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Comparative Analysis of Hybrid Converter with Different Controllers

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Abstract— *A hybrid converter that provides both AC (alternating current) and DC (direct current) outputs can be designed using a combination of power electronics components. This type of converter is often used in various applications where both AC and DC power are required, such as in renewable energy systems, uninterruptible power supplies (UPS), and hybrid electric vehicles. The transient response of the hybrid converter is compared with the different types of controllers like FOPID controller and Fuzzy logic controller. The simulation results of the standard and modified systems are compared. The converter has beneficial cross-regulation properties in response to dynamic load modifications. Simulink is implemented to model the closed loop FOPID and fuzzy logic controlled systems. The voltage regulation observations are compared to those of the both open loop and closed loop system in terms of time behavior. The hardware system is built using the PIC 16F84A microprocessor. The experimental outcomes are obtained after evaluating this model in the laboratory. The experimental and simulation observations are tabulated and the results are presented.*

Keywords: Fuzzy Logic Controller(FLC), Fractional Order Proportional Integral Derivative Controller(FOPID), Hybrid Converter, PIC 16F84A Microcontroller.

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I. INTRODUCTION

A cutting-edge solution in the field of power electronics is the Boost-Derived Hybrid Converter for AC and DC loads, which is the outcome of combining boosting algorithms with hybrid converters. This innovative converter shows possibilities as a beneficial development in the perpetually growing market for flexible and efficient power management systems. The following paper offers a thorough investigation of the Boost-Derived Hybrid Converter, describing its justification, essential constituents, architecture, and possible benefits. Through the smooth integration of boosting algorithms with hybrid converter technology, this methodology seeks to maximize power delivery, responding to the complementary needs of both AC and DC loads in different kinds of applications.

The following overview establishes the framework for a detailed analysis of the Fuzzy Logic Controlled Hybrid Converter with Boost, highlighting its mechanism, benefits, design concepts, and constructive application in a range of domains. The assistance of the capacity to optimize power distribution in smart grids and boost the efficiency of renewable energy systems, this hybrid converter has the potential that marked the beginning in the next phase of intelligent energy conversion. Enter the hybrid converter, a groundbreaking solution that blends the strengths of different conversion topologies to maximize efficiency and flexibility. This introduction explores the innovative application of fuzzy logic control in harnessing the full potential of hybrid converters, enabling robust and adaptive performance in dynamic environments

The Boost-Derived Hybrid Converter for AC and DC loads represents a significant advancement in power electronics, offering a novel approach by merging boosting algorithms with hybrid converter technology. This integration not only enhances power delivery but also addresses the diverse requirements of both AC and DC loads across various applications. By seamlessly combining boosting algorithms with hybrid converter technology, this innovative methodology promises to revolutionize power management systems, catering to the increasing demand for flexibility and efficiency in the market.

Furthermore, the Fuzzy Logic Controlled Hybrid Converter with Boost introduces a sophisticated control mechanism that optimizes power distribution with remarkable precision. Its adaptive and robust performance makes it particularly well-suited for dynamic environments, where traditional control methods may fall short. With its capacity to optimize power distribution in smart grids and enhance the efficiency of renewable energy systems, this hybrid converter is poised to usher in a new era of intelligent energy conversion.

This overview sets the stage for a comprehensive examination of the Boost-Derived Hybrid Converter and the Fuzzy Logic Controlled Hybrid Converter with Boost. Through detailed analysis, these converters' mechanisms, benefits, design concepts, and applications across various domains will be explored, shedding light on their potential to reshape the landscape of power electronics and energy management.

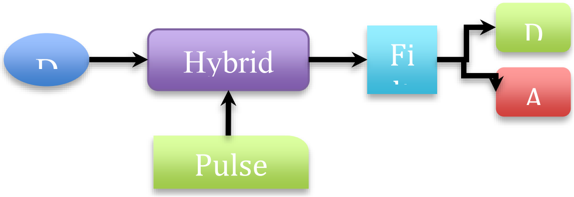


Fig 1. Block Diagram of Proposed hybrid Converter with Inverter System

II.HYBRID CONVERTER

To develop hybrid converter topologies, a voltage-source-inverter bridge network can be used in place of the controlled switch seen in single-switch boost converters. Because of the inverter stage's inherent shoot-through safety, the hybrid converters generate more reliable dc and ac outputs while consuming less switching power. Multiple output converters with higher processing density and dependability can be useful for systems with simultaneous dc and ac demands, such as nano grids in residential applications.

The paper analyzes the use of a single boost-stage architecture to provide hybrid loads. Conventional voltage sensing interrupters (VSIs) would be used in hybrid converters with dead time circuitry to stop shot through. Similarly, the inverter leg switches may be misgated, leading to switch damage, as a result of electromagnetic interference (EMI) or other invalid noise. This is more significant than the other type of noise. It operates in three separate modes: zero interval, power mode, and shoot-through mode.

2.1 Hybrid Converter - MODES OF OPERATION:

2.1.1 Interval I — ST interval:

The proposed converter's comparable design during the first interval is shown in Figure 2.1. Interval occurs when the switches on any one leg—Q1–Q4 or Q3–Q2—are turned on simultaneously [20]. The duration of the shoot-through (ST) interval (Dst) determines the Step-up converter duty cycle. The uncontrollably biased device "D" is inverted. The output current of the inverter is circulated by the switches in the bridge network. As a result, BDHC allows for more switching states than VSI expressly prohibits. In the ST interval, the current flow direction is displayed.

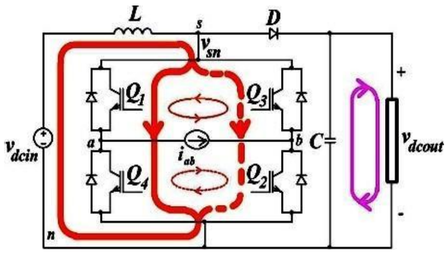


Fig 2.1.1 Equation for the BDHC circuit during the ST interval.

2.1.2 Interval II—Power interval:

During the power interval, inverter current enters or departs the bridge circuit at main node "s". The voltage of a switch and the voltage of a conducting diode are equal [21]. During this time, either Q1-Q2 or Q2-Q4 are enabled.

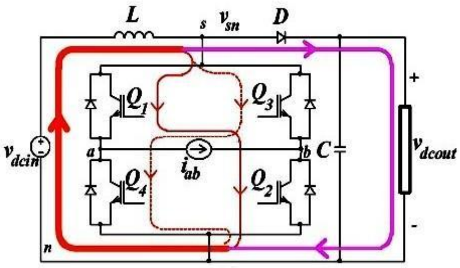


Fig 2.1.2 Equation directing circuits and currents BDHC in the course of the power cut

2.1.3 Interval III—Zero interval:

When the inverters on the bridge are operating, there will be a zero current interval. During this period, the diode "D" conducts. It shows which way the zero current interval is oriented.

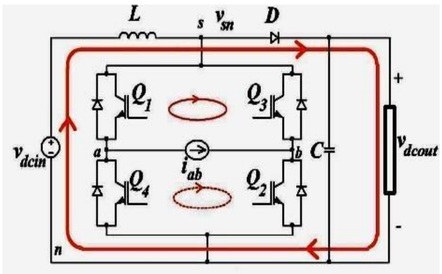


Fig 2.1.3 Equation directing circuits and currents BDHC among the Zero

III. CONTROLLERS

Different control strategies with various controllers are compared and analyzed. The impact of each controller is highlighted and results are discussed. FOPID and fuzzy controllers are used to obtain the transient response of the hybrid converter. Fractional Order Proportional-Integral-Derivative is referred to as FOPID. It is an advancement over the conventional PID (Proportional-Integral-Derivative) controller, a popular control technique in industrial and technical settings. FOPID and PID controllers vary primarily in that fractional order calculus is used. Fuzzy logic is a style of reasoning used by fuzzy logic controllers (FLCs) to simulate human thinking in decision-making. They are especially helpful in systems where the complexity, ambiguity, or imprecision of typical control methods may make implementation difficult. A mathematical framework known as fuzzy logic allows for degrees of truth between true and false in order to cope with ambiguity and imprecision.

3.1 RULE OF FUZZY LOGIC CONTROLLER

An intellectual control method called an FLC facilitates easy interpolation between the rules. FLC defines uncertainty in occurrences. It gauges the degree to which an event occurs rather than whether it occurs at all. Fuzzy theory is a commonly utilized method in the study of multidimensional efforts because it may determine outcomes for a given set of inputs without requiring a conservative, formal model. Fuzzy theories just become tacit theories since they may be made to look more like high-level languages than mathematical languages. We develop a membership function that defines a universe of conversation using fuzzy sets named "hot" and "cold". An input's level of membership in the fuzzy set of this membership job is largely determined by the role
membership functions play in converting linguistic terms into standards that a computer can comprehend.

Membership functions are created by specialists who are familiar with the structure under investigation. In essence, FCC is a set of guidelines that specify what actions to take in response to certain input types. Fuzzy theory can be incorporated into control theory through linguistic means, utilizing rules in the pattern IF{condition} THEN{action}. To construct a membership function, the input variables can be divided into overlap sets that correlate to language in an analogous way. These FLC sets are typically triangular in shape, but they can also be created using trapezoids and Gaussian functions. The relationship that exists between the membership function and the rule set is further illustrated by the membership values that dictate how each rule "fires".

The membership functions' guiding principles involve allocating linguistic variables to three fuzzy subsets: Positive Medium, Positive Low, Zero Error, and Positive High. The input variables are the linguistic variables S error and X error. There are two types of membership functions: triangular and output. Figures 3.1, 3.2, and 3.3 display the membership functions for the variables The linguistic variable X error that is entered has a range of (-10m to 10m).

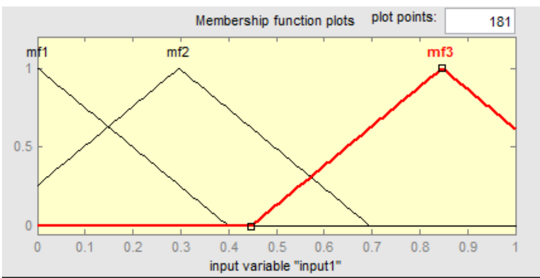


Fig 3.1 Membership function of the input1

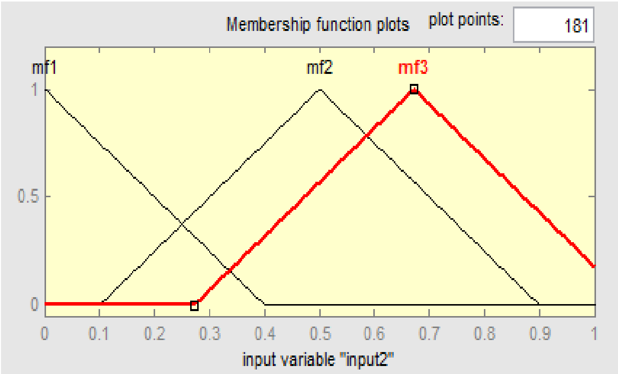


Fig 3.2 Membership function of the input2

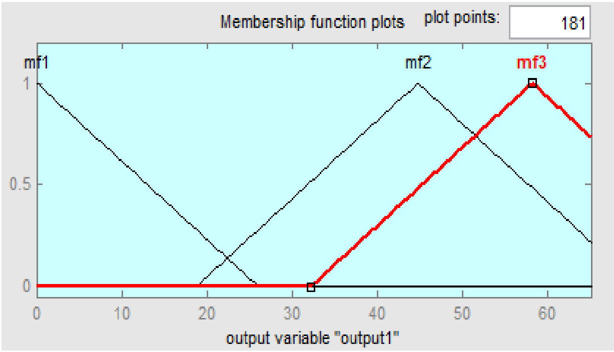


Fig 3.3 Membership functions of the output.

Table 3.1 Fuzzy rule base

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

IV. SIMULATION RESULTS

The simulation are carried in the following sequence to do the detailed analysis of hybrid converter with the different controllers:

- To simulate existing boost converter with inverter in open loop system
- To simulate a hybrid converter in an open loop system.
- To simulate a hybrid converter in a closed loop Fractional order proportional integral derivative controlled system.
- To simulate a hybrid converter in a closed loop Fuzzy logic-controlled system.
- To develop hardware and test it.
- This intriguing future project, a fuzzy logic controlled dual-output hybrid converter, has potential applications in many different sectors.
- The range may include integration with renewable energy sources, enhanced control techniques, and effective energy conversion.
- Examine new developments in fuzzy logic algorithms, dual-output configuration optimization, and system stability and reliability issues.

- Further investigation into the converter's flexibility to various loads and its effect on overall energy efficiency may further increase the project's importance.

V. CLOSED LOOP

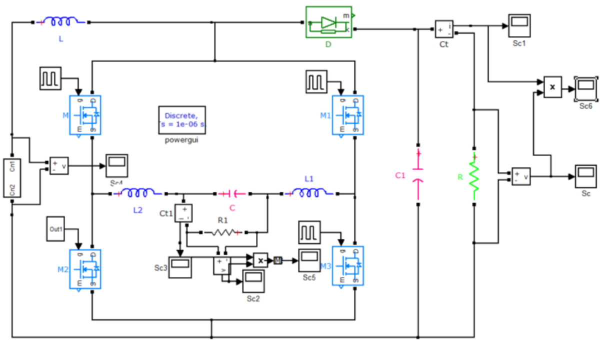
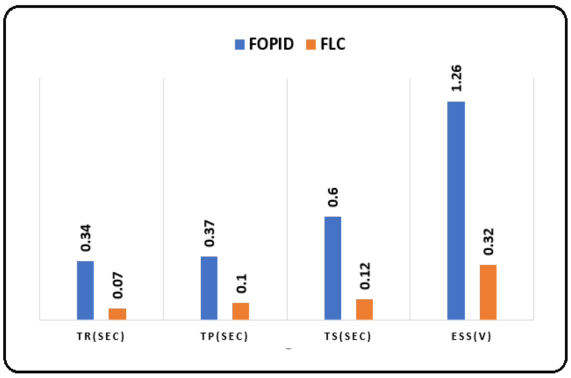


Fig 5.1 Proposed Boost-Derived Hybrid Converter Circuit Diagram with Source Disturbance

Table 5.1 Analysis and comparison of time domain parameters

Types of controller	Tr(s)	Tp(s)	Ts(s)	Ess(V)
FOPID	0.34	0.37	0.60	1.26
FLC	0.07	0.10	0.12	0.32



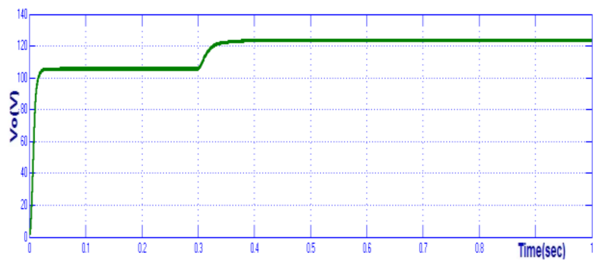


Fig 5.2 DC output voltage

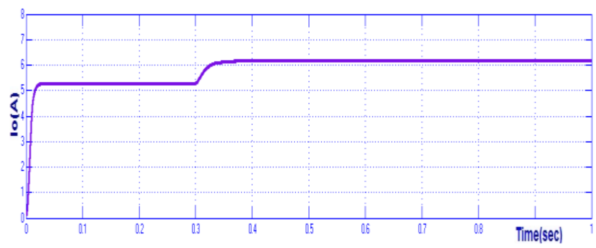


Fig 5.3 DC output current

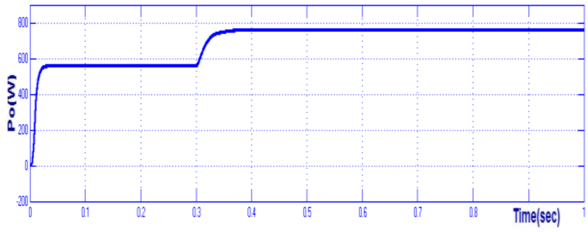


Fig 5.4 Power of the DC output

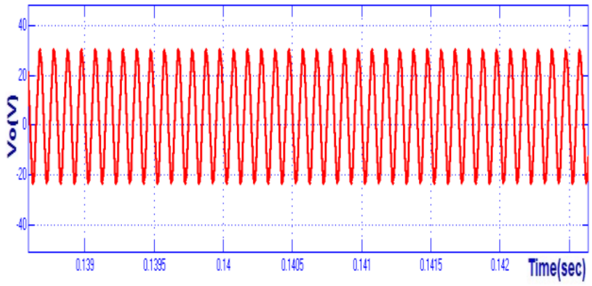


Fig 5.5 Voltage of the AC output

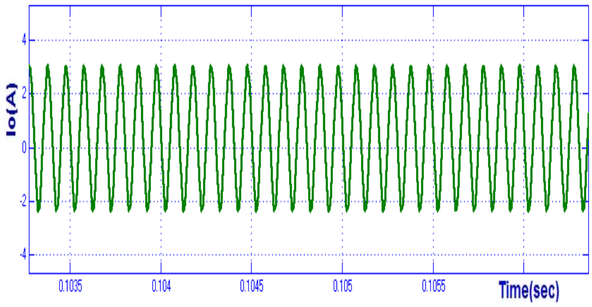


Fig 5.6 Current of the AC output

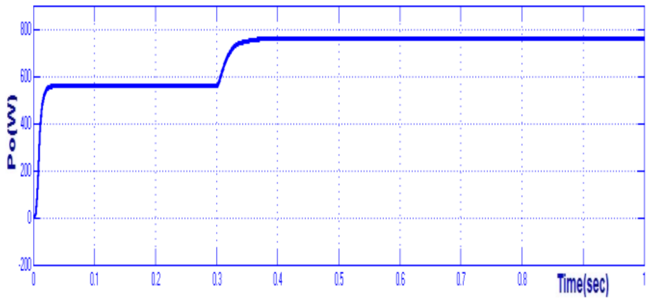


Fig 5.7 Power of the AC output

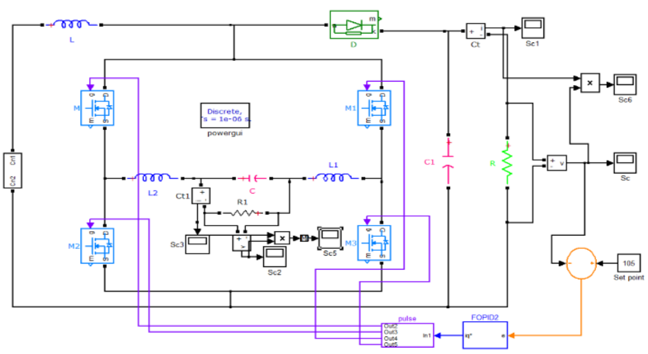


Fig 5.8 The circuit schematic for the suggested Boost-Derived Hybrid Converter includes a closed loop FOPID controller.

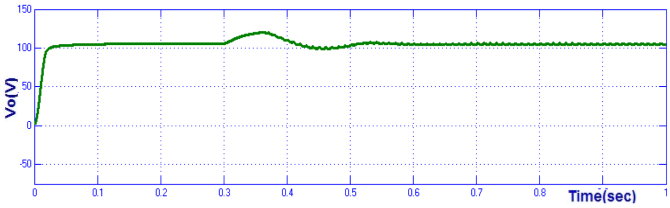


Fig 5. 9 Voltage of the DC output

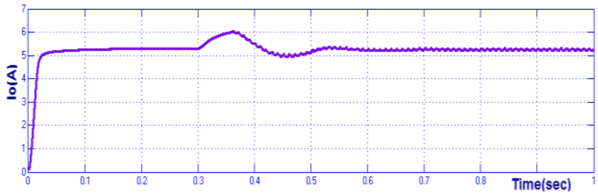


Fig 5.10 Current of the DC output

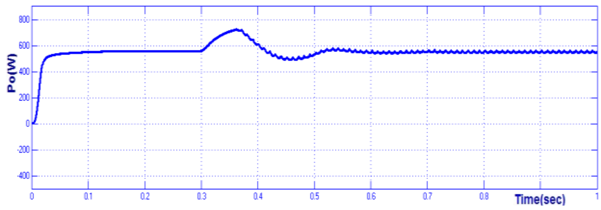


Fig 5.11 Power of the DC output

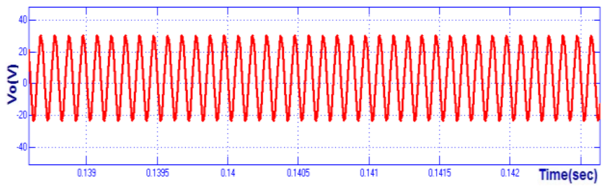


Fig 5.12 Voltage of the AC output

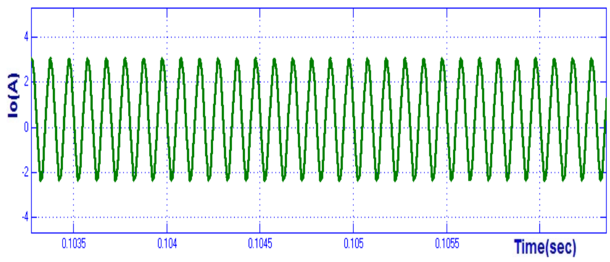


Fig 5.13 Current of the AC output

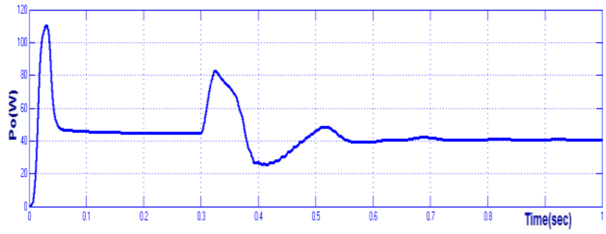


Fig 5.14 Power of the AC output

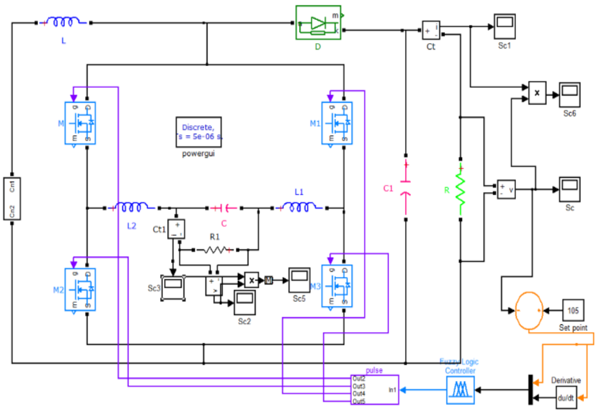


Fig 5.15 Circuit diagram of Proposed Boost-Derived Hybrid Converter with closed loop Fuzzy logic controller

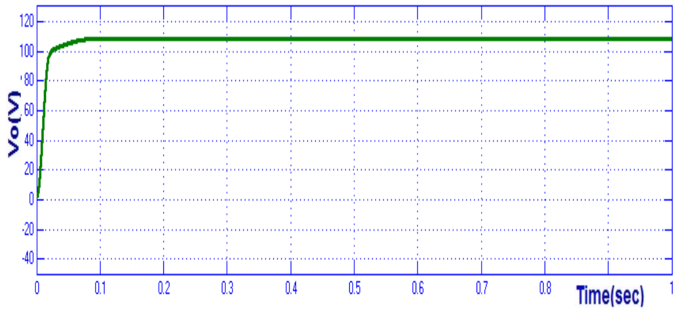


Fig 5.16 Voltage of the DC output

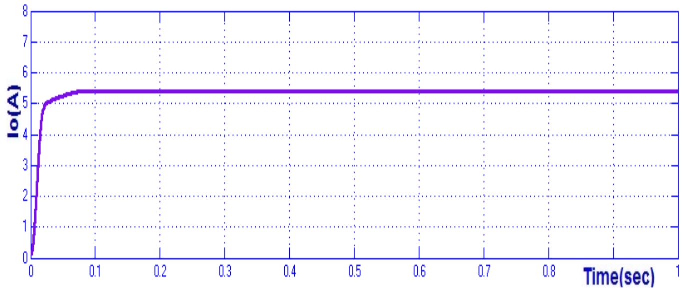


Fig 5.17 Current of the DC output

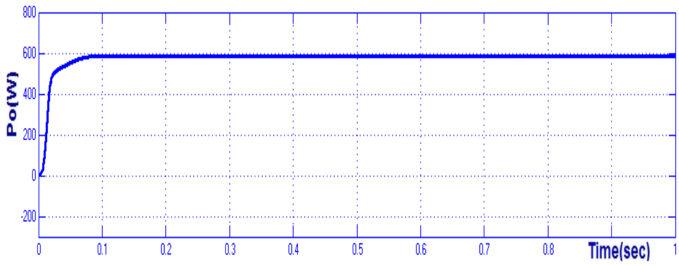


Fig 5.18 Power of the DC output

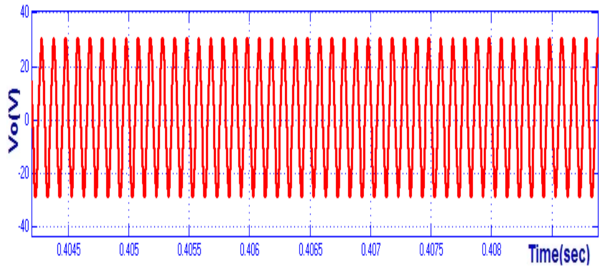


Fig 5.19 Voltage of the AC output

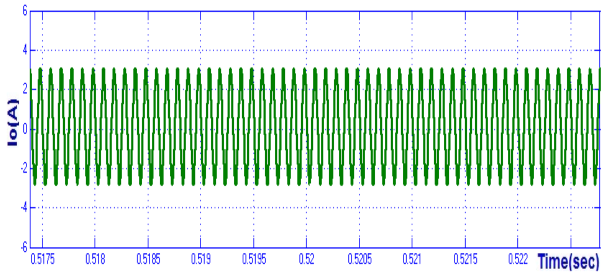


Fig 5.20 Current of the AC output

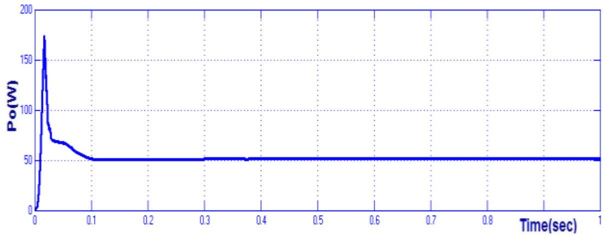


Fig 5.21 Power output in AC

VI. HARDWARE OUTPUT

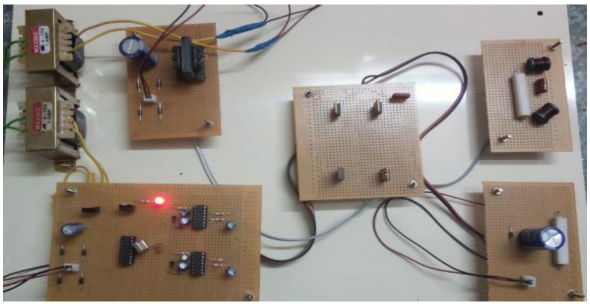


Fig 6.1 A hardware picture of the hybrid converter

Fig 6.2 voltage of the inverter's output

Fig 6.3 R-load's DC output voltage
Vin-15V
Vo-55V

VII.CONCLUSION

An inverter system and hybrid boost converter schematic are simulated. The hybrid boost converter's output voltage increased from 86 V to 108 V, its output power increased from 370 W to 583 W, its output voltage improved from 21 V to 24 V, its output power increased from 28 W to 50 W, and its output current THD decreased from 9.54% to 4.18%. As a result, the hybrid boost converter system performs better than the standard setup. A simulation of a hybrid boost converter's schematic that includes an inverter and a source disturbance system. The closed loop PI controller system and inverter are included in the simulated circuit schematic of the hybrid boost converter. A simulation of a hybrid step-up converter's circuit diagram includes an inverter, a closed-loop FOPID controller system, and a closed-loop fuzzy controller system. The Fuzzy Controller reduces the Rise time from 0.34 s to 0.07 s. Peak time is reduced from 0.37 seconds to 0.10 seconds by using a fuzzy controller. The settling time is shortened by the fuzzy controller from 0.60 to 0.12 seconds. A fuzzy controller is used to reduce error from 1.26 V to 0.32 V. By employing a fuzzy controller, the overall harmonic distortion of the output current is decreased from 3.66% to 3.07%. The systems above are contrasted. Thus, the results demonstrate that the closed loop fuzzy controller performs better than closed loop FOPID controller of hybrid boost converter system.

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