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Neuro Fuzzy Based Fuel Cell Model on Grid Connected Power Generation System

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ABSTRACT: In recent years, with the depletion of traditional primary energy, the exploitation of renewable energy such as Fuel Cell energy and wind energy is urgently required. More and more scholars have devoted themselves to the research of Fuel Cell generation technology. The inverter is indispensable since the DC power generated by Fuel cells need to be converted into AC power to be used. The transformer less inverter is widely used for the characteristic of light weight, small size and low cost. Normally, a three-phase Fuel cell grid connected inverter without isolation transformer is mainly composed of DC-DC converter and DC-AC inverter. This project proposes Luo converter based single phase three level voltage source inverter for Fuel Cell. The MPPT used ANFIS logic algorithm is used to extract the maximum power from the Fuel Cell system. The maximum power point tracking (MPPT) is usually accomplished in the DC-DC part in order to improve the efficiency of Fuel cell system and in the DC-AC part; the DC power is turned into AC power to inject to the grid. This three phase voltage source inverter is controlled by PI controller. This project is implemented using Matlab simulation

I. INTRODUCTION

In recent years, with the depletion of traditional primary energy, the exploitation of renewable energy such as Fuel Cell energy and wind energy is urgently required. More and more scholars have devoted themselves to the research of Fuel Cell generation technology. The inverter is indispensable since the DC power generated by Fuel cells need to be converted into AC power to be used. The transformer less inverter is widely used for its desirable characteristics of light weight, small size and low cost. Normally, a two-stage single-phase Fuel cell grid connected inverter without isolation transformer is mainly composed of DC-DC converter and DC-AC inverter. The maximum power point tracking (MPPT) is usually accomplished in the DC-DC part in order to improve the efficiency of Fuel cell system and in the DC-AC part. In this paper Fuel cell based buck boost converter with different MPPT algorithm is proposed such as hills clamping MPPT method.The buck-boost converter can track the MPP with a reasonably higher efficiency in all the subjected atmospheric conditions of insulation and temperature. It provides 93.82% efficiency at boost mode[1]. In this paper, HC and ANN maximum power point tracking (MPPT) algorithms in a fuel cell electrical energy generation system are analyzed and compared. In ANN MPPT algorithm it does not need any internal parameters like voltage and current reference. But in HC algorithm its needs different reference parameters. The ANN algorithm attains maximum power at very short duration compared to HC algorithm [2]. In this paper FUEL CELL based five level inverter is proposed to reduce the THD in inverter output voltage.Further, this paper also presents the analysis for the terminal voltage across the FUEL CELL array and common mode voltage of the inverter based on switching function.The output voltage is fed to the grid without using any transformer[3]. In this paper Wind energy conversion system proposed with SEPIC converter. This converter input current is continuous; also ripple factor is very less. So that it makes voltage and current ripples were very less. Its voltage boost ratio is high so that system efficiency is high[4]. In this paper wind DC-DC (Buck boost) converter which gives maximum output voltage, power and maximum efficiency at any condition. The grid voltage and frequency is synchronized by using PLL techniques. Development of maximum tracking algorithm is presented and implemented by using DSP processor which gives the maximum efficiency of wind system [5]. In this paper fuzzy based energy management unit (FBEMU) for a renewable

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energy system (RES) is introduced. Its hybrid energy system so that energy harvesting problems will not come. The inverter output voltage is fed to the grid through suitable control technique, so it can control the PQ problems in grid side [7]. In this the current fuel cell technologies are reviewed, with emphasis on their use for combined cycles of heat and power. The advantages of not generating polluting gases in their operation, providing high-energy efficiency and low level of noises are emphasized[8]. An efficient method based on sliding mode control (SMC) is proposed for the PEM fuel cell/lithium-ion battery bank storage system. The closed loop system includes the PEM fuel cell, boost and buck converters, lithium-ion battery bank and the SMC. Simulations allow analyzing the dynamic performance and power management for the different components [9]. The salient features of implemented system, are as follows

- To implement Fuel cell energy based power generation system.
- The proposed system consists of 50 kW-625 Vdc Fuel cell, DC-DC Luo converter, three phase voltage source inverter and grid.
- To maintain constant output voltage to the load or grid, high gain DC-DC Luo converter with ANFIS based MPPT algorithm is proposed.
- The voltage source inverter is controlled by means of PI controller, whose reference voltage is derived from the grid using abc-dq transformation.
- This project is implemented using Matlab simulation.

II. MODELLING

OPERATION OF FUEL CELL PANEL

A fuel cell consists of a fuel electrode (anode) and an oxidant electrode (cathode), separated by an ion-conducting electrolyte as shown in Fig. 1. The electrodes are

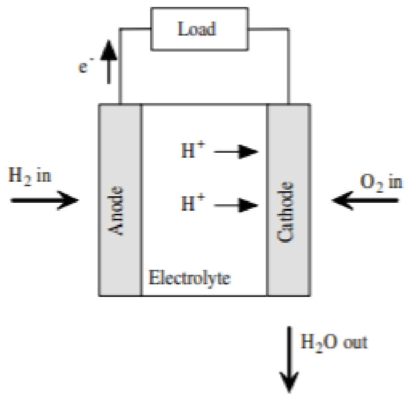

Fig.2.1. Operation of a Fuel Cell

connected externally through a load, thus completing the electronic - ionic circuit. A basic fuel cell with hydrogen as the fuel and oxygen as the oxidant is considered. The hydrogen is ionized at the anode to give hydrogen ions and electrons. The electrolyte allows only the ionic flow and resists the electronic flow. Hence the electrons flow through the electrical circuit and reach the cathode after supplying power to the load whereas the hydrogen ions flow through the electrolyte to reach the cathode. Oxygen at the cathode reacts with the electrons and the hydrogen ions to form water. The overall reaction is the sum of the anodic and the cathode reactions producing water. In high temperature fuel

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cells, the ionic carriers are carbonate ions for molten carbonate electrolyte fuel cells and oxide ions in the case of solid oxide fuel cell .

MAXIMUM POWER POINT TRACKING

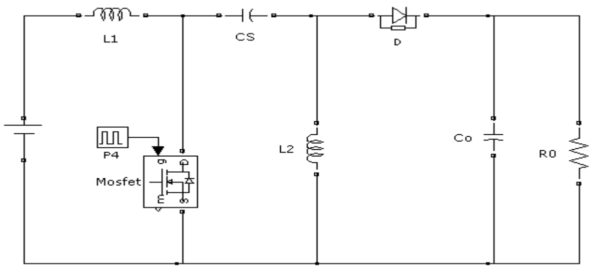
Maximum power point tracing (MPPT) system is an electronic control system that can be able to coerce the maximum power from a FUEL CELL system. It does not involve a single mechanical component that results in the movement of the modules changing their direction and make them face straight towards the sun. MPPT control system is a completely electronic system which can deliver maximum allowable power by varying the operating point of the modules electrically.

There are many algorithms which help in tracing the maximum power point of the FUEL CELL module. They are following:

a. P&O algorithm
b. IC algorithm
c. Parasitic capacitance
d. Voltage based peak power tracking
e. Current Based peak power tracking

LUO CONVERTER

LUO is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the LUO is controlled by the duty cycle of the control transistor.



LUO is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output voltage is of the same polarity as the input voltage), the primary means of coupling energy from the input to the output is via a series capacitor, and true shutdown mode.

FUZZY LOGIC CONTROLLER

Fuzzy logic expressed operational laws in linguistics terms instead of mathematical equations.
Many systems are too complex to model accurately, even with complex mathematical equations; therefore traditional methods become infeasible in the subsystems. However fuzzy logic linguistic terms provide a feasible method for defining the operational characteristics of such system.

Fuzzy logic controller can be considered as a special class of symbolic controller. The configuration of fuzzy logic controller block diagram is shown in Fig.3.17

The fuzzy logic controller has three main components

- Fuzzification
- Fuzzy inference
- Defuzzification

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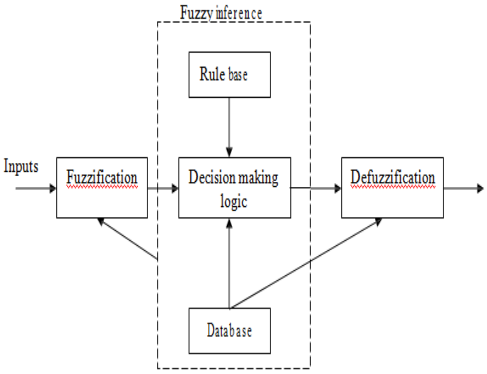

Fig2.2 Block Diagram of Fuzzy logic control

PI CONTROLLER

The below fig shows the block diagram of PI Controller. The DC Side Capacitor voltage is sensed and compared with a reference voltage. This error e= Vdc, ref – Vdc is used as the input for PI Controller. The error signal is passed through Butterworth design based Low Pass Filter (LPF).

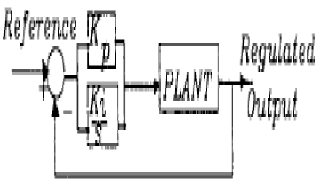

Fig 2.4PI Controller

III. PROPOSED SYSTEM

INTRODUCTION

In grid connected mode of distributed generation applications, the elimination of line frequency transformer is possible without impacting system characteristics related to grid integration, ground leakage current, dc injection, safety issues etc. This project presents the design, modeling, simulation and implementation of LUO Converter based closed loop operation of a novel inverter topology suitable for transformer-less single phase grid connected fuel cell systems. The fuzzy logic control scheme ensures extraction of maximum power from the Fuel cell Fuel cell (FUEL CELL) source, synchronization with the grid and controlled active and reactive power transfer to the grid using PI controller. Simulation results with both dc source and Fuel cell FUEL CELL as input, incorporating MPPT, are discussed in the project.

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BLOCK DIAGRAM

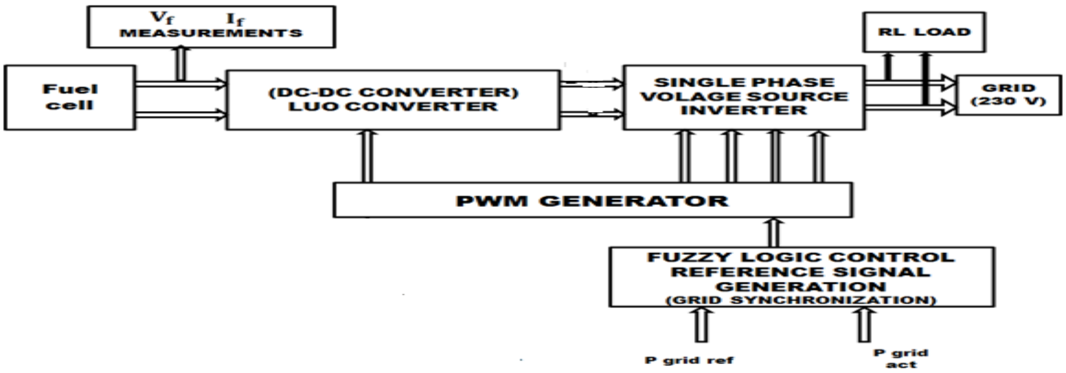

Fig.3.1Proposed system block diagram

OPERATION

Fuel cell panel output voltage and current is given to the LUO converter. The LUO converter allows arrange of dc voltage to be adjusted to maintain a constant voltage output. Dc-dc converters operate by rapidly turning on and off a IGBT generally with a high frequency pulse.

The FUZZY LOGIC CONTROLLER feedback loop should be able to increase the duty cycle to raise the output when the output is too low and decrease it when the output is too high. To do this, the output will need to be compared to a reference voltage which remains constant even if the input changes. The error between the output and the reference voltage is then amplified and added to a set bias voltage. The resulting voltage is then used as the control voltage for PWM. When the output is too low, the amplified error increases which causes the control voltage to increase. The increase in control voltage increases the duty cycle until the output is correct. The output voltage of a specific converter is given to input of the inverter. Output voltage of an inverter can be higher or lower than the input voltage of the inverter is depending on the modulation index when Sinusoidal Pulse width Modulation (SPWM) technique is used. The PI CONTROLLER feedback loop should be able to increase the duty cycle to raise the output when the output is too low and decrease it when the output is too high. To do this, the output will need to be compared to a reference voltage which remains constant even if the input changes. The error between the output and the reference voltage is the amplified and added to a set bias voltage. The resulting voltage is then used as the control voltage for SPWM. When the output is too low, the amplified error increase switch causes the control voltage to increase. The increase in control voltage increases the duty cycle until the output is correct. The inverter output is directly connected to the grid line without transformer for reactive power compensation. Grid active and reactive power is measured by a measurement block measurement block output is given to the PI controller. Here Function of PI controller is reducing the error corresponding to the carrier signal for generating the pulse to the inverter. The main function of inverter in this system is to produce an ac output current equal to the reference current and in phase with it. The FUEL CELL grid connected system provides a power conversion from the FUEL CELL power is the line power. PI controller is a closed loop control. Input of PI controller is voltage and current taken from the grid. Inverter gate pulse is controlled by using of PI controller.Inverter output voltage is directly connected to grid . Using a smooth reactor and get a pure sinusoidal voltage. These voltage is directly connected to grid.

IV. RESULTS AND DISCUSSION

PROPOSED SYSTEM SIMULATION DIAGRAMS

The proposed system is developed using matlab environment. The fuel cells based system is integrated with the Luo converter ,three phase voltage source inverter and grid to improve the efficiency of the cell.Simulation is done in Simulink MATLAB to execute the system and plot the corresponding results.

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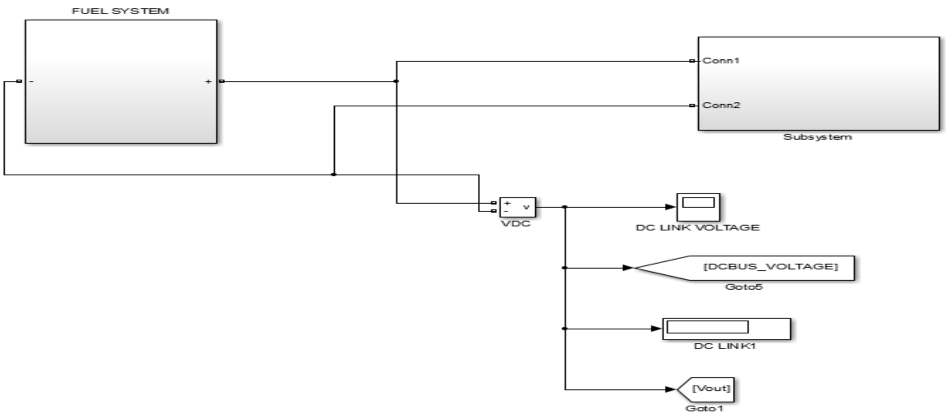
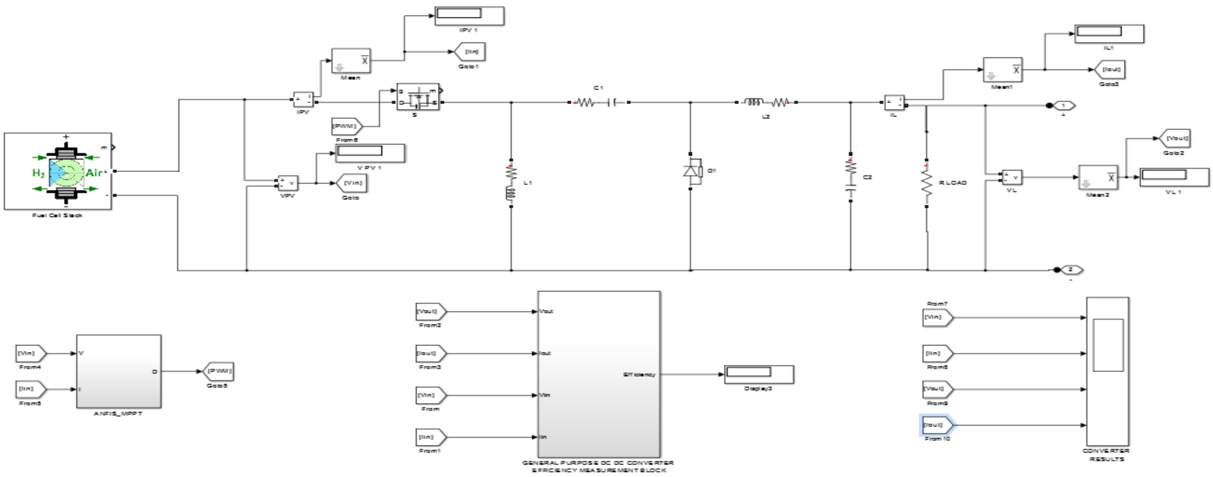


Fig.(a)Simulink model of proposed system



Fig(b).Simulink model of Fuel system

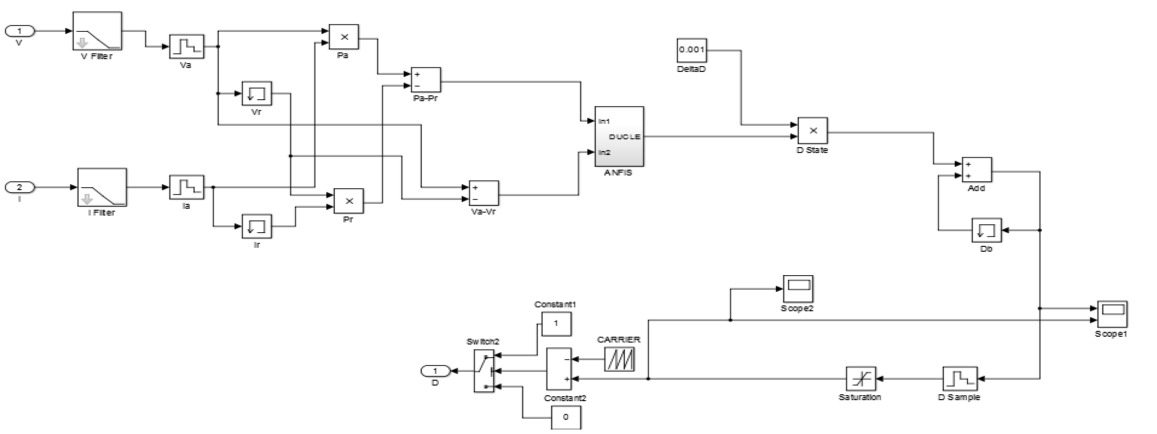


Fig.(c).Simulink model of PWM circuit for LUO-Converter

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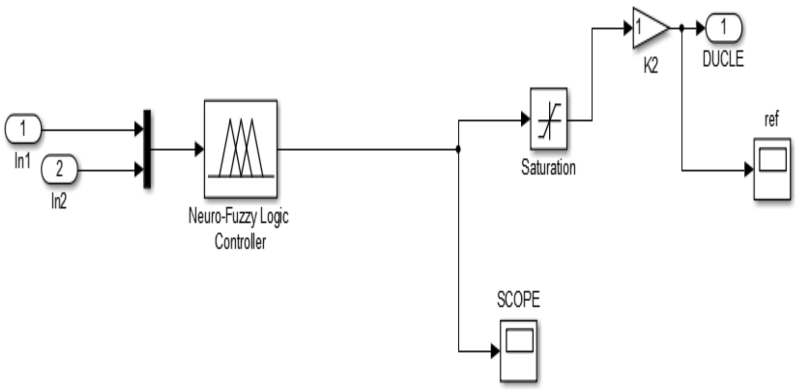

Fig.(d).simulink model of ANFIS controller

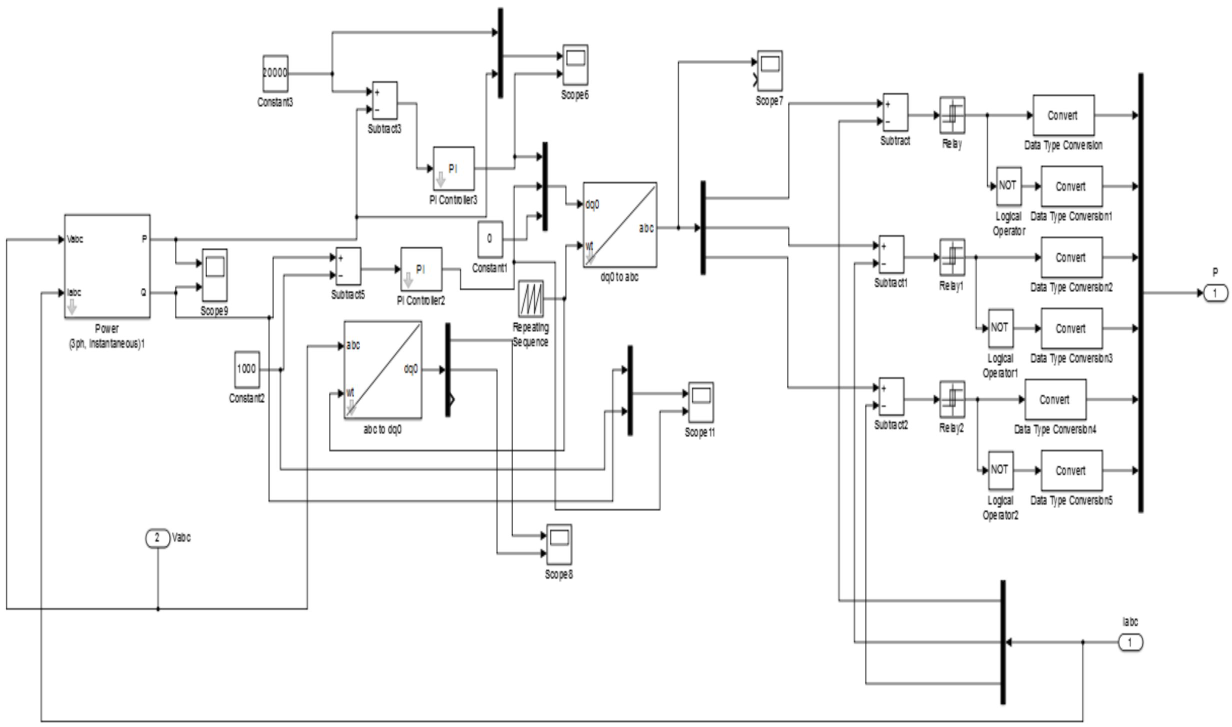

Fig.(e). Simulink model of PWM circuit for inverter

The above fig (a) represents the whole simulation model of the proposed system. Fig (b) represents the simulink model of the fuel stack with the LUO converter through the ANFIS controller. Fig (c) represents the Simulink model of PWM circuit for LUO-Converter. Fig (d) represents the simulink model of PWM generator circuit for three phase voltage inverter. Fig (e) represents the simulink model of PWM circuit for inverter.

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V. RESULTS

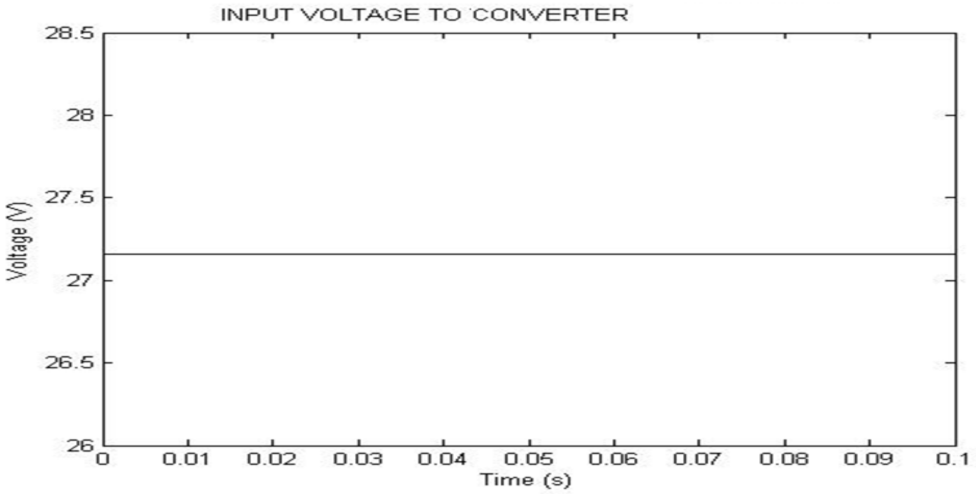

Fig. Input voltage to the LUO converter

The above shows the result of constant input voltage to the converter.

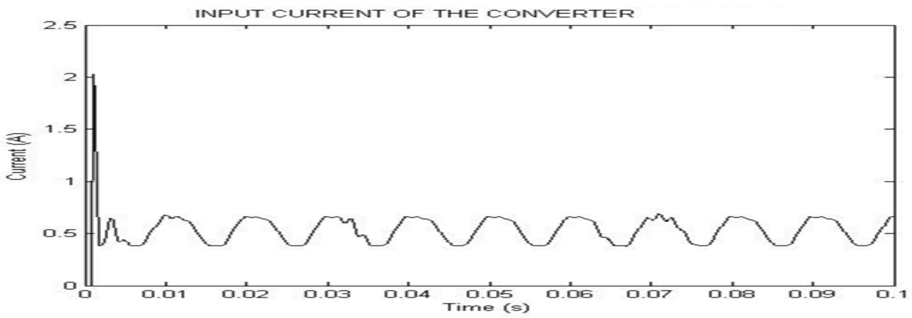

Fig.4.7Input current to the LUO converter

The above fig shows the input current given to the converter.

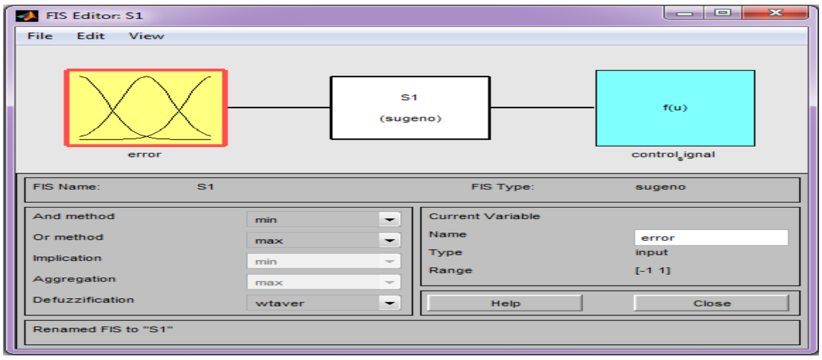

Fig.(a). FIS Editor

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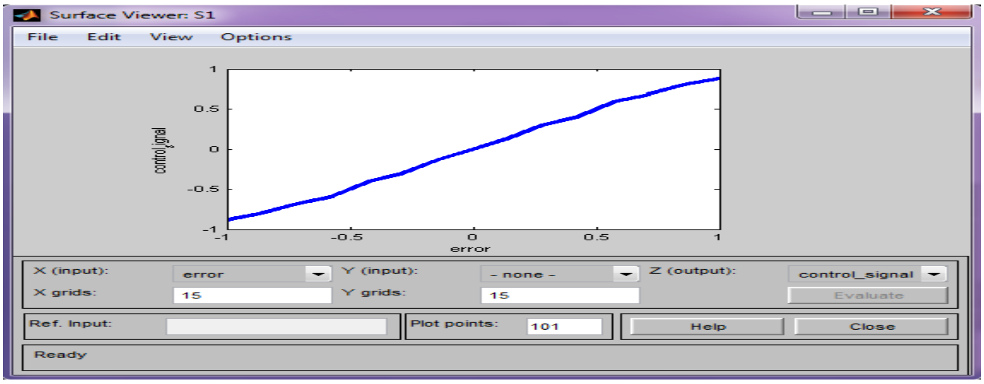

Fig.(b). Surface view

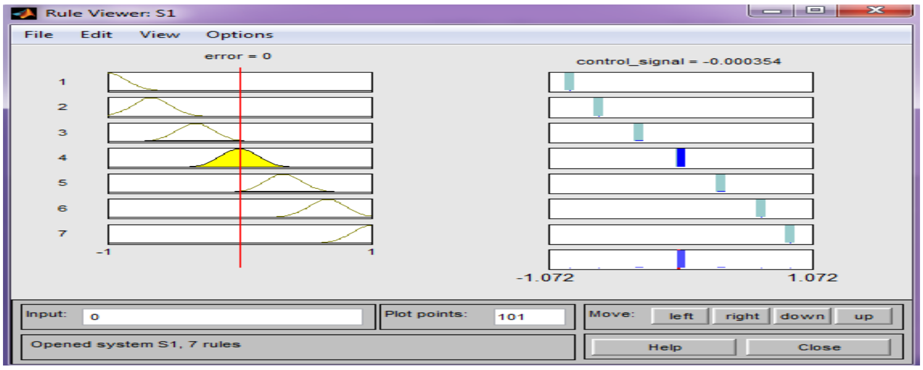

Fig.(c). Rule view

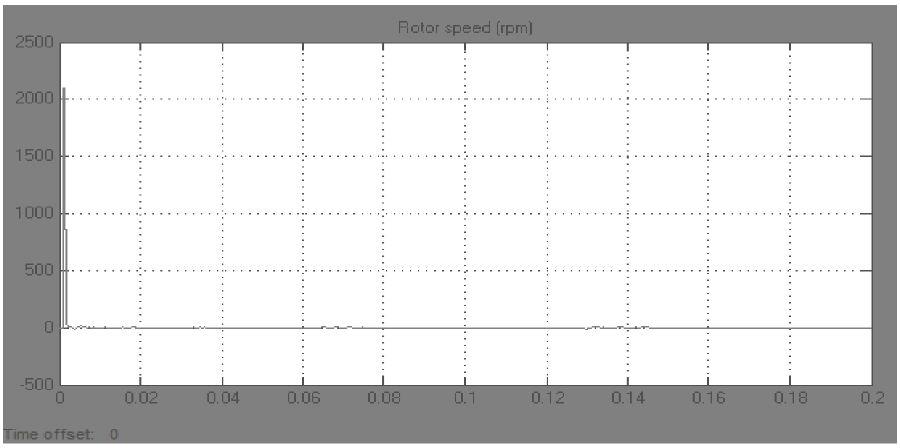

Fig.(d). Input of ANFIS Data-1 (Error)

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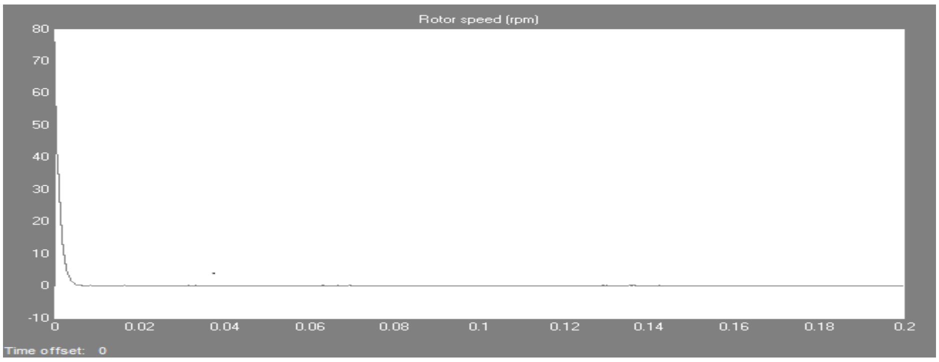

Fig.(e). Input of ANFIS Data-2(change of error)

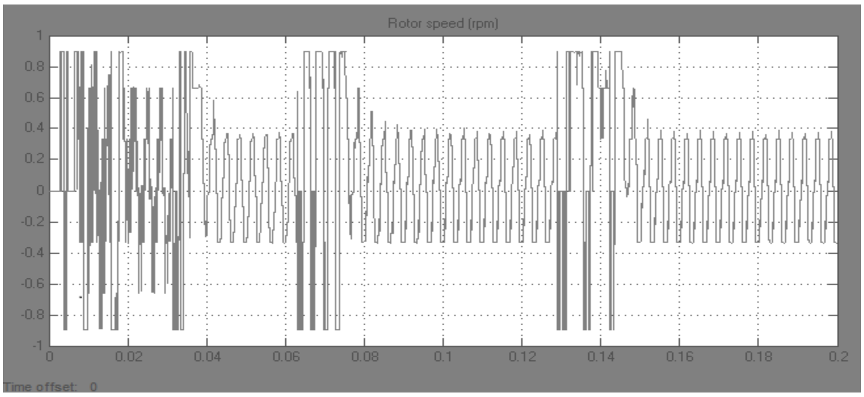

Fig.(f) Output of ANFIS (duty cycle)

The above Fig represents the (a).FIS editor (b)Surface view (c) Rule view (d)Input1 (e)Input2 (f)Output of ANFIS controller.

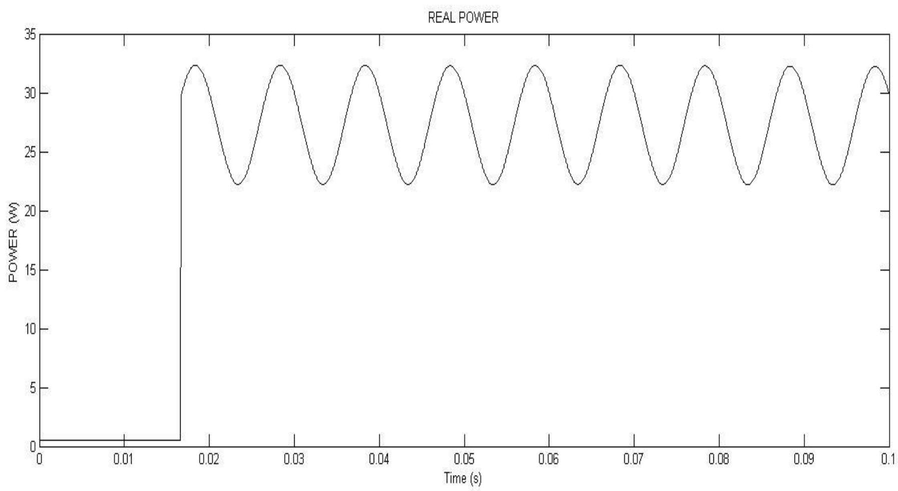

Fig.(a) Real power waveform of inverter

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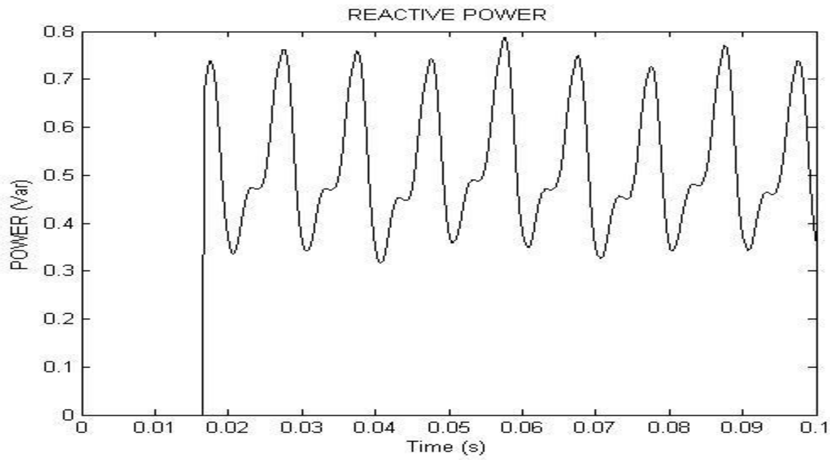

Fig. (b)Reactive power waveform inverter

The above Fig (a) and (b) shows the real and reactive power of the three phase voltage inverter .

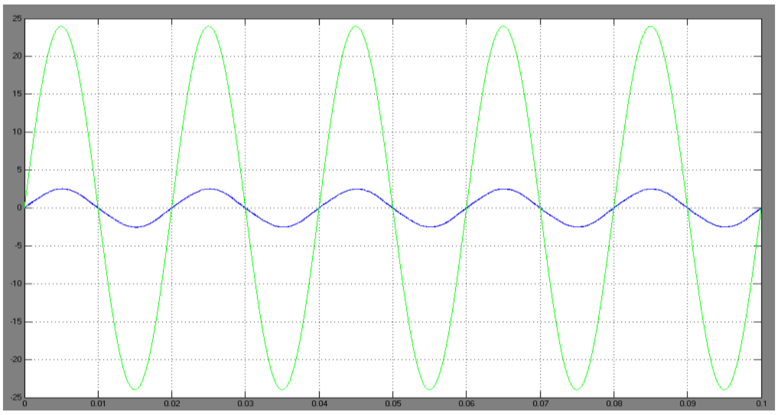

Fig. Grid synchronization wave

This above fig shows the grid synchronization of voltage and current.

V. CONCLUSION

This work includes the modeling of Fuel cell, Luo DC-DC converter, three phase voltage source inverter and grid system.MPPT based ANFIS controller is designed for Luo converter controlling and PI controller for three phase voltage source inverter. Compared to the conventional controller the proposed MPPT based ANFIS controller has increased the average dc link voltage, the average time taken to reach the maximum power point is reduced. Thus state of current output when the PI current controller is absent and present also has been compared and verified using matlab simulink software. Based on these findings the PI controller has reduced DC component, steady state error and total harmonic distortion**.**

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