawbacks are need for cooling of that inductor as well as higher price and occupied board-space. The bottle neck for wider ACF usage in ICS is lack of appropriate electronic components on the market. However, as ACF is known for having less EMI-related problems that could be the key-advantage for this application.

4.2.1 Operating Modes

The converter operates in four major modes during one switching cycle:

1. Mode I (Primary Switch ON – Energy Storage Phase):

When the main switch (QL) is turned ON, current flows through the primary winding, and energy is stored in the magnetizing inductance of the transformer. The secondary diode is reverse-biased during this period.

2. Mode II (Main Switch OFF – Energy Transfer Phase):

When QL turns OFF, the magnetizing current forces the voltage across the primary winding to reverse. The secondary diode becomes forward-biased, and energy is transferred to the output through the secondary winding.

3. Mode III (Clamp Switch ON – Energy Recovery Phase):

The clamp switch (QH) is turned ON, allowing the leakage energy stored in the transformer to be transferred to the clamping capacitor (Cc). This process recycles energy instead of dissipating it in a snubber circuit, thus improving efficiency.

4. Mode IV (Clamp Switch OFF – Reset Phase):

The clamping capacitor discharges, restoring the system for the next switching cycle. During this time, the ZVS condition is achieved for the main switch, reducing switching losses and improving reliability.

4.3. FUZZY LOGIC CONTROLLER

A` FLC is an intellectual control method that easily interpolates among the rules. `FLC describe event ambiguity. It measures the degree to which an event occurs, not whether it occurs. Fuzzy theory is a prevailing utensil in the investigation of multifaceted effort because of its facility to conclude outputs for a given set of inputs without using a conservative, mathematical model. Fuzzy theories become simply tacit since it can be made to be similar to a high-level language instead of a mathematical language. To express a universe of conversation, fuzzy sets with names such as “hot” and “cold” are used to create a membership function. In decisive the degree of membership of an input in the fuzzy set of this membership task, the role of membership functions plays in decoding the linguistic terms to the standards a computer can use.

Membership functions are intended by experts with acquaintance of the structure being analyzed. `FLC is basically a set of rules telling a set of actions to be engaged for a specified set of inputs. By means of a linguistic approach, fuzzy theory can be included into control theory using rules of the form IF {condition} THEN {action}. In this equivalent way the input variables can be partition into overlap set which have a linguistic correspondence to sketch out a membership function. Those `FLC sets are mostly often triangle in shape but trapezoid and Gaussian function have been used. The membership values organize the degree to which every rule “fires”, illustrate the interdependent relationship among the rule set and the membership function`.

The principles of the membership functions are assigning to linguistic variables using three `fuzzy subsets called Positive Medium, Positivelow, Zero error, Positive High. The linguistic variables X error and S error are the input variables. The output is the firing on PV of CL- CBRBIS with FL-FL which gives desired braking or acceleration. Triangular membership functions are using in both input and output variables. The membership functions for the Variables X error, S error and the output are shown in Fig. 4.2, Fig 4.3, and Fig 4.4.

The input linguistic variable X error ranges from (-10m to 10m).

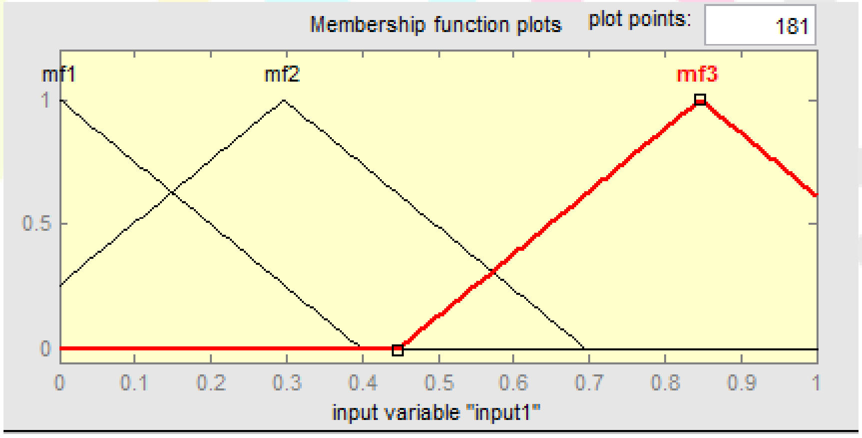

Fig 4.2. Membership function of the input1

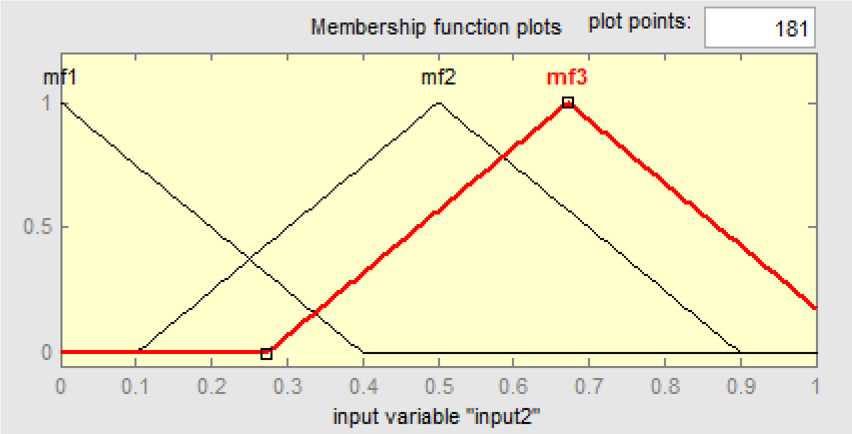

Fig.4.3. Membership function of the input2

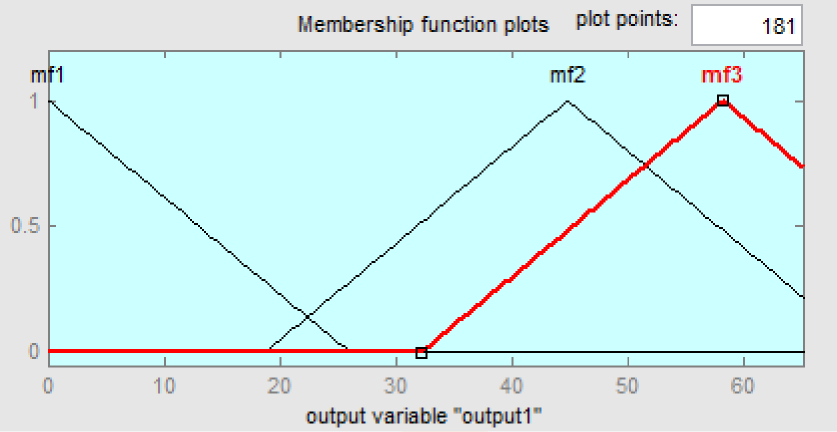

Fig.4.4. Membership functions of the output.

Table.4.1 Fuzzy Rule Base

e/Δe	PL	PM	PH
PL	PH	PL	PM
PM	PL	Z	PH
PH	Z	PM	PH

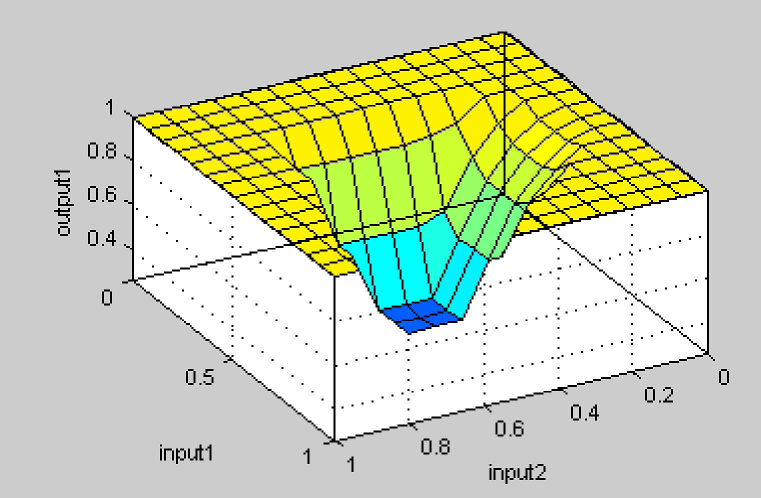

Fig.4.5. Surface plot of voltage Response

4.4. BLOCK DIAGRAM

The Fig 4.6 shows Proposed Block Diagram of Flyback Converter Based Full-bridge Rectifier with Π-filter System.

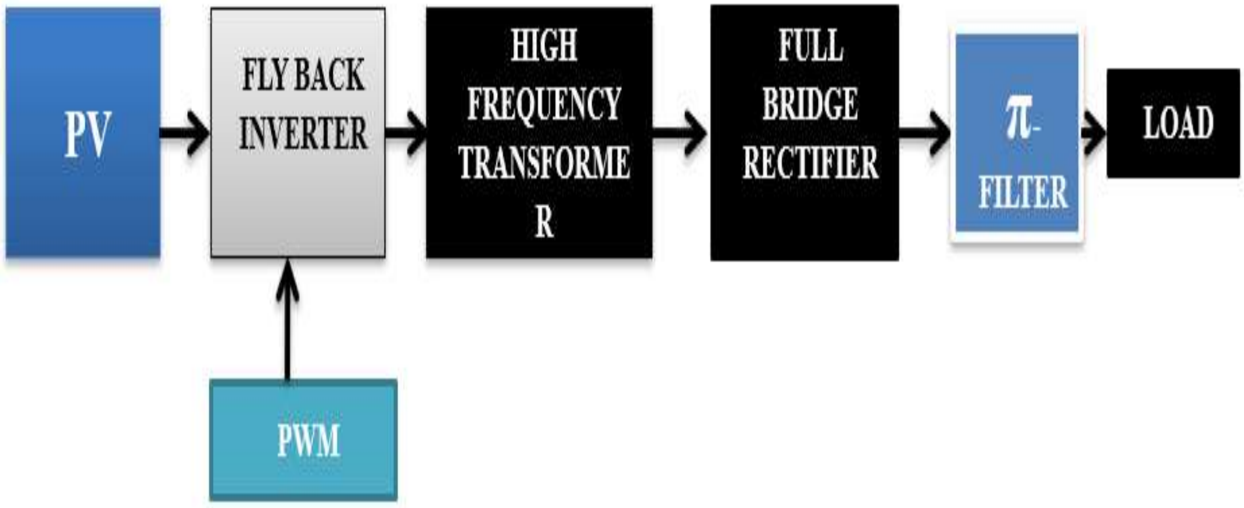

Fig 4.6 Proposed Block Diagram of Flyback Converter Based Full-bridge Rectifier with Π-filter System

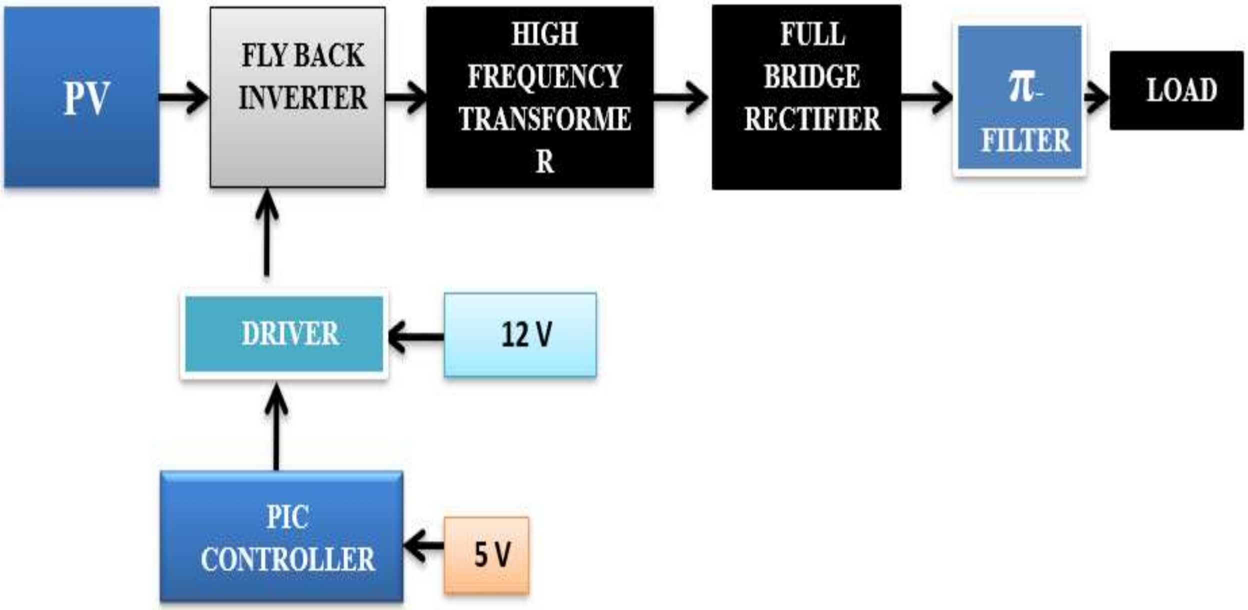

Fig.4.7. Hardware Block Diagram of Flyback Converter based Full-bridge Rectifier with Π-filter

The Fig 4.7 shows the Hardware Block Diagram of Flyback Converter based Full-bridge Rectifier with Π-filter. The Fig 4.8 shows Closed Loop Simulation Block Diagram of Flyback Converter with PI/Fuzzy Logic Controlled System.

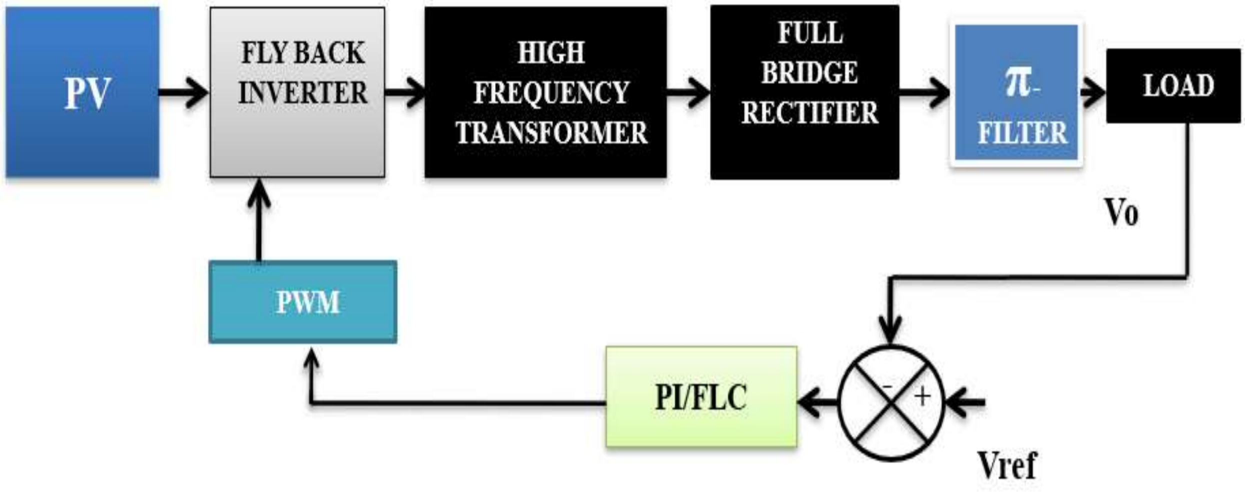

Fig.4.8. Closed Loop Simulation Block Diagram of Flyback Converter with PI/FL Controlled System

4.5 CIRCUIT DIAGRAM

The Proposed Circuit Diagram of Flyback Converter Based Full-bridge Rectifier with Π-filter System is shown in Fig 4.9.

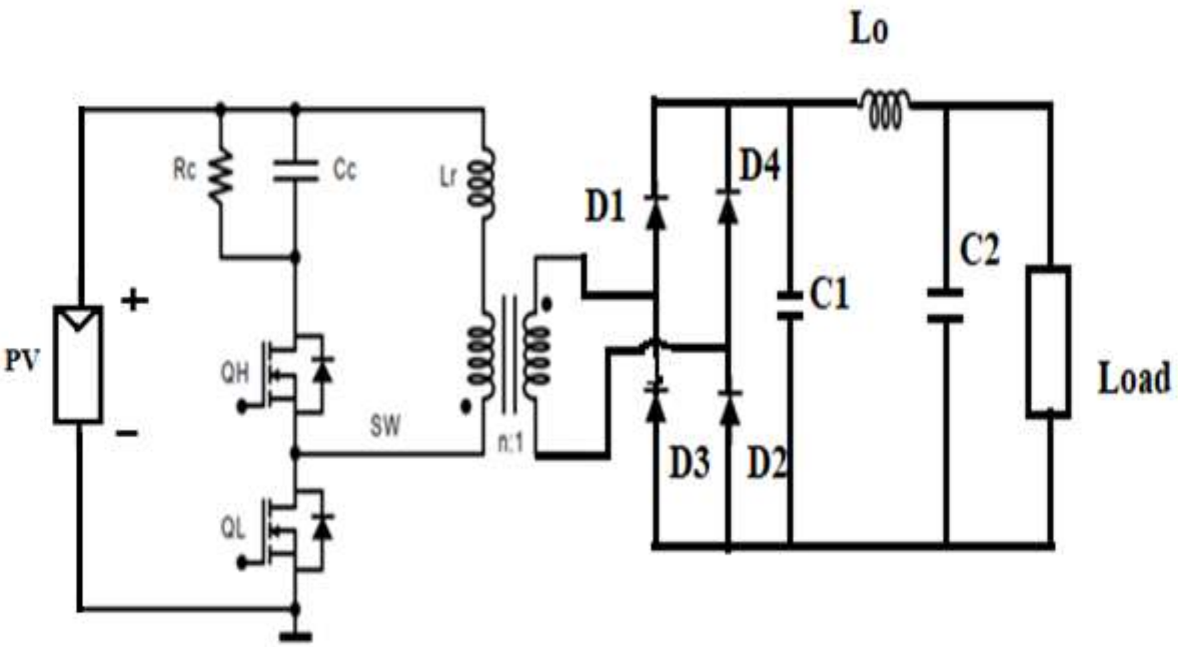

Fig.4.9. Proposed Circuit Diagram of Flyback Converter Based Full-bridge Rectifier with Π-filter System

Closed Loop Circuit Diagram of Flyback Converter with PI/FL Controlled System is shown in Fig 4.10. Measured voltage is compared with the reference voltage and the error is applied to the PI/FL controller. The output of voltage PI/FL is compared with the reference current and the error is applied to PWM generator.

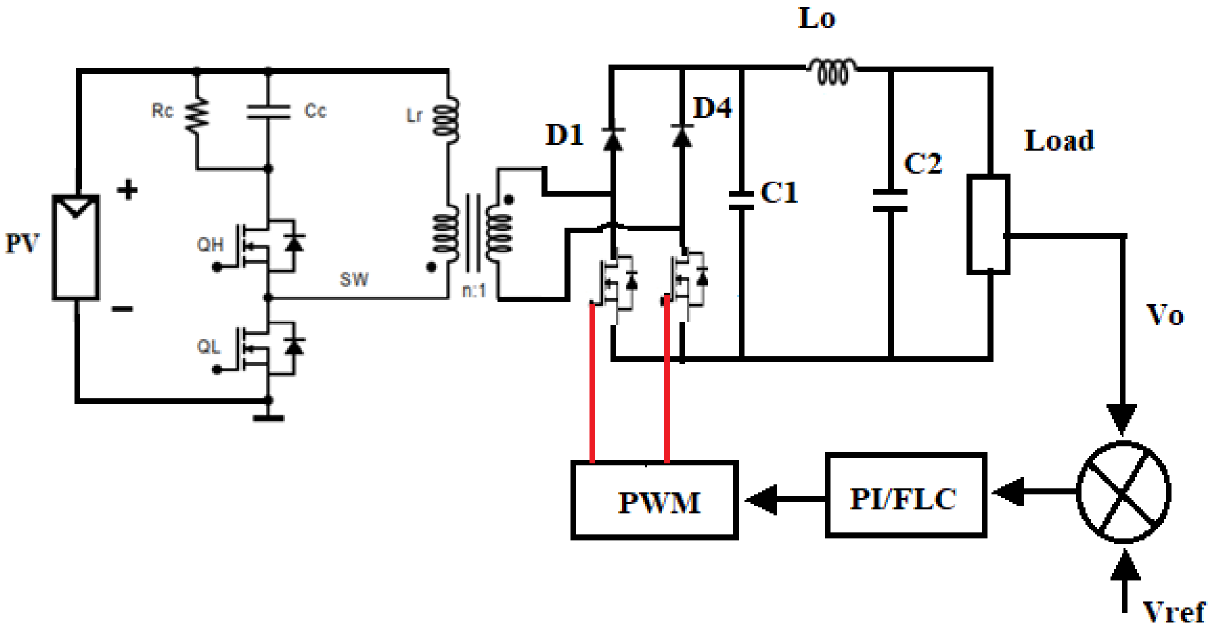

Fig.4.10. Closed Loop Circuit Diagram of Flyback Converter with PI/FL Controlled System

It includes:

Main Switch (QL) – controls energy transfer between primary and secondary sides.

Clamp Switch (QH) – enables energy recovery and ZVS operation.

Clamp Capacitor (Cc) – stores leakage energy.

Transformer (T) – provides isolation and voltage scaling.

Output Diode and Filter (D, CLC) – reduce the Noises, ripple voltage and current and deliver smoothed DC output.

Fuzzy Logic Controller – adjusts the duty ratio dynamically based on error feedback.

4.6. EFFICIENCY IMPROVEMENT

By recovering the leakage energy through the clamping circuit instead of dissipating it, the converter efficiency improves by 5–15% depending on the load and switching frequency.

4.7. PROPOSED SYSTEM ADVANTAGES

- Handling large power
- Reduced ripple voltage and current
- Low Switching Losses
- Reduced spike voltages
- High efficiency

4.8. APPLICATIONS

- Speed control of DC motor.
- Battery charging.
- Battery operated Electric vehicle.
- SMPS.

CHAPTER-5

MATLAB AND SIMULATION RESULTS

5.1 GENERAL

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it. The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation, it is quite impossible to proceed further.

It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complementary to each other. However, computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe the simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

5.1.1 Introduction to MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include

1. Math and computation
2. Algorithm development
3. Data acquisition
4. Modeling, simulation, and prototyping
5. Data analysis, exploration, and visualization
6. Scientific and engineering graphics
7. Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation.

MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available to include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

5.1.2. The Role of Simulation in Design

Electrical power systems are combinations of electrical circuits and electro-mechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation.

Land-based power generation from hydroelectric, steam or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance objectives.

Sim Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Sim Power Systems uses the Simulink environment, allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and Sim Mechanics share a special Physical Modeling block and connection line interface.

5.1.3 Sim Power Systems Libraries

You can rapidly put Sim Power Systems to work. The libraries contain models of typical power equipment such as transformers, lines, machines, and power electronics. These models are proven ones coming from textbooks, and their validity is based on the experience of the Power Systems Testing and Simulation Laboratory of Hydro-Québec, a large North American utility located in Canada, and also on the experience of Ecole de Technologiesupérieure and Université Laval. The capabilities of Sim Power Systems for modeling a typical electrical system are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies.

The Sim Power Systems main library, power lib, organizes its blocks into libraries according to their behavior. The power lib library window displays the block library icons and names. Double-click a library icon to open the library and access the blocks. The main Sim Power Systems power lib library window also contains the powergui block that opens a graphical user interface for the steady-state analysis of electrical circuits.

5.2. SIMULATION RESULTS:

5.2.1 Open loop simulation results

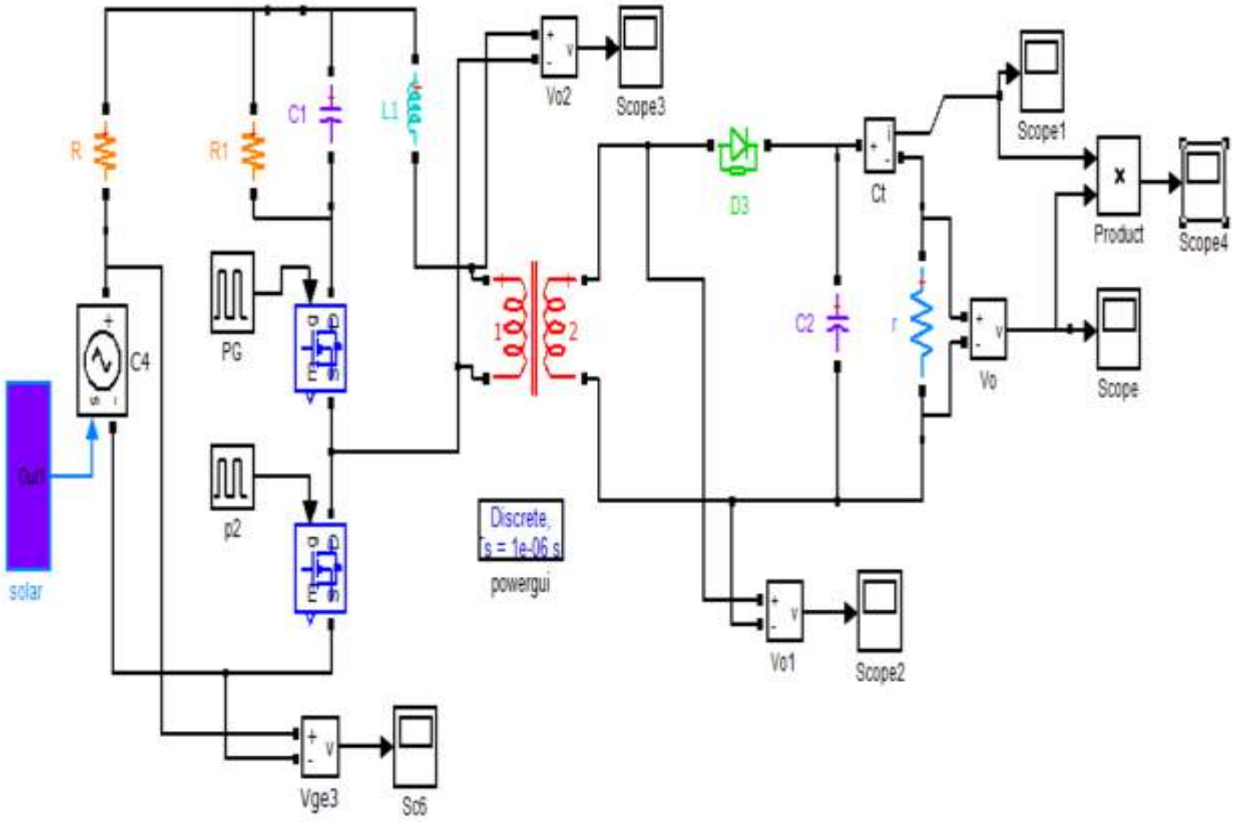

Fig.5.1. Circuit diagram of existing fly back converter

Circuit diagram of existing fly back converter with C-filter system is shown in Fig-5.1. Input voltage is shown in Fig-5.2 and its value is 15V. Switching pulse for fly back converter S1, S2 is shown in Fig-5.3 and its value is 1V respectively.

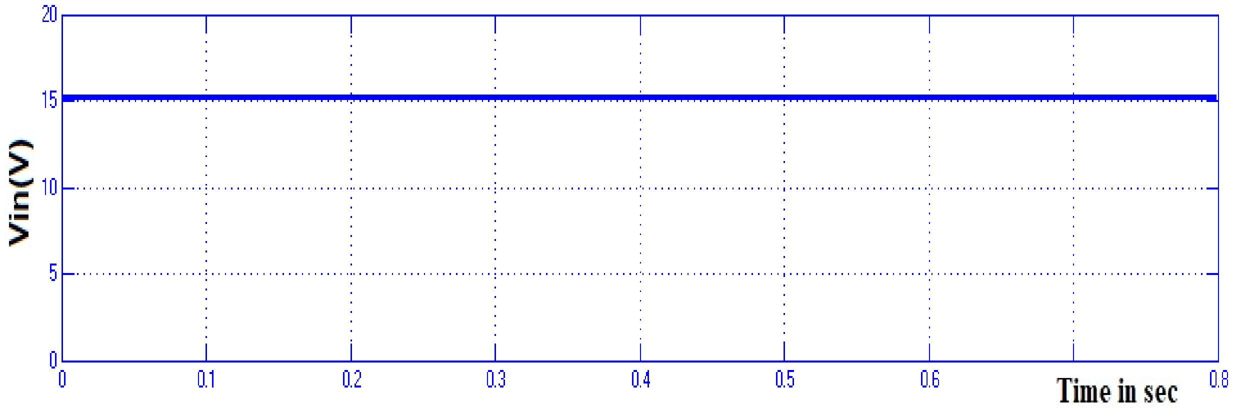

Fig.5.2. Input voltage

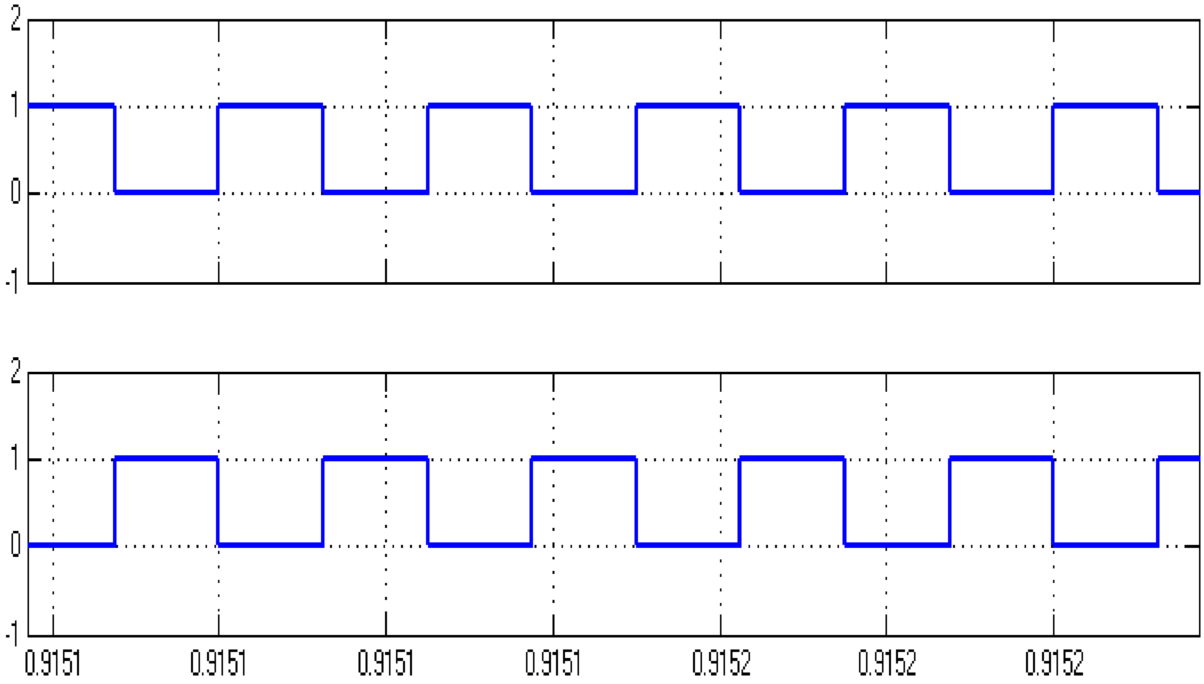

Fig.5.3. Switching pulse for fly back converter S1, S2

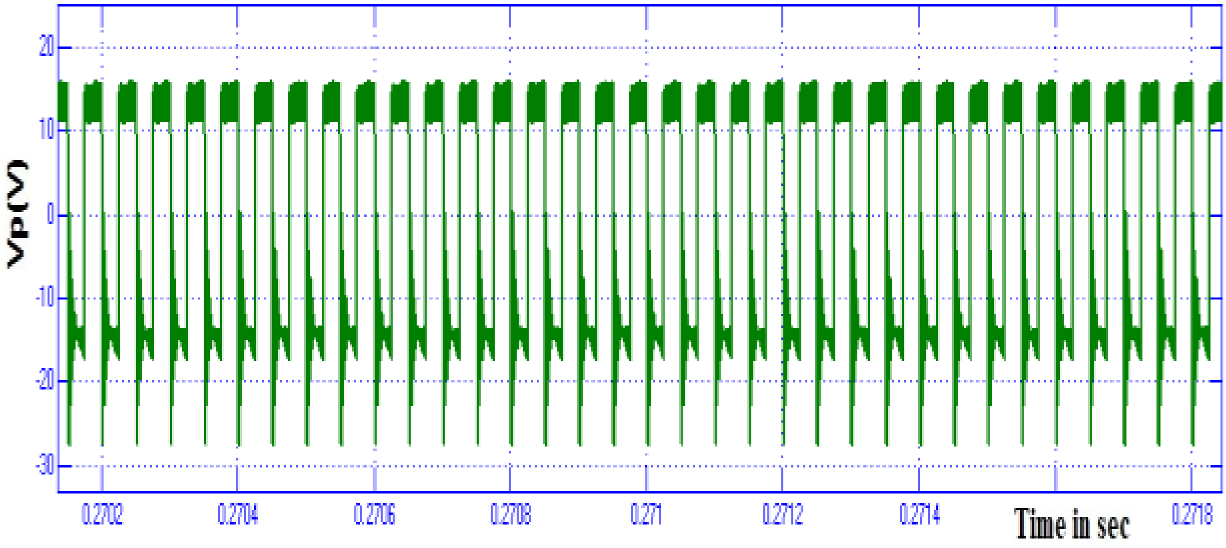

Fig.5.4. Transformer primary voltage

Transformer primary voltage is shown in Fig-5.4 and its value is 15V. Transformer secondary voltage is shown in Fig-5.5 and its value is 56V. Output voltage across R-load is shown in Fig-5.6 and its value is 56V. Output voltage Ripple across R-load is shown in Fig-3.7 and its value is 1.6V.

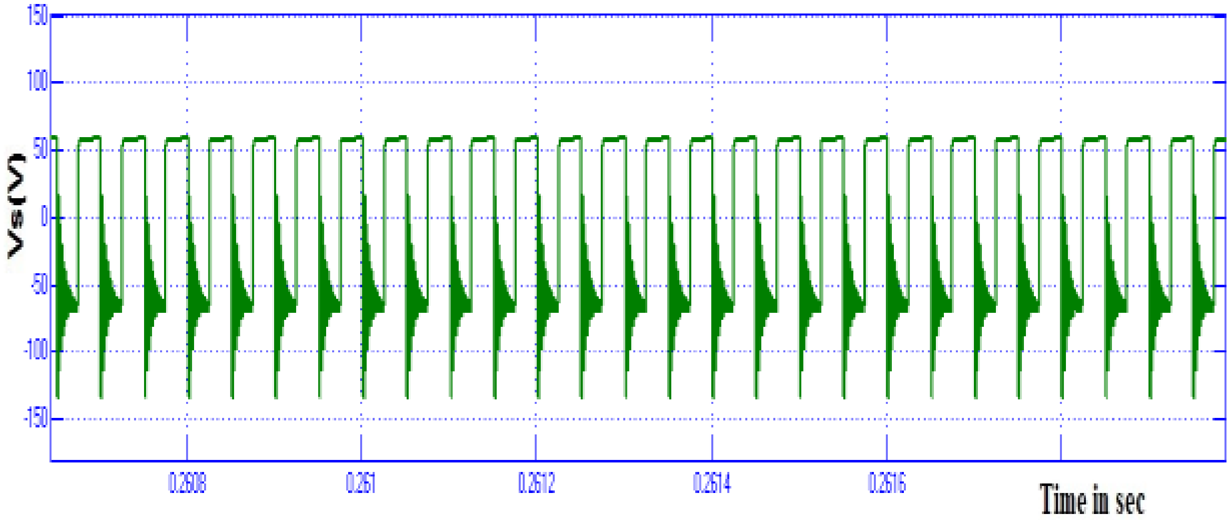

Fig.5.5. Transformer secondary voltage

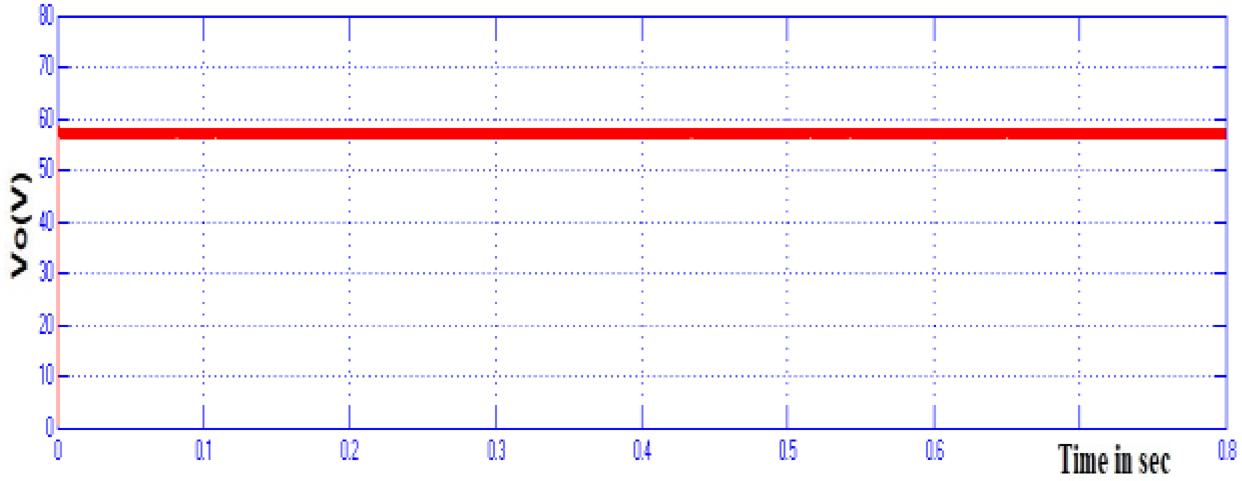

Fig.5.6. Output voltage across R-load

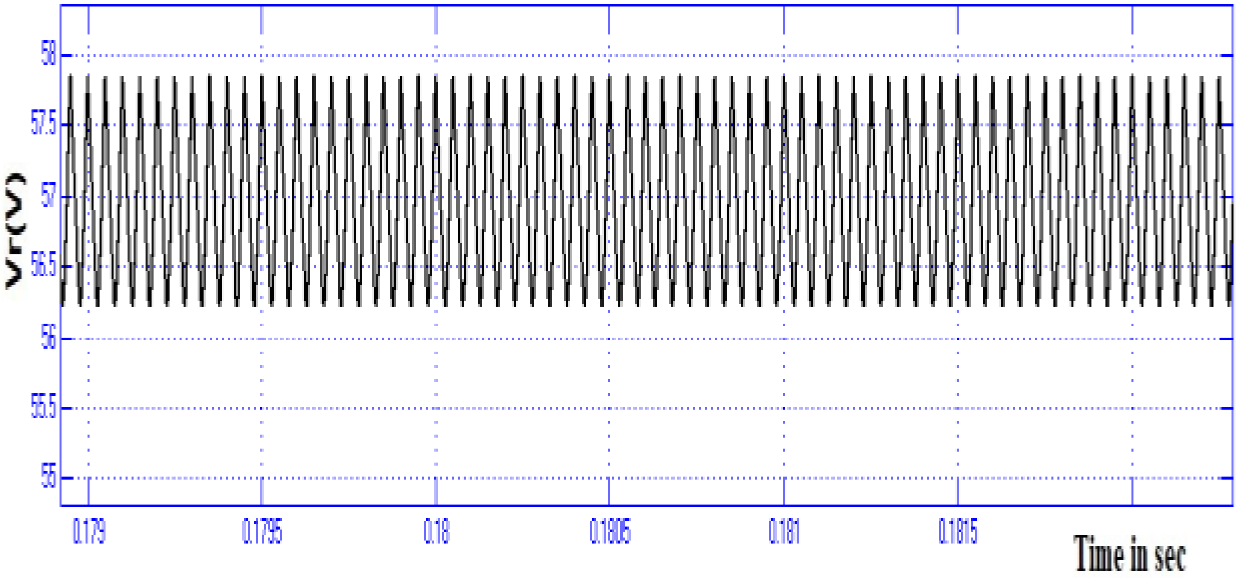

Fig.5.7. Output voltage Ripple across R-load

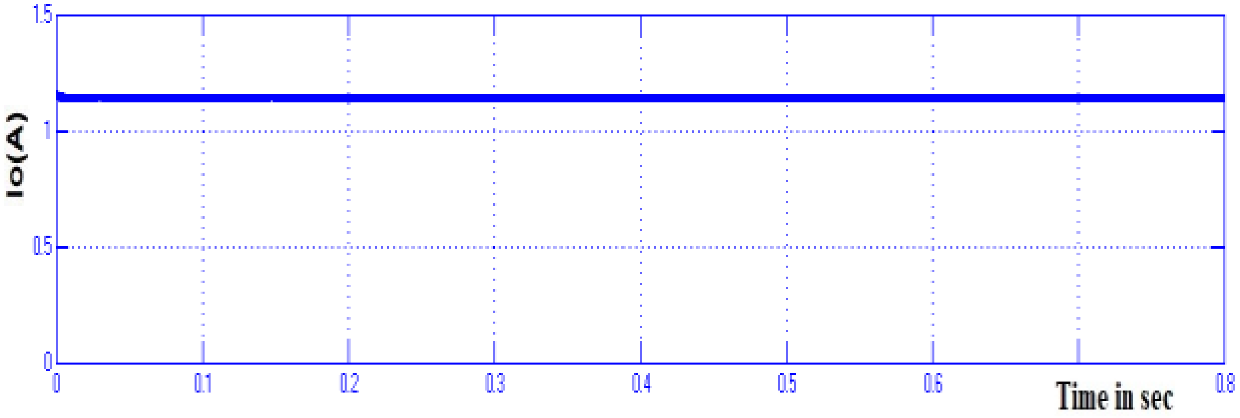

Fig.5.8. Output current through R-load

Output current through R-load is shown in Fig-5.8 and its value is 1.14A. Output power is shown in Fig-5.9 and its value is 65W. Output power ripple is shown in Fig-5.10 and its value is 4W.

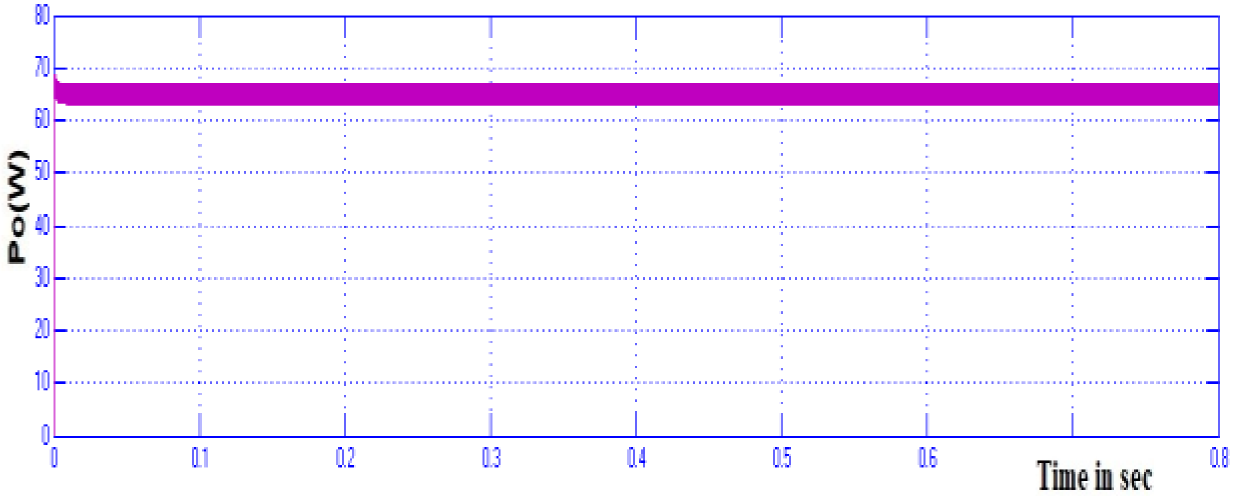

Fig.5.9. Output power

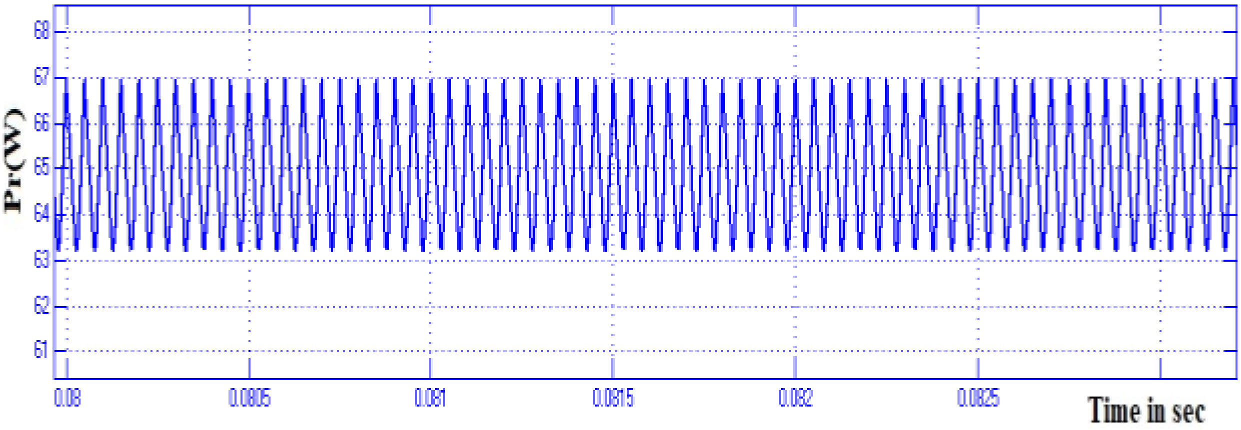

Fig.5.10. Output power ripple

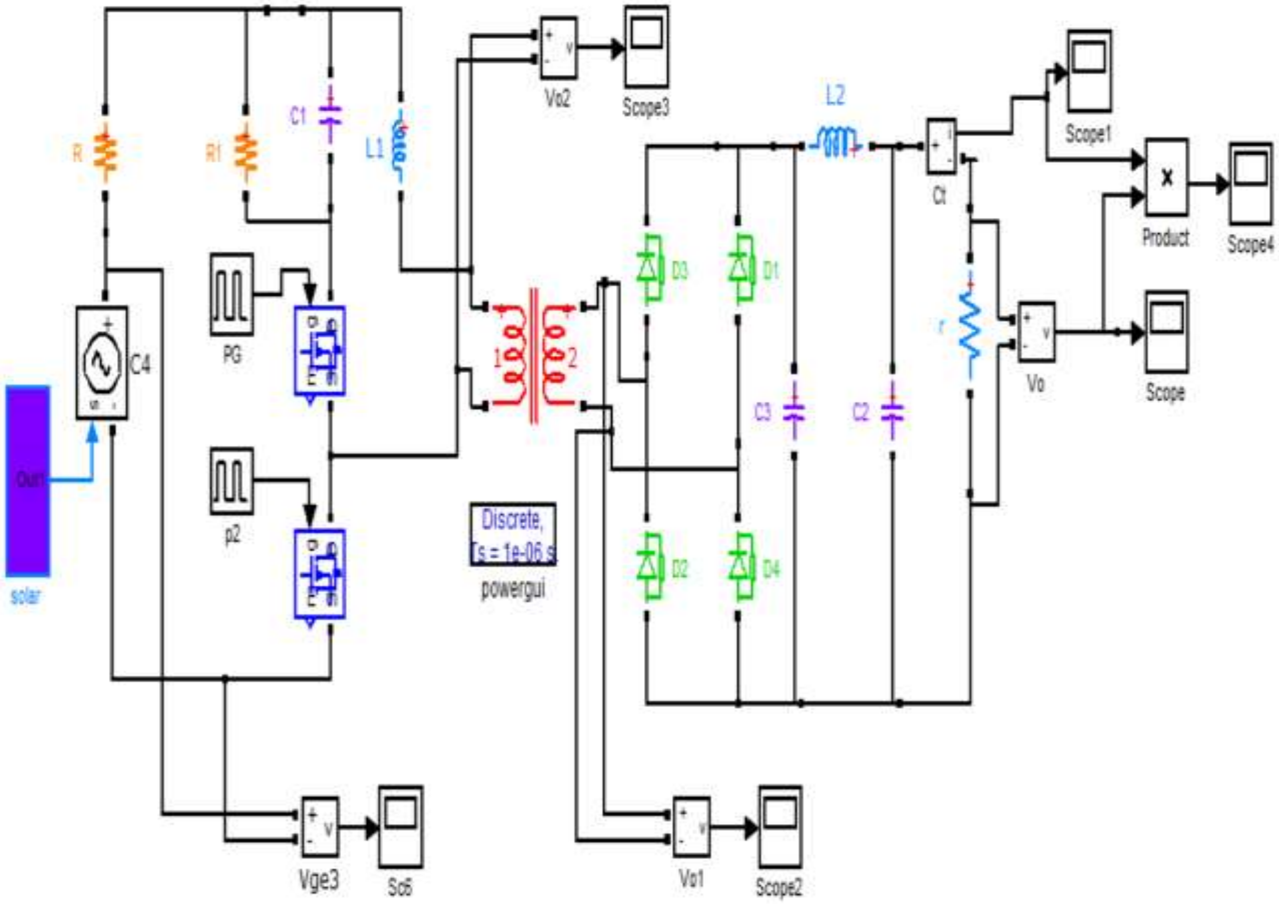

Fig.5.11. Circuit diagram of proposed fly back converter

Circuit diagram of proposed fly back converter with Π-filter system is shown in fig-5.11. Input voltage is shown in fig-5.12 and its value is 15V. Switching pulse for fly back converter S1, S2 is shown in fig-5.13 and its value is 1V respectively.

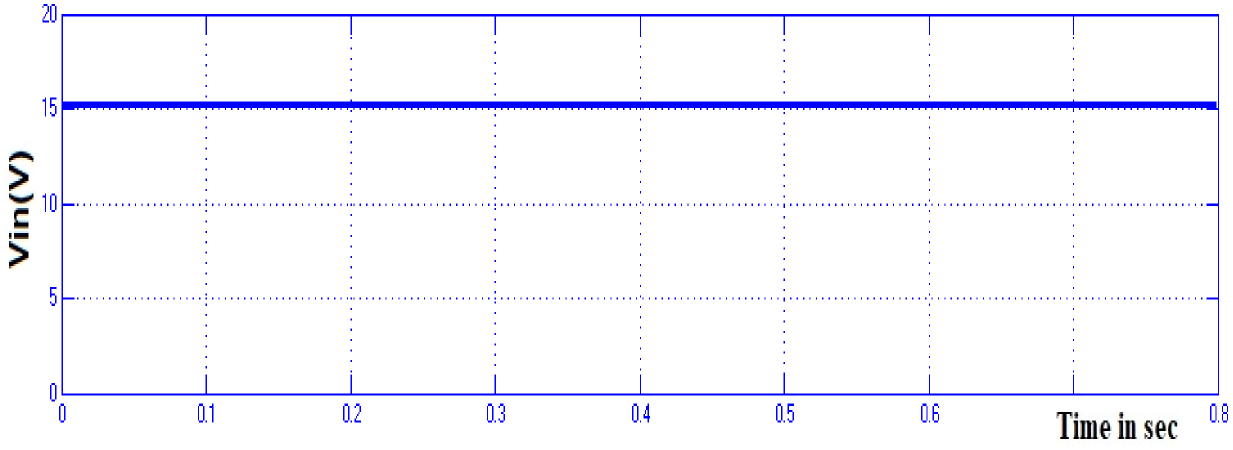

Fig.5.12. Input voltage

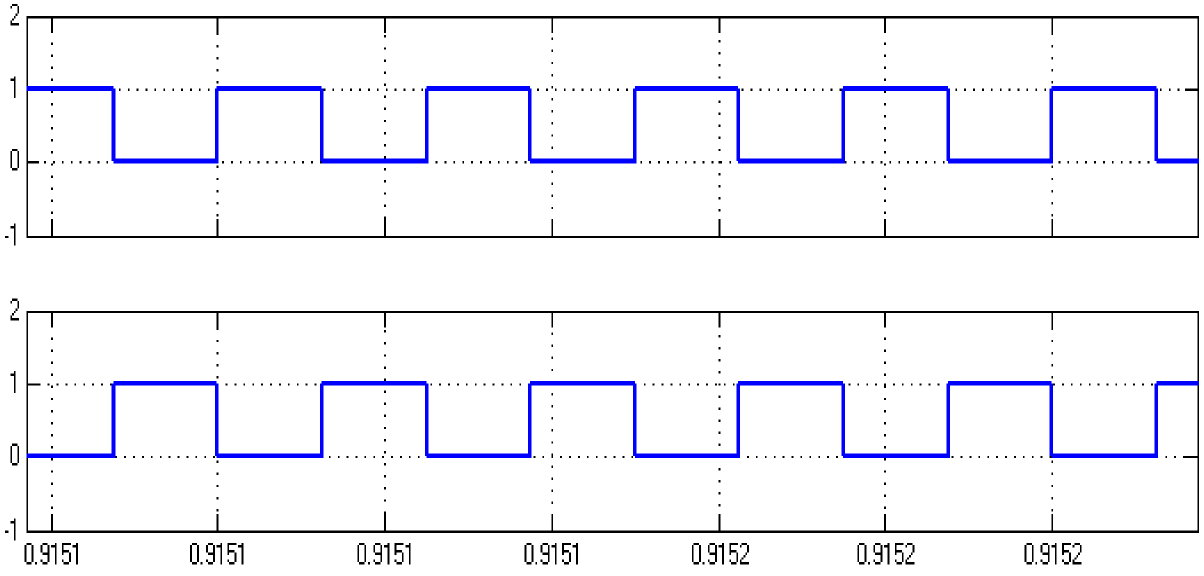

Fig.5.13. Switching pulse for fly back converter S1, S2

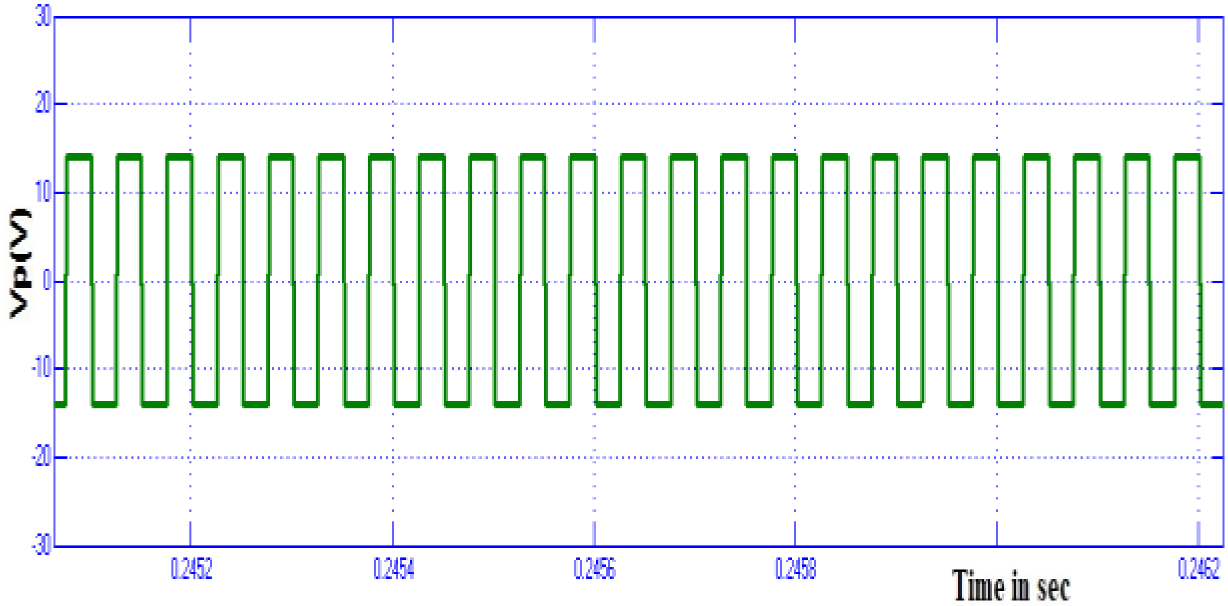

Fig.5.14. Transformer primary voltage

Transformer primary voltage is shown in fig-5.14 and its value is 15V. Transformer secondary voltage is shownin fig-5.15 and its value is 60V. Output voltage across R-load is shown in fig-5.16 and its value is 60V. Output voltage Ripple across R-load is shown in fig-5.17 and its value is 0.8V.

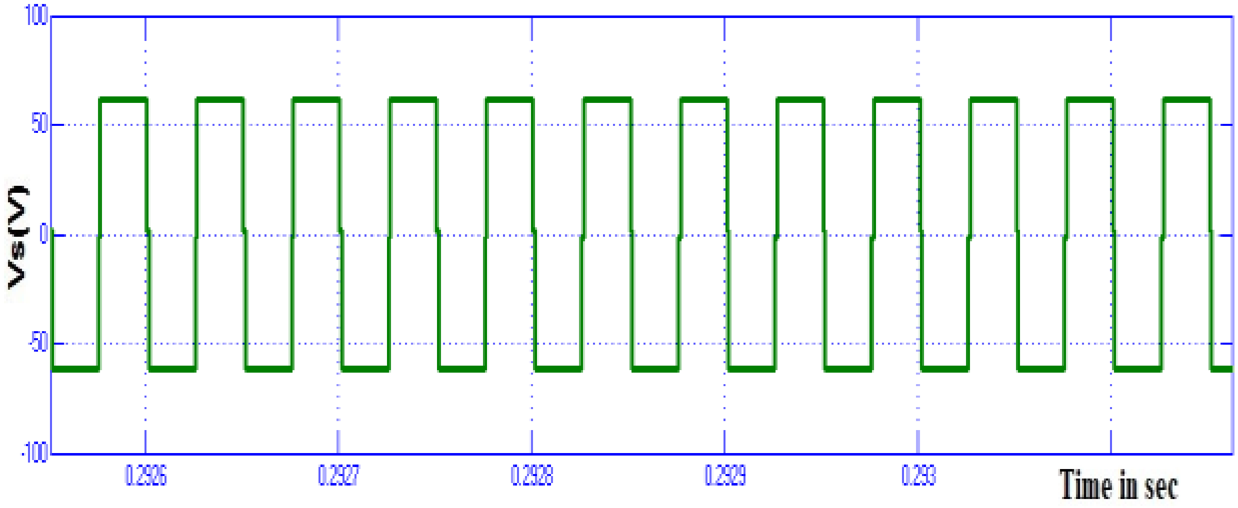

Fig.5.15. Transformer secondary voltage

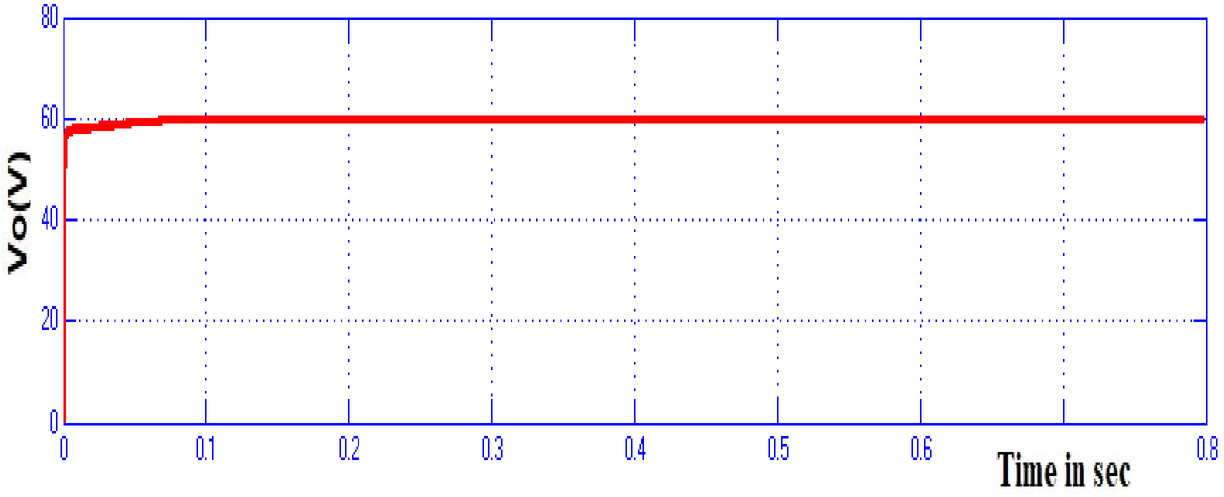

Fig.5.16. Output voltage across R-load

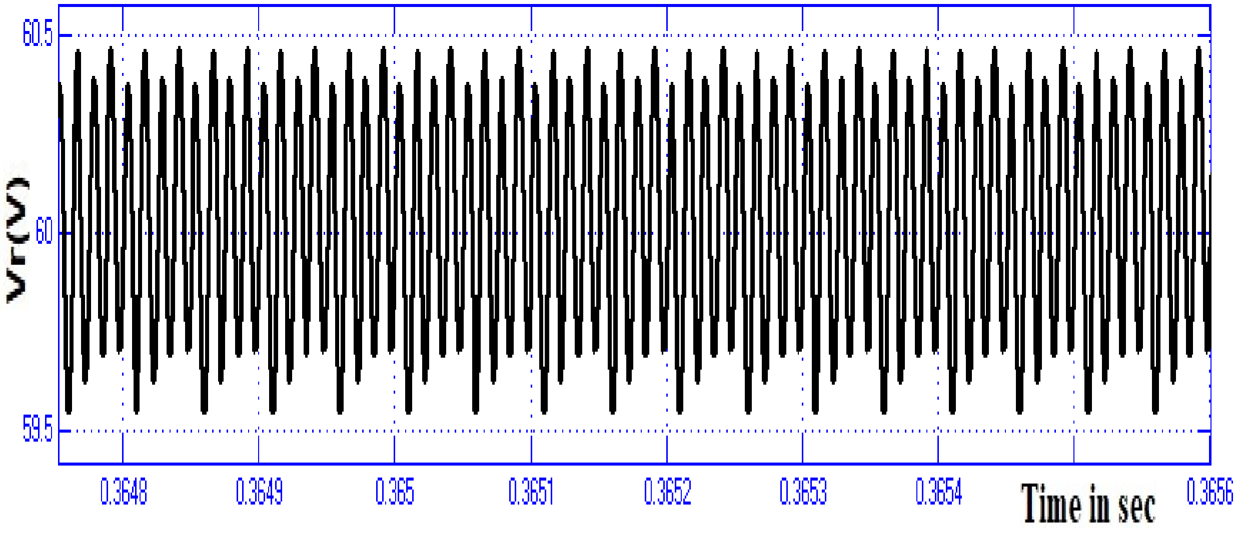

Fig.5.17. Output voltage Ripple across R-load

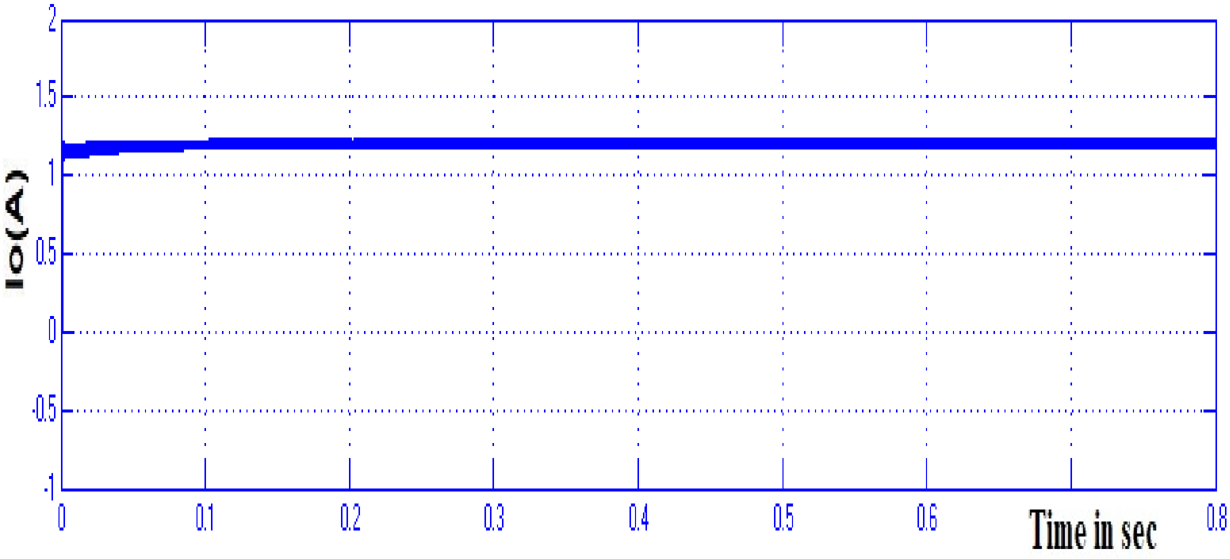

Fig.5.18. Output current through R-load

Output current through R-load is shown in fig-5.18 and its value is 1.21A. Output power is shown in fig-5.19 and its value is 72W. Output power ripple is shownin fig-5.20 and its value is 2W.

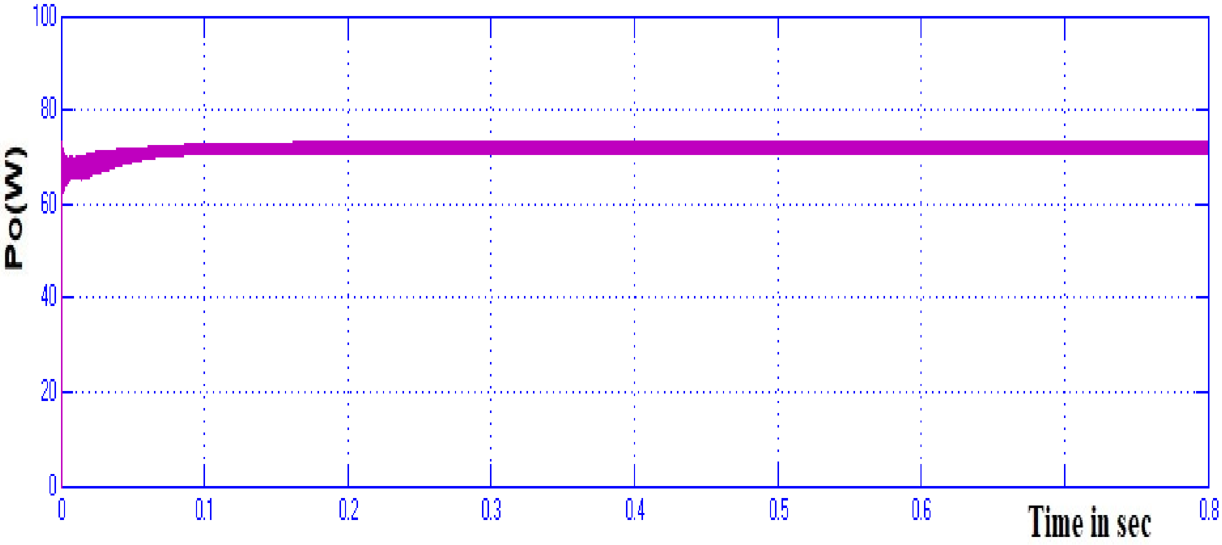

Fig.5.19. Output power

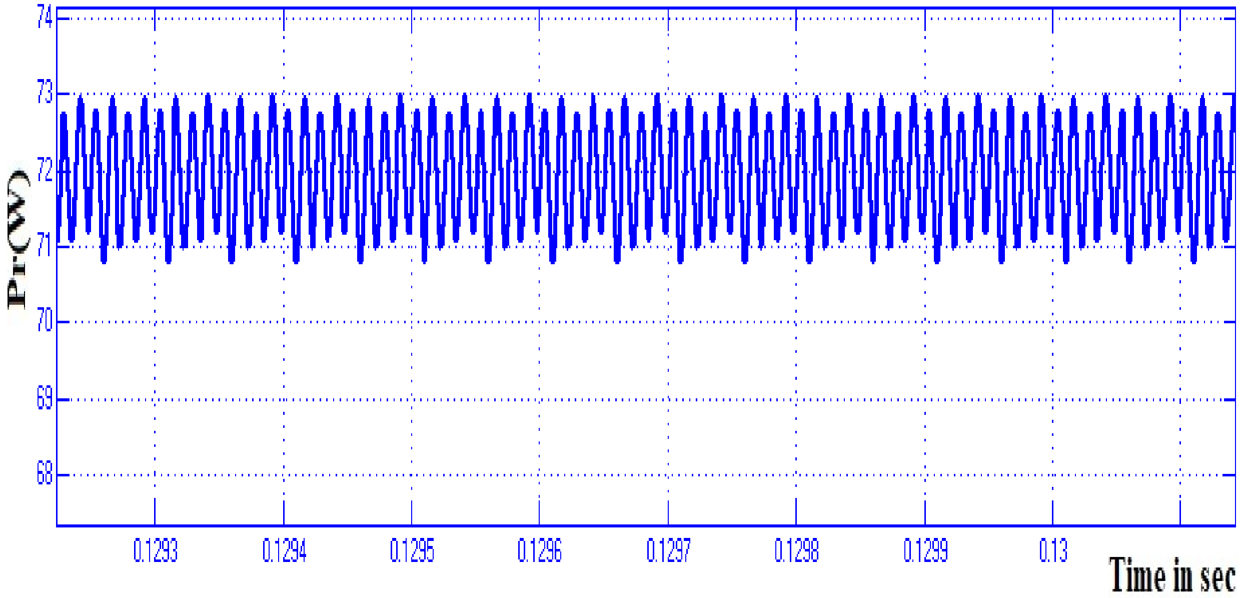

Fig.5.20. Output power ripple

Table-5.1 Comparison of output voltage, ripple voltage, output power and output power ripple

Fly back converter	**Vin(V)**	**Vo(V)**	**Vr(V)**	**Po(W)**	**Pr(W)**
Existing flyback converter	15	56	1.6	65	4
Proposed flyback converter	15	60	0.8	72	2

In table-5.1gives the Comparison of output voltage, ripple voltage, output power and output power ripple for existing and proposed fly back converter. Bar chart Comparison of output voltage and output power for existing and proposed fly back converter is shown in fig-5.21. Bar chart Comparison of output ripple voltage and output power ripple for existing and proposed fly back converter is shown in fig-5.22.

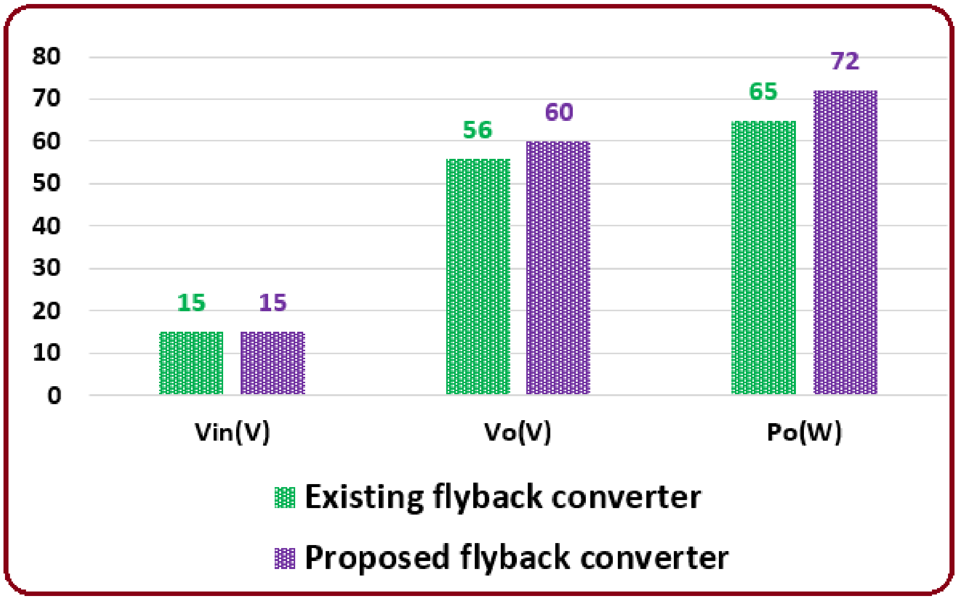

Fig. 5.21. Bar chart Comparison of output voltage and output power

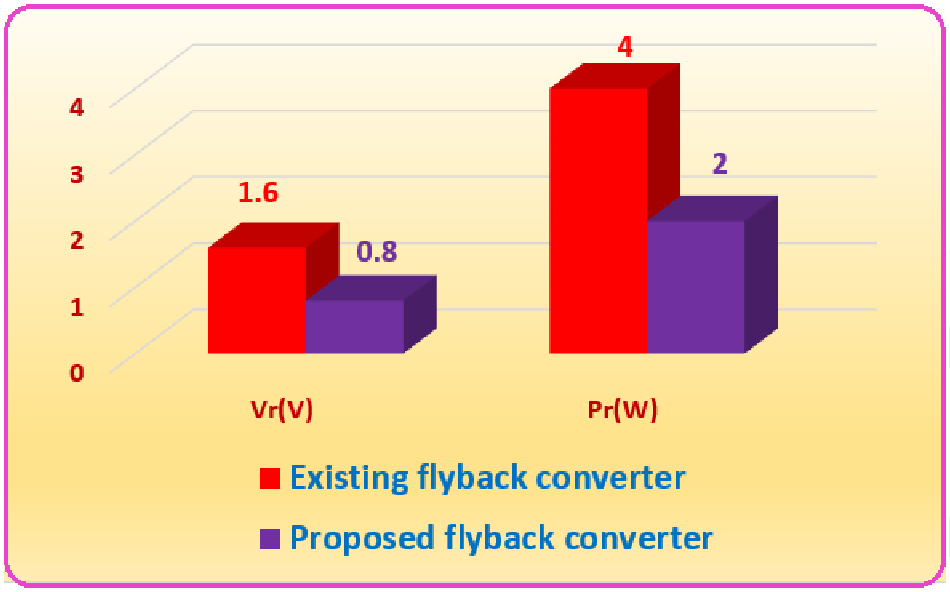

Fig. 5.22. Bar chart Comparison of output ripple voltage and output power ripple

By using Proposed Fly back Converter system, The Output voltage across R-load is improved from 56V to 60 V; The Output power is improved from 65 W to 72W; The Output voltage Ripple across R-load is reduced from 1.6V to 0.8 V; The Output power ripple is reduced from 4W to 2W.

Hence the Proposed flyback Converter system has better performance than conventional flyback Converter system.

5.2.2 Closed loop simulation results

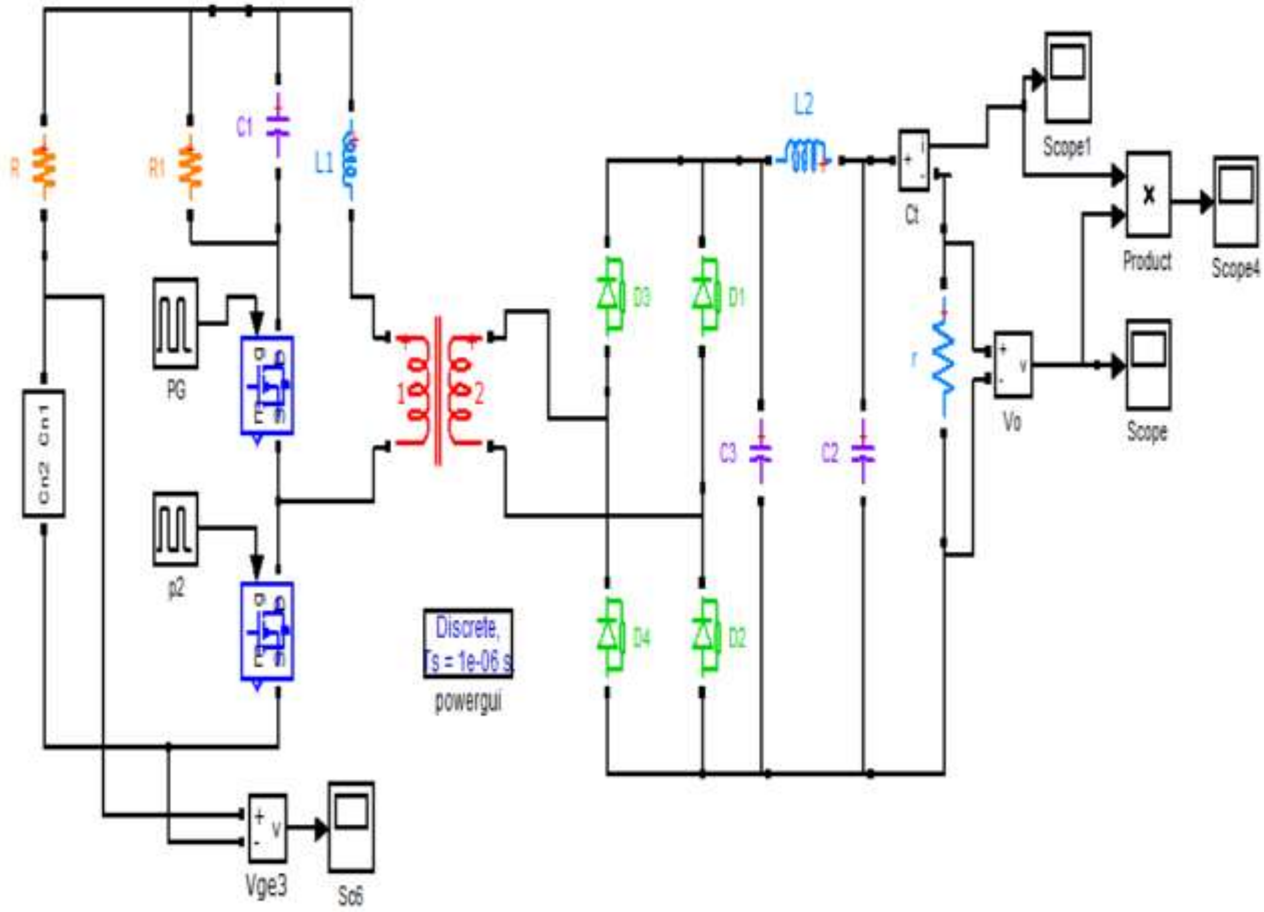

Fig.5.23. Circuit diagram of fly back converter with disturbance system

Circuit diagram of proposed fly back converter with disturbance system is shown in Fig 5.23. Input voltage is shown in Fig-5.24 and its value is 20V. Output voltage across R-load is shown in Fig-5.25 and its value is 80V. Output current through R-load is shown in Fig-5.26 and its value is 1.62A. Output power is shown in Fig-5.27 and its value is 142W.

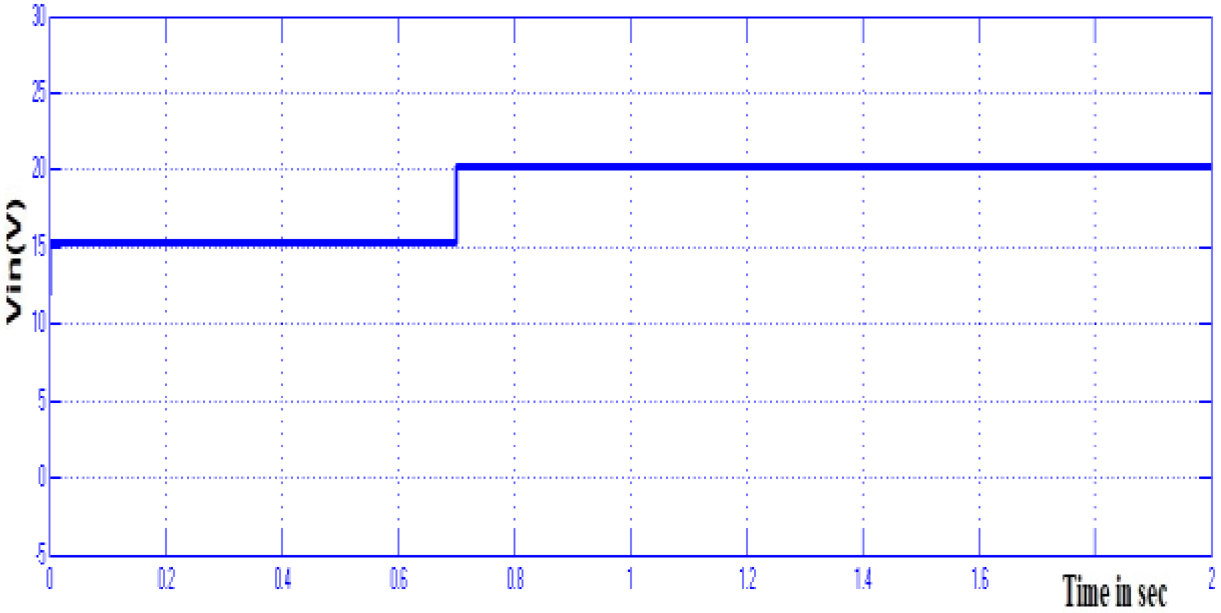

Fig.5.24. Input voltage

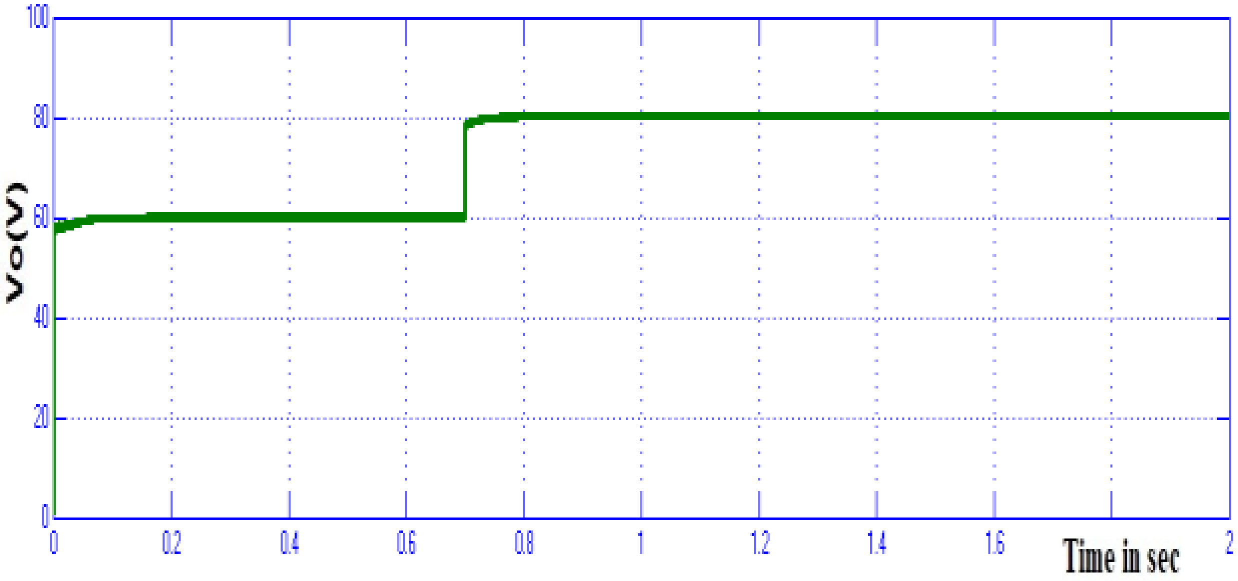

Fig.5.25. Output voltage across R-load

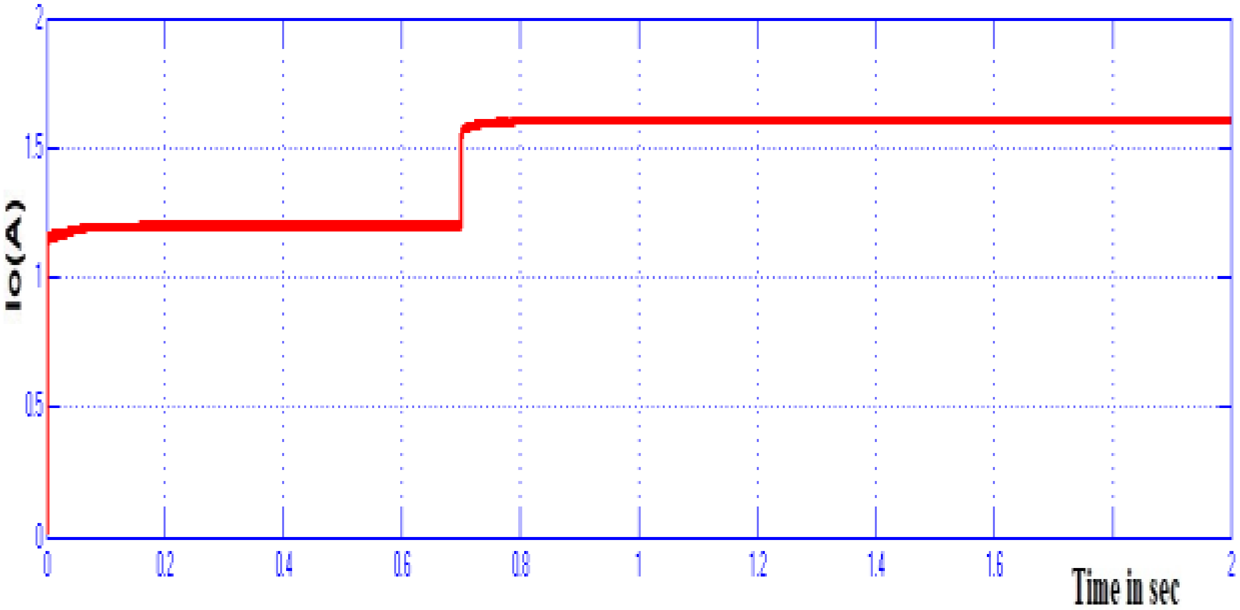

Fig.5.26. Output current through R- load

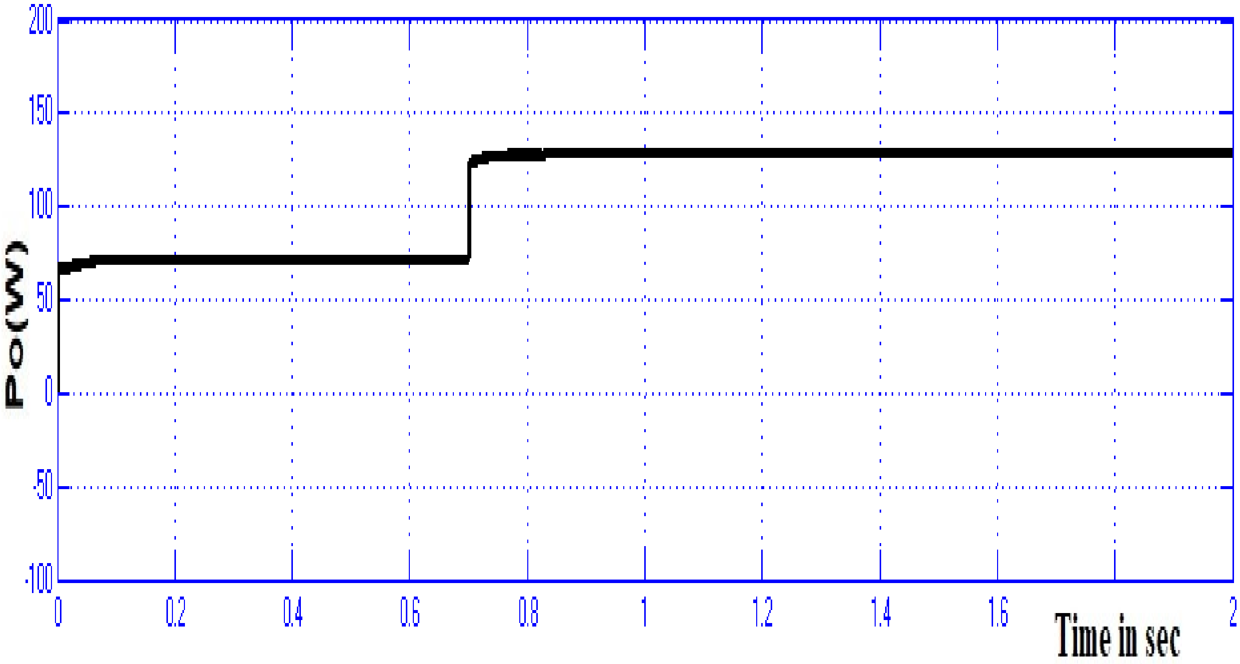

Fig.5.27.

Output power

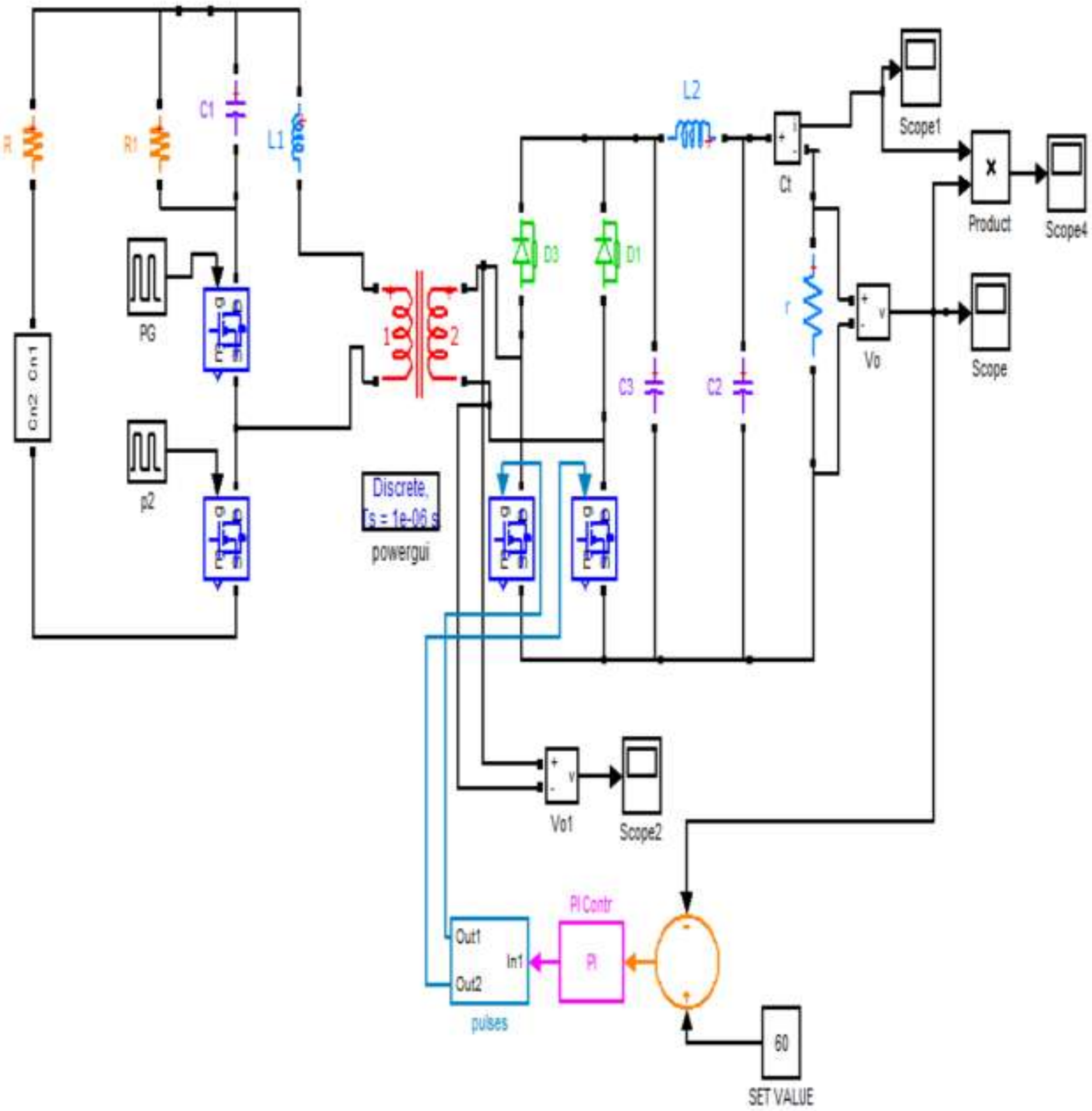

Fig.5.28. Circuit diagram of fly back converter with closed loop PI controller

Circuit diagram of proposed fly back converter with closed loop PI controller system is shown in Fig 5.28. Input voltage is shown in Fig-5.29 and its value is 20V. Output voltage across R-load is shown in Fig-3.30 and its value is 60V. Output current through R-load is shown in Fig-5.31 and its value is 1.24A. Output power is shown in Fig-5.32 and its value is 72W.

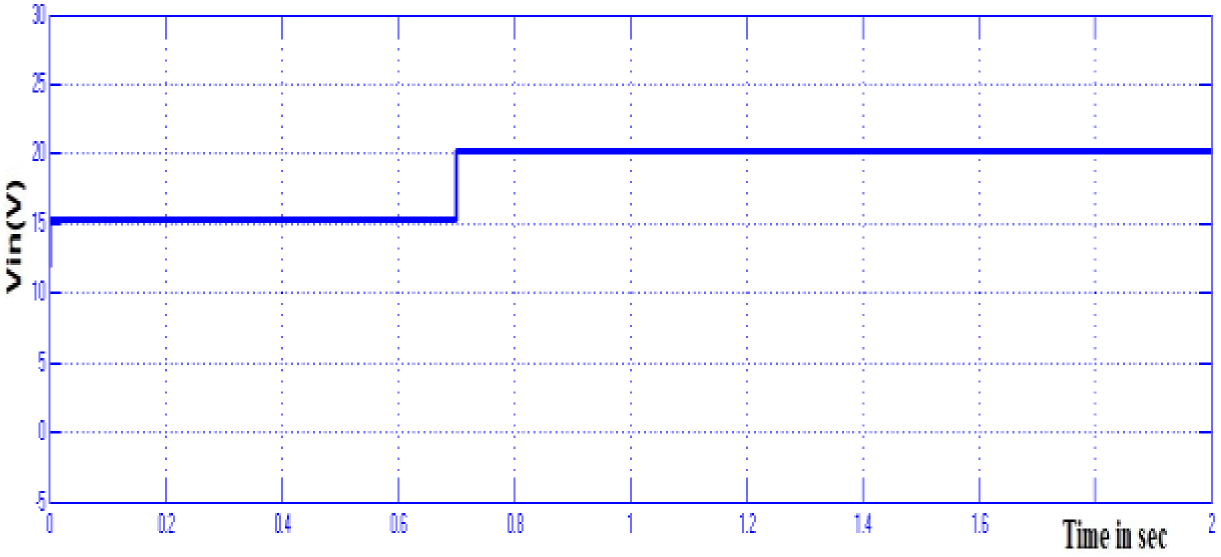

Fig.5.29. Input voltage

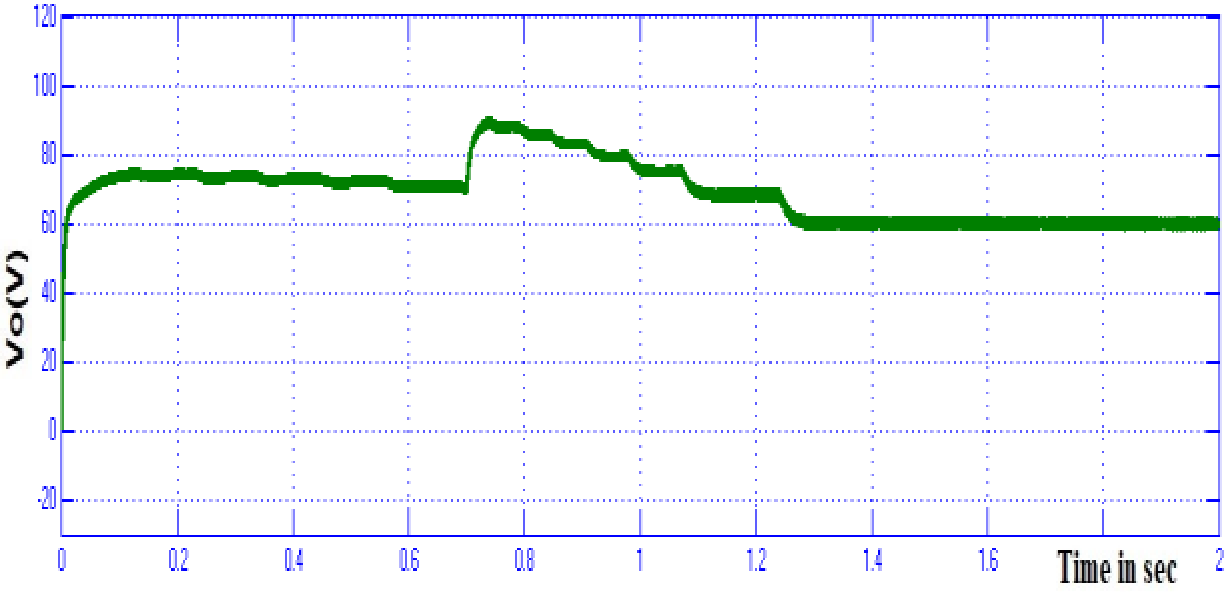

Fig.5.30. Output voltage across R-load

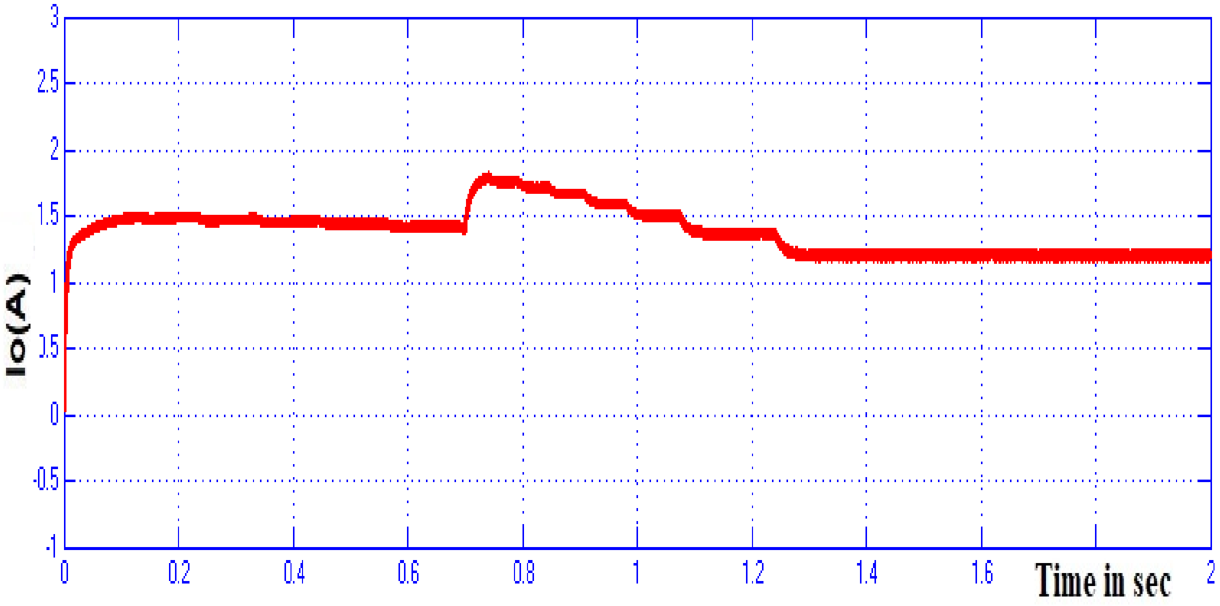

Fig.5.31. Output current through R-load

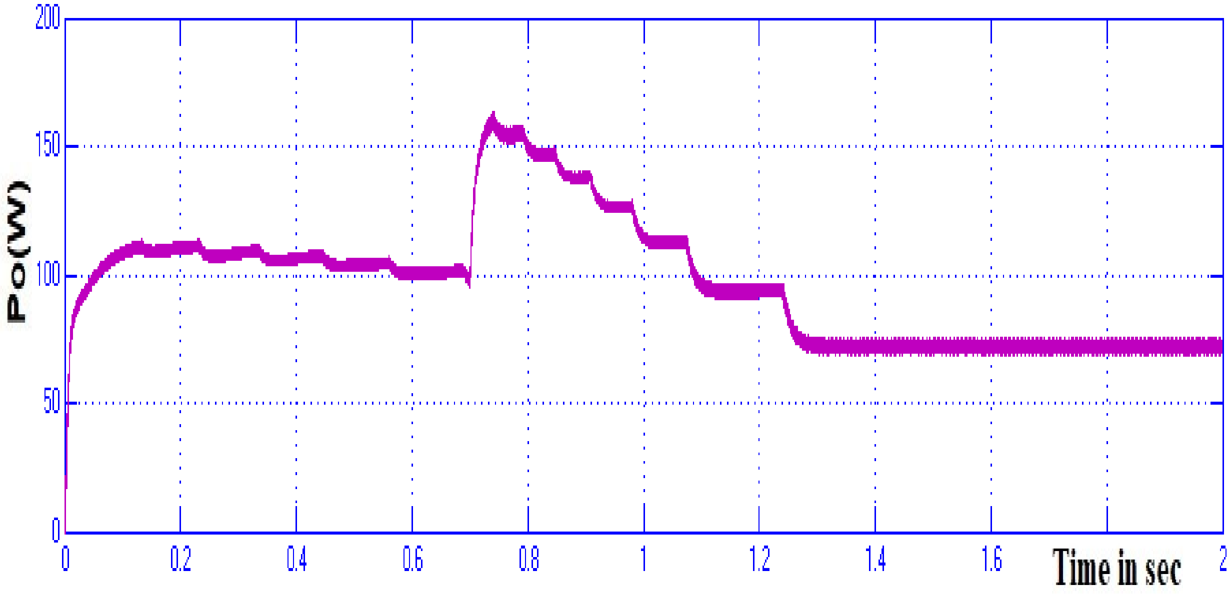

Fig.5.32.

Output power

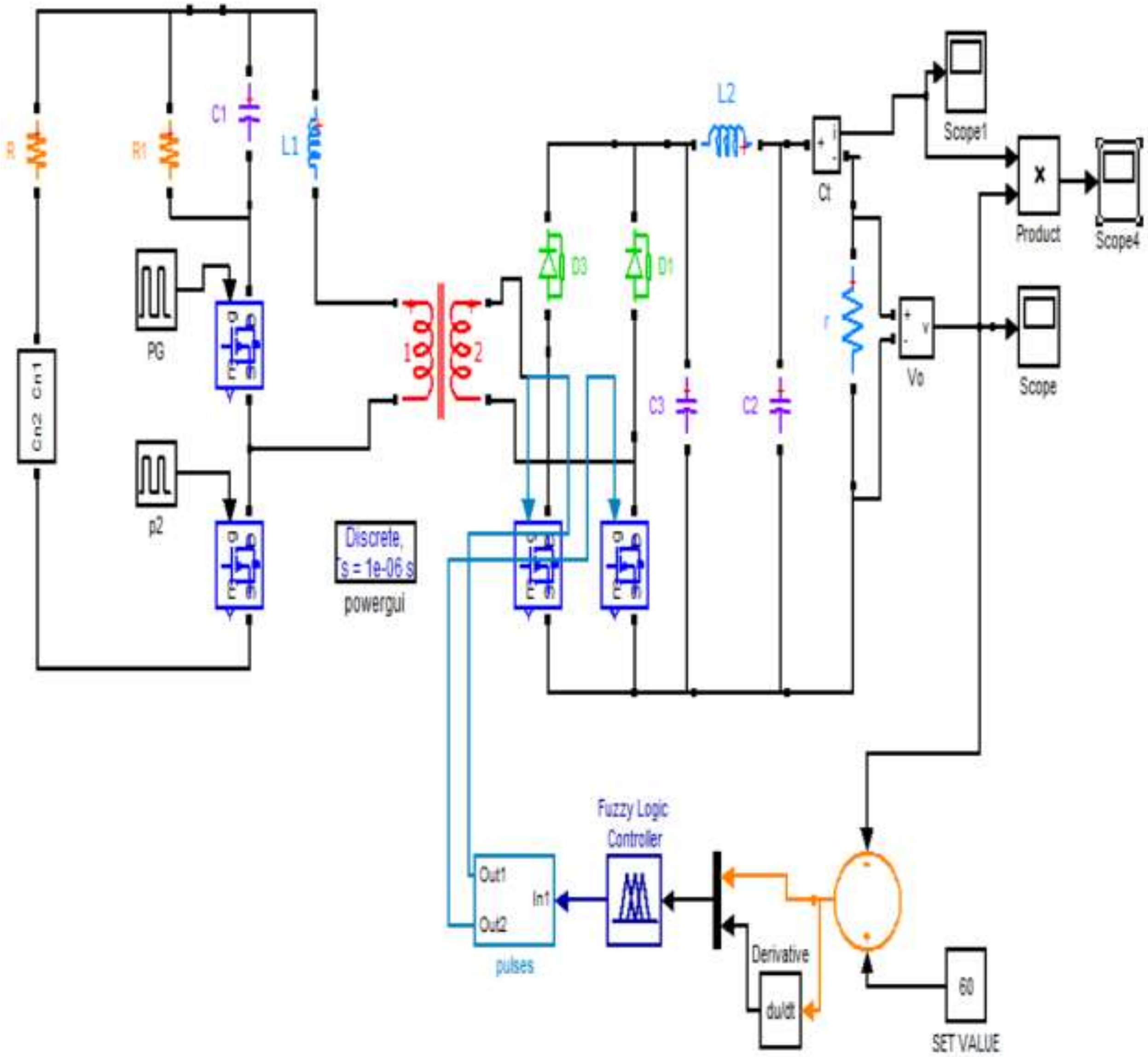

Fig.5.33. Circuit diagram of fly back converter with closed loop fuzzy logic controller

Circuit diagram of proposed fly back converter with closed loop Fuzzy Logic controller system is shown in Fig 5.33. Input voltage is shownin Fig-5.34 and its value is 20V. Output voltage across R-load is shown in Fig-5.35 and its value is 60V. Output current through R-load is shown in Fig-5.36 and its value is 1.24A. Output power is shown in Fig-5.37 and its value is 72W.

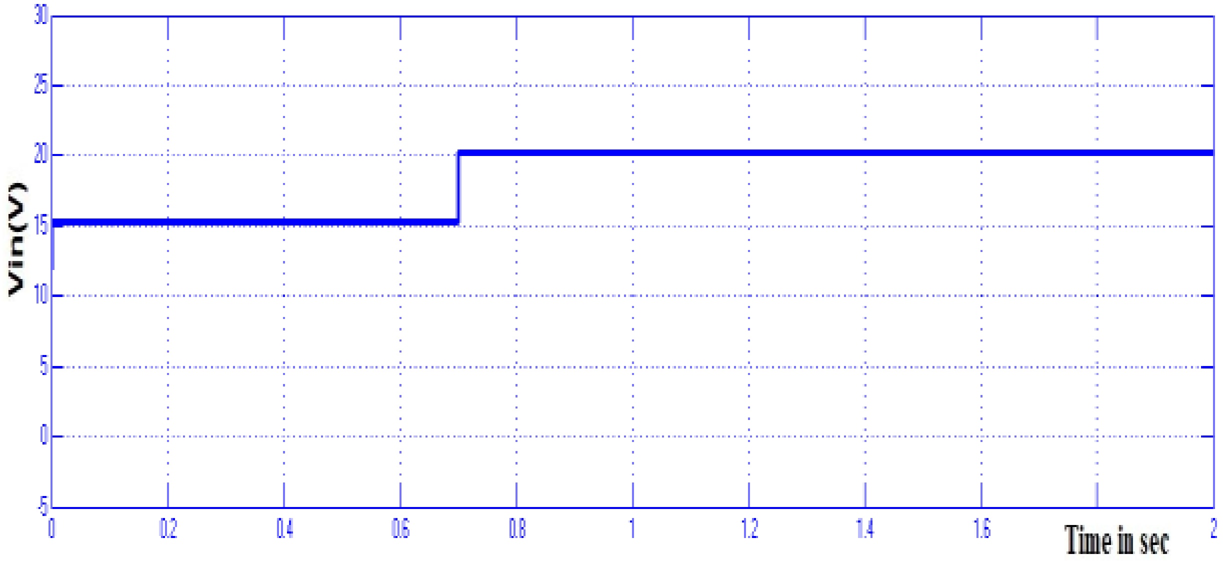

Fig.5.34. Input voltage

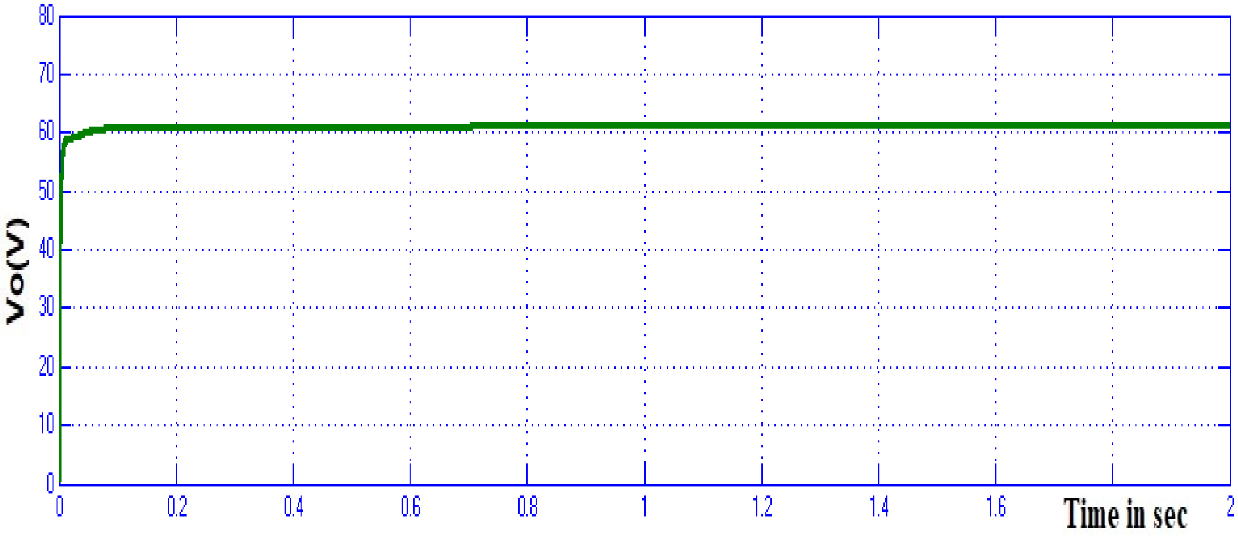

Fig.5.35. Output voltage across R-load

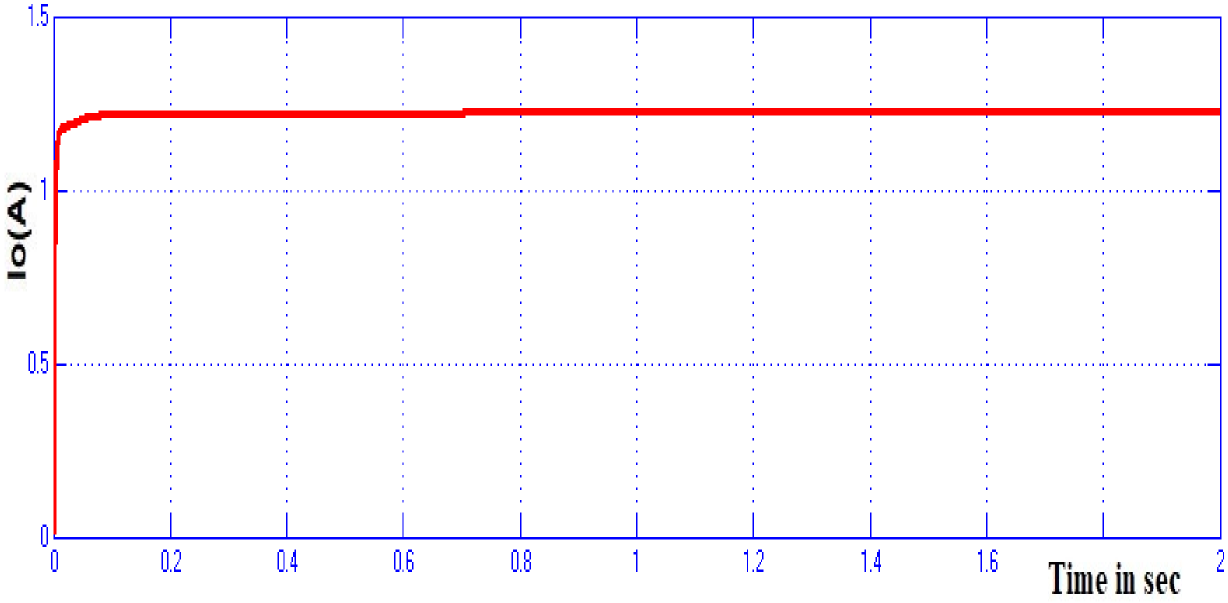

Fig.5.36. Output current through R-load

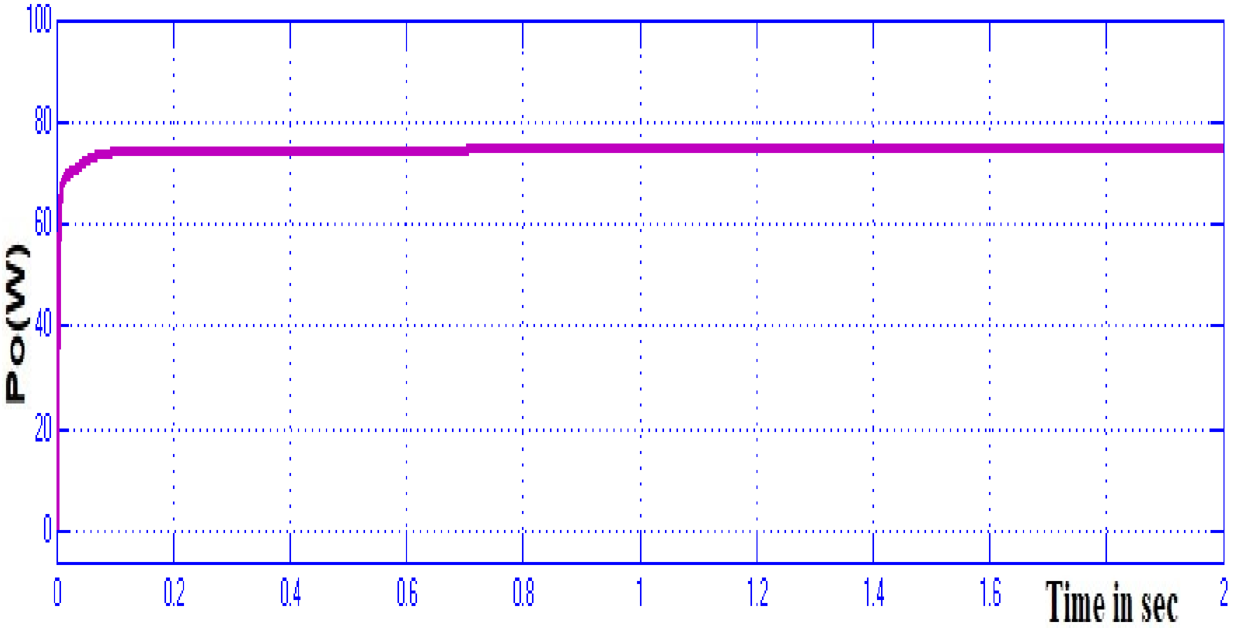

Fig.5.37. Output power

Table -5.2 Comparison of Time Domain Parameters

Types of controller	Tr	Tp	Ts	Ess
PI	**0.74**	**0.76**	**1.28**	**1.56**
FLC	**0.12**	**0.13**	**0.15**	**0.23**

In Table-5.2 gives the Comparison of time domain parameters for closed loop PI and Fuzzy Logic controlled proposed fly back converter system. Bar chart Comparison of time domain parameters for closed loop PI and Fuzzy Logic controlled proposed fly back converter system is shown in Fig-5.38.

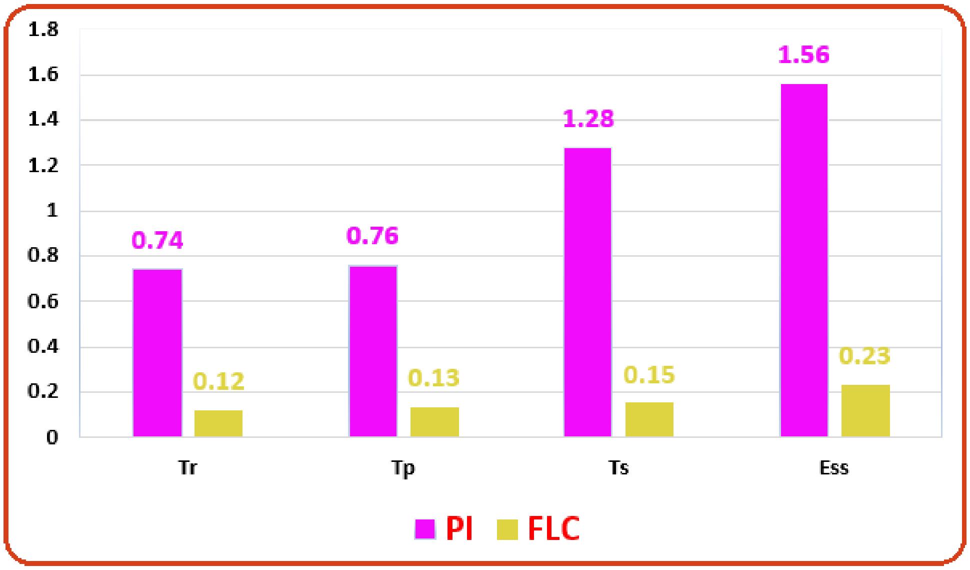

Fig.5.38. Bar chart Comparison of time domain parameters

By using Proposed flyback Converter with closed loop Fuzzy logic controller, The Rise time is reduced from 0.74 s to 0.12 s; The Peak time is reduced from 0.76s to 0.13 s; The settling time is reduced from 1.28s to 0.15 s; The steady state error is reduced from 1.56 V to 0.23 V.

Hence the outcomes show the closed loop Fuzzy Logic controller is superior to closed loop PI controller of existing flyback Converter system.

CHAPTER-6

CONCLUSION

Existing Circuit Diagram of Flyback Converter Based Half-Bridge Rectifier with C-filter system is simulated. Proposed Circuit Diagram of Flyback Converter Based Full-bridge Rectifier with Π-filter System is simulated. Above systems are compared. By using Flyback Converter Based Full-bridge Rectifier with Π-filter System; Output voltage is improved from 56 V to 60 V;

Output current is improved from 1.14 A to 1.21 A; Output Power is improved from 65 W to 72 W; Output ripple voltage is condensed from 1.6 V to 0.8 V; Output ripple Power is condensed from 4 W to 2 W. Hence the Flyback Converter Based Full-bridge Rectifier with Π-filter system has better performance than conventional Flyback Converter Based Half-Bridge Rectifier with C-filter system. Circuit diagram of fly back converter with source disturbance system is simulated. Circuit diagram fly back converter with closed loop PI controller system is simulated. Circuit diagram of fly back converter with closed loop Fuzzy Logic controller system is simulated. Time domain parameters are compared with PI and Fuzzy Logic controllers. By using fly back converter with closed loop Fuzzy Logic controller system, The Rise time is reduced from 0.74 s to 0.12 s; The Peak time is reduced from 0.76 s to 0.13 s; The settling time is reduced from 1.28 s to 0.15 s; The steady state error is reduced from 1.56 V to 0.23 V. Hence the outcomes show the fly back converter with closed loop Fuzzy Logic controller is advanced than closed loop PI controller system.

CHAPTER-7

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