Asian Journal of Applied Science and Technology (AJAST)

(Peer Reviewed Quarterly International Journal) Volume 3, Issue 1, Pages 307-315, Jan-March 2019

Enhancing the Power Quality of Wind and Solar Hybrid System by Fuzzy Based Logic Controller

S.Joganna Jesvan[1] & M.Surendar[2]

[1]*M.E (Power Electronics and Drives), Department of (Electrical and Electronics), CSI College of Engineering, Ketti, The Nilgiris.*
[2]*Assistant Professor, Department of (Electrical and Electronics), CSI College of Engineering, Ketti, The Nilgiris.*

Article Received: 30 August 2018 Article Accepted: 29 December 2018 Article Published: 27 March 2019

ABSTRACT

During the past few decades the advanced technological nation of the world have been engaged in an energy and resources race that has brought us to the position of energy crisis. A new topology and effective power transfer scheme with minimum number of converters is proposed for a grid connected wind/photovoltaic (PV) system. Distributed generation sources considered are permanent magnet synchronous generator (PMSG)-based wind energy conversion system and PV array system. Two voltage source converters with a common DC-link serve as wind side converter (WSC) and grid side converter (GSC), respectively. The PV array is directly tied to the DC link without any power converter providing variable DC-link voltage. The Perturb and Observe technique extracts the maximum power from PV and the DC-link voltage is set to the maximum power point (MPP) voltage of the PV array. Nevertheless, system based on either wind or solar energy is unreliable due to seasonal and diurnal variation of these resources. Therefore hybrid based system such as wind-diesel system were employed to overcome the diluteness of the renewable resources, but the recurring need of the diesel oil and frequent maintenance requirement of the diesel-generator made such system to be inappropriate for off-grid supplies. Hence an intelligent control technique using fuzzy logic control associated with a MPPT controller is in need which improves the energy conversion efficiency of the photovoltaic system. An attempt has been made to introduce a fuzzy logic based intelligent controller for wind-solar hybrid scheme with only seven linguistic variables to control the output load voltage constant under varying solar irradiations, wind speeds and loads.

Keywords: Wind Energy, Solar Energy, Fuzzy Logic Controller, Energy Conversion.

1. INTRODUCTION

Problem of conventional energy sources are ozone layer depletion, global warming, acid rain which causes environmental pollution, so that renewable energy sources increase in demand. Renewable energy sources which is generated from natural resources i.e. sunlight, wind, rain, tides, and geothermal heat which is naturally replenished, continues and nearly non pollutant. Distributed generator (DGs) requires new power electronics interface and new control strategies for improving efficiency and quality. With change in environmental condition or seasonal variation the solar and wind energy get fluctuated [3]. The renewable energy resources are complementary in nature since PV generates more power in during day time. And Strong wind occurred at cloudy days or during night time. Operating with hybrid system has more dependability to give reliable and steady power than each of them operating individually. Wind energy conversion system, converts mechanical energy into electrical energy. This conversion requires various types of generators but conventional dc generator having disadvantage that high cost, high weight and commutator requires regular maintenance. Therefore Permanent magnet synchronous generator (PMSG) and induction generator are used for mechanical to electrical power conversion. Hybrid scheme Permanent magnet synchronous generator is generally used, because it does not require any reactive power support , also eliminate the gear box so that avoid regular maintenance and it having self excitation property operated with higher power factor and higher efficiency than other machines.

CITE THIS ARTICLE: S.Joganna Jesvan & M.Surendar, "Enhancing the Power Quality of Wind and Solar Hybrid System by Fuzzy Based Logic Controller", *Asian Journal of Applied science and Technology*, Volume 3, Issue 1, Pages 307-315, Jan-March 2019

Renewable energy sources have attracted wide attention because of its abundant nature. Wind power can be easily captured by generators with high capacity. It is one of the promising and clean energy sources. Photovoltaic (PV) power is global and it can be extracted without using rotational generators. PV power is also another clean energy resource. PV and wind power are complementary in nature. During sunny days the winds will be weak and strong winds blow during nights and cloudy days. Hence, to get an uninterrupted supply wind-PV hybrid power generation system can be implemented. It provides higher reliability and continuous supply of power from any one of the resources either solar or wind [5].

The wind energy conversion system consists of wind turbine and PMSG. WECS converts the mechanical energy into electrical energy. Wind turbine gives mechanical output which is converted into electrical energy by permanent magnet synchronous (PMSG) generator. It is a directly driven generator. It does not require any dc field excitation. The ac output from WECS is converted into dc by three phase diode rectifier. Since the wind speed is constant, the duty cycle of one of the switches of the converter corresponding to PV input is controlled by fuzzy logic controller. The inputs to the fuzzy logic controller are provided Maximum power point tracking algorithm (MPPT). The output voltage of VSI is regulated by PI controller. The gating pulses to VSI are generated by the PI controller. Also, PI controlled system is less responsive to real and relatively fast alterations in state and so the system will be slower to reach the set point.

The objective of this work is to design a scheme to control the power flow of a hybrid renewable energy system with multiple renewable energy sources with the focus on solar energy and wind energy and multiple energy storage systems. The use of energy storage is necessary due to the intermittency of the renewable energy sources and the consequent peak power shift between the sources and the load. In addition, the use of the energy storage can increase the overall system reliability and stability. In this work, batteries are used as the primary energy storage system for short to medium storage term, while hydrogen fuel cell is used as the long-term energy storage. A supervisory control system is designed to handle various changes in power supply and power demand by managing power intermittency, power peak shaving, and long-term energy storage. Since both power supply and demand are not fully predictable and they have time-variant nonlinear behavior, computational intelligence is introduced to solve this issue and provide suitable control algorithm. This type of control is based on fuzzy logic, combines knowledge of the system and control. The proposed methodology can be optimized such that the system is able to adapt to its working environment and deliver best results under given circumstances.

2. RELATED WORK

Various combinations of hybrid micro grid systems consisting of both PV and wind are discussed in the literature. A system with both PV and PMSG as sources and battery as primary energy storage device is discussed in [1], where both the source and storage systems are connected to a common DC bus through individual power electronic converters, which in turn is connected to the grid through an inverter unit. Bae and Kwasinski [2] describe a grid connected hybrid renewable energy system with PV and PMSG, but MPP tracking (MPPT) for PMSG is not implemented. Various configurations of a hybrid DG system with PV and PMSG as their sources are reported [3].

In [4] a single-phase grid connected hybrid PMSG–PV array where the PV array is directly connected to DC link is proposed.

An uncontrolled diode bridge rectifier followed by DC–DC converter and single phase inverter are used and the DC-link voltage is tracked based on the duty cycle variation of DC–DC converter. However, the implemented control scheme achieves active power transfer and DC-link voltage regulation only. In all the above mentioned PV and PMSG systems, the system employs individual power electronic interface units for the sources and backup supply. Furthermore, complex control algorithms were employed for tracking maximum power from the intermittent sources. However, higher efficiency can only be achieved by employing lesser power converter stages and this paper attempts for a system schema with minimum converters where three-phase voltage-source converter (VSC) is used on either side of the DC link. The proposed control scheme performs active maximum power transfer, DC-link voltage regulation, load compensation, and reduces torque pulsations in PMSG simultaneously. MPPT is employed for both PMSG and PV system.

A linear quadratic regulator-based current controller for a three-phase modular boost converter supplied from a PMSG is proposed [5], where each phase of PMSG is connected to a single-phase diode rectifier and a DC–DC converter. In [6] a B-spline artificial neural network controller is proposed which enhances system performance. In addition, adaptive proportional–integral (PI) controllers are employed to regulate current, frequency and DClink voltage. In this paper, a control scheme for the hybrid DG system based on wind and PV under varying wind velocity and solar irradiation is proposed which effectively works to transfer maximum power to the grid by employing a wind side converter (WSC) and grid side converter (GSC). Simple controllers such as the hysteresis and PI controllers form the control schema which transfers maximum available power, provides compensated grid currents, servo regulates DC-link voltage and controls harmonics in PMSG stator currents. All these functions are accomplished simultaneously, which makes the system suitable for domestic and high-power industrial applications.

3. EXISTING SYSTEM

This paper presents a study analysis of a wind energy conversion system (WECS) based on a doubly fed induction generator (DFIG) connected to the electric power grid. The aim of the work is to apply the dynamic performances of type of controllers (namely, classical PI) for the WECS in terms of tracking and robustness with respect to the wind fluctuation as well as the impact on the quality of the energy produced.

Today, wind energy is the most competitive form of renewable energy. In the past decade the size and capacity of wind turbines have increased dramatically. Meanwhile, the structural components have been made relatively lighter to keep down costs. This has put higher demands on wind turbine control schemes, and implementation of advanced control systems is considered a promising way of decreasing fatigue loads. In this paper we explains the strategy to follow to order rotoriquement wind with a speed control loop equipped with a PI controller to optimize the maximum extraction of wind energy through continuous electronic adjustment of the specific speed of the turbine, which leads to an optimal point at each time the wind speed varies [6].

A typical structure of a PI control system is shown in Fig. 1, where it can be seen that in a PI controller, the error signal e (t) is used to generate the proportional and integral actions, with the resulting signals weighted and summed to form the control signal u (t) applied to the plant model. A mathematical description of the PI controller is

$$u(t) = K_p\left[e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau\right] = u_p(t) + u_i(t)$$

Where K_p is proportion gain, T_i is integral time constant of PI controller, u(t) is the input signal to the plant model, the error signal e(t) is defined as e(t)= r(t)-y(t), and r(t) is the reference input signal. The PI controllers are the most often type used today in industry. A control without D mode is used when: 1) Fast response of the system is not required. 2) Large disturbances and noise are present during operation of the process. 3) There is energy storage in process (capacitive or inductive). 4) There are large transport delays in the system.

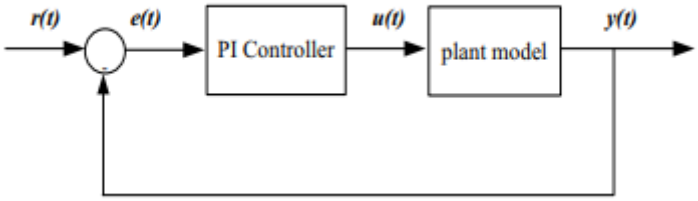

Figure No: 1 PI Control Structure

The closed loop PI controller is also used for MPPT of solar array, which varies the duty cycle of DC-DC converter. Moreover, the system will not respond quickly to rapid changes in temperature or irradiance. On the other hand, the PI controllers are fixed-gain feedback controllers and they cannot compensate the parameter variations in the process and cannot adapt changes in the environment. Also, PI controlled system is less responsive to real and relatively fast alterations in state and so the system will be slower to reach the set point. Therefore an intelligent control technique using fuzzy logic control associated with a MPPT controller is in need which improves the energy conversion efficiency of the photovoltaic system.

4. MODEL OF PROPOSED FRAMEWORK

In hybrid disbursed generator machine wind and photovoltaic requires man or woman electricity converter for each source or require battery backup. Power converter requires complex controls for switching operation. As boom in energy converter there's increase in conduction and switching losses. Those losses may be minimized via use of less wide variety of power converters (or power conversion degree). In this work, new proposed scheme is used the PV array is directly linked to the dc link as opposed to connecting it through the dc- dc improve converter, which removes using greater converter requirement, which makes the machine more reasonably priced. Also use of converter requires to control, various complex control strategy and extra power conversion stage eliminated in this work. For tracking the maximum power from the sources simple Wind MPPT with optimal torque control method is employed, which generates the duty cycle for boost converter and this method doesn't require any sensors so the

cost effective operation is being achieved. An inverter is controlled by grid side controller in which problem with DG system unbalance load and unbalanced current is compensated also maintaining the dc link constant [2].

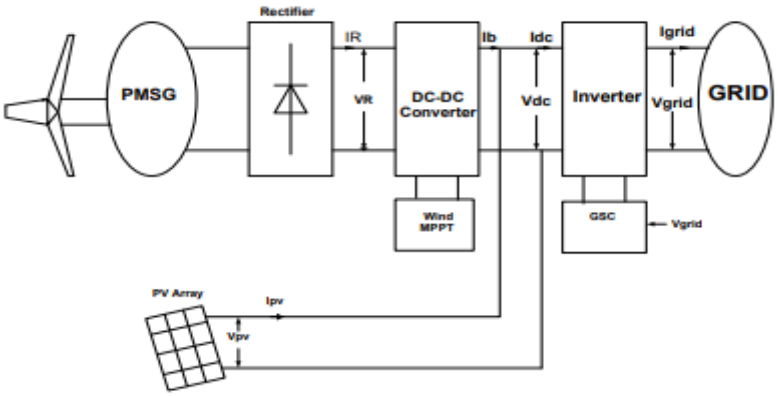

Figure No: 2 Proposed Methodology

Fig.2. indicates block diagram of the hybrid distributed generator machine in which the solar photovoltaic and wind are the resources. Wind generates the mechanical electricity that is then converted into electric energy through direct driven PMSG. The PMSG output that's rectified and transformed AC strength into DC power via the diode rectifier circuit, rectifier output voltage varies with the wind speed, in view that output of rectifier is enter of dc-dc boost converter. The output voltage of PV array (V_{pv}) is fixed into the output voltage of improve converter consequently, their output is tied collectively and forming a common dc hyperlink. Output voltage of boost converter is controlled by using Wind MPPT controller wherein foremost torque manipulate technique is used. To manipulate the inverter grid side controller is used.

4.1 Appliance of Fuzzy Controller

To design a fuzzy controller and to improve the performance of the dc capacitor voltage variation as compared to the performance of the traditional PI controllers. The PI controllers always have a very vital role concerning the constancy of the power system. However the performance of the double fed induction generator greatly depends on the suitable choice of the control gain parameters of the PI. The difficulty regarding the PI controller gain is the fine tuning of the controller so as to achieve the optimal operation of the task. The major drawback of the PI controller is faced when the process is nonlinear and also when the system is having oscillations. Considering all these facts, a fuzzy logic controller was implemented. The fuzzy controller can work in linear as well as in nonlinear design parameters. The advantage regarding fuzzy controller is the systematic approach to control a non linear based procedure depending on the knowledge and experience based of human being. A fuzzy controller can use multiple inputs and multiple output variables.

a) Fuzzification

The term fuzzification means to fuzzify the data. This is done by converting the classical set to fuzzy set. For this process we need different fuzzifiers such as Triangular, Trapezoidal, Singleton and Gaussian [7]. With the help of these fuzzifiers we assign some membership function to each and every input and convert it into fuzzy set.

b) Membership Function

It is a graph between input and the membership value, which varies from 0 to 1. The membership function provides impreciseness to the fuzzy logic. There are various types of membership functions: Trapezoidal, Triangular, Gaussian, Sigmoid and Piecewise linear.

c) Fuzzy inference Engine

It consists of knowledge base, in which the rules are framed. Fuzzy inference engine can be broadly categorized into two types of methods: i. Mamdani method ii. Sugeno method Mamdani method is a fuzzy inferencing method in which the linguistic logic is used to make the rules. Mamdani method is easy to implement, user friendly and widely accepted method of fuzzy inferencing. The reason being is its wide area of application to most of the problems. On the other hand sugeno method is based on mathematical analysis and calculations [8]. It is more complex compared to the Mamdani method. Sugeno method works well with the linear systems. One major advantage is that it is computationally efficient.

d) Defuzzification

It is a process of converting a fuzzy set into classical set. It is the inverse process of fuzzification. It is of much importance as by Defuzzification process we convert the fuzzy values back into the classical or crisp values. There are different methods for Defuzzification such as the centroid method, bisector method, largest of maximum, middle of maximum and finally the smallest of maximum. Among all of this the most efficiently used Defuzzification method is the centroid method. A fuzzy controller can operate in a broad range of operations along with the variation of the parameters and load existence as compared to PI controllers.

The system is very dynamic, nonlinear, unpredictable, has a lot of uncertainty and its mathematical model is somehow complicated so the best choice is to use one of the expert-based systems, intelligent, such as fuzzy logic. The fuzzy logic will manage the flow of energy throughout the system to assure high-quality uninterruptible power delivery to the demand regardless of intermittent in the power generation. The controller has three main states as discharging mode which allows battery and hydrogen fuel cell to support the load, balance mode when supply power equals demand and controller at rest, and lastly, charging mode that allows battery and water electrolysis receive an excess of energy and store it to be used later.

5. RESULTS AND DISCUSSION

A grid-connected hybrid PV–wind- power with MPPT with fuzzy is proposed. The proposed hybrid system provides an elegant integration of PV and wind source to extract maximum energy from the two sources. The proposed system aims to satisfy the load demand, manage the power flow from different sources, inject the surplus power into the grid, and change the battery from the grid as and when required. And here fuzzy is proposed, this DC-DC converter system is proposed by close loop (FUZZY).Not many attempts are made to optimize the circuit configuration of these systems that could reduce the cost and increase the efficiency and reliability Detailed simulation studies are carried out to ascertain the viability of the scheme. The results are shown below:

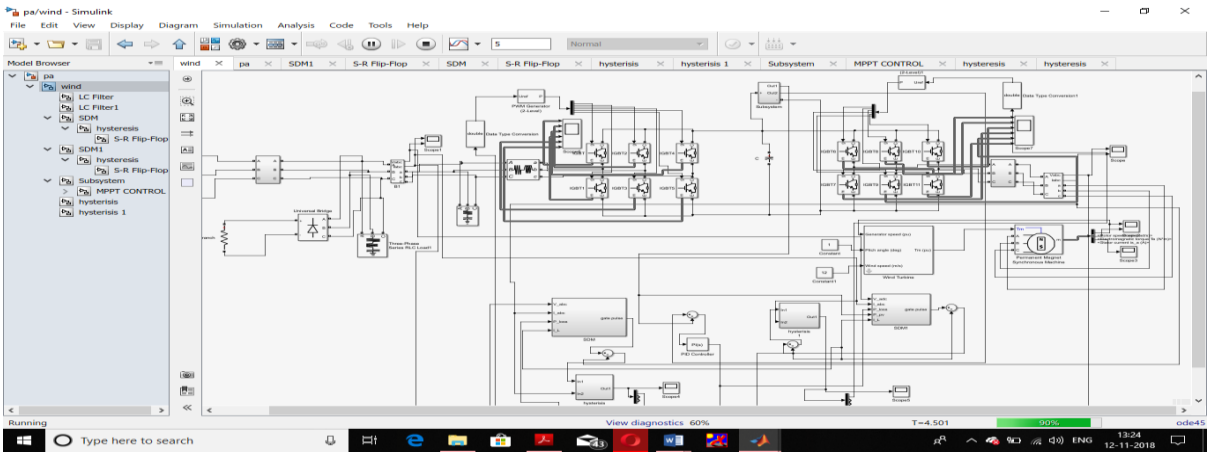

Figure No: 3 Full Model with PI Control

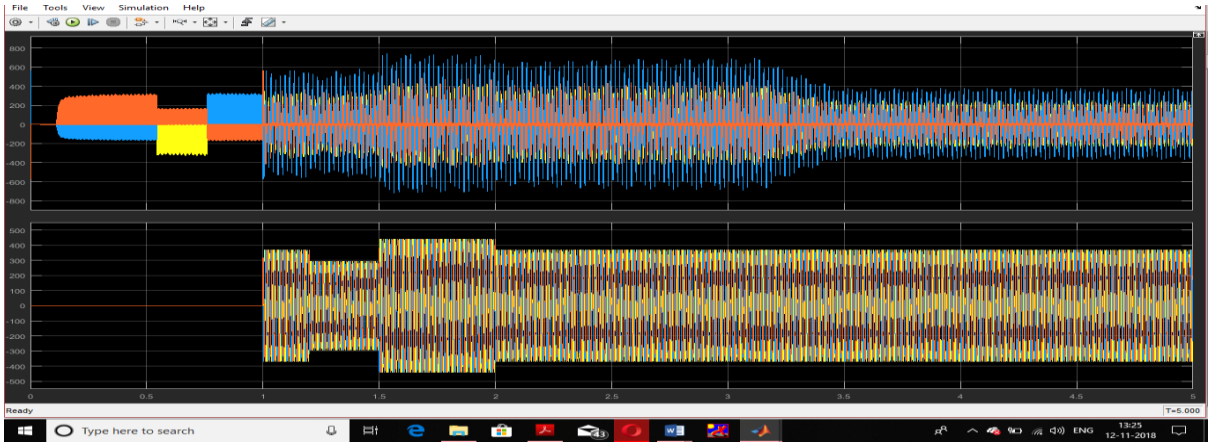

Figure No: 4 Wind and Solar Hybrid System

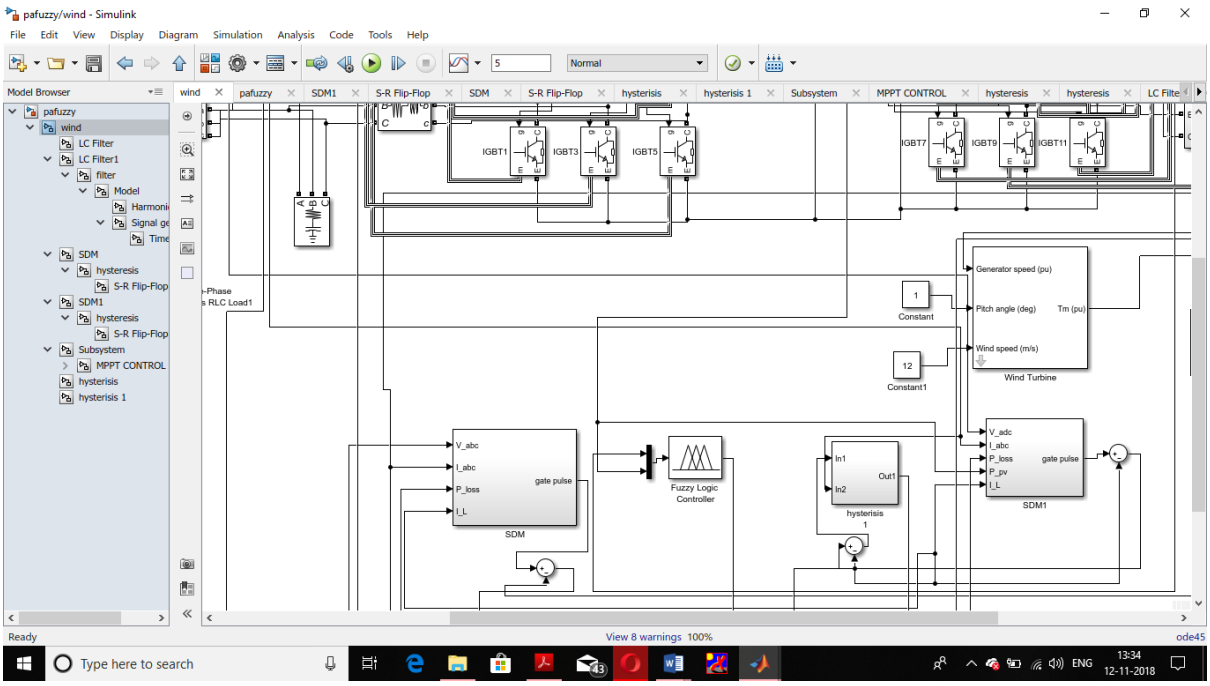

Figure No: 5 Full Model of Fuzzy Design

 Online ISSN: 2456-883X

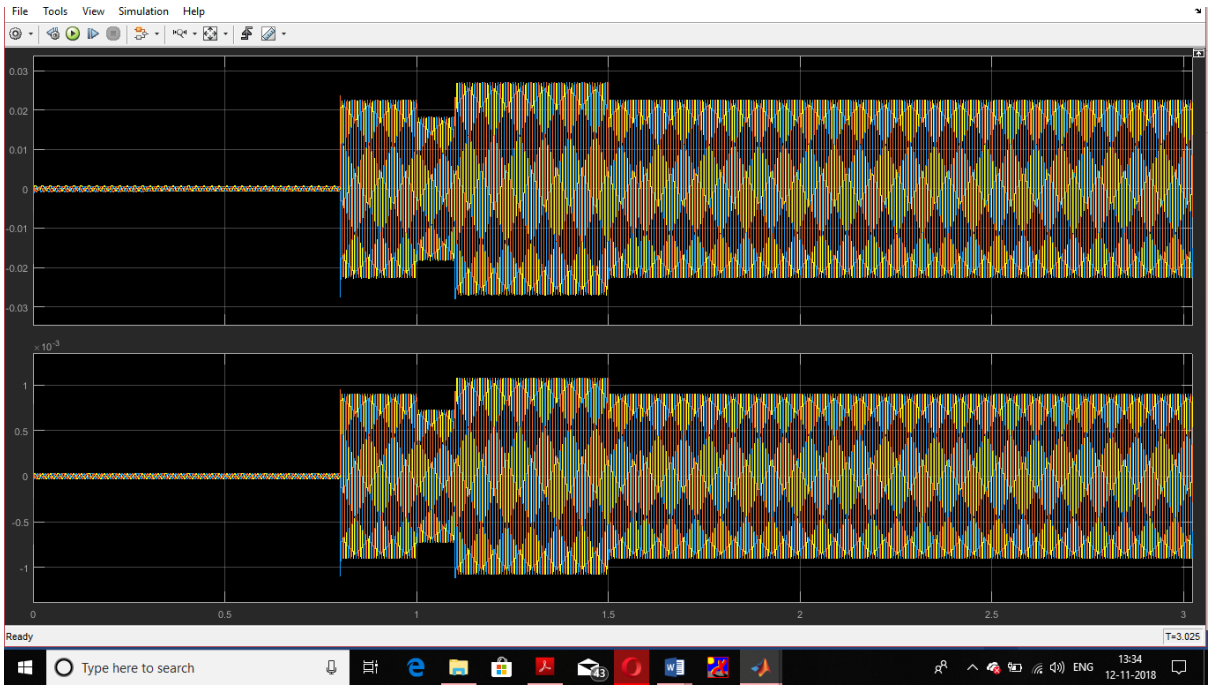

Figure No: 6 Fuzzy Design

The steady state performance of new reliable hybrid distributed generator fed PMSG-PV system with single boost converter followed by inverter has been studied and implemented. The mathematical modeling of hybrid PMSGPV system has been developed and corresponding voltage of both the sources matched. At the steady state condition the electromagnetic torque of PMSG is same as mechanical torque has been achieved. Maximum power extraction from both the sources takes place, load will satisfies the demand. Low cost, maintenance-free operation and reliability is required for distributed generator system for this reason low cost, simple wind maximum power point tracking with optimal torque control method is implemented. The proposed scheme easily finds the application in smart grids and domestic consumer sites.

6. CONCLUSION

The energy-related issues have been discussed and renewable energy is introduced as an alternative solution to minimize the financial and environmental effects of current energy sources specifically the ones relying on fossil fuels. Out of that discussion, the necessity of having energy storage system is shown as the system is driven by renewable sources and those sources are affected by weather conditions which are nonlinear, non-predictable and highly variable. Using at least two kinds of energy storage systems and two kinds of renewable resources will strengthen the system and increase its reliability and stability. However, this kind of systems requires an intelligent controller to manage the power flow and sustain the system. This electric combination allowed us to run the control strategy designed to wind system studied was the extraction of the maximum power demand "MPPT" using a speed servo controlled by a PI controller in adjusted earnings by trial and error. Moreover a solar based inverter has been developed along with fuzzy based controller which provides the reactive power requirement (in addition to the fixed capacitance) of induction generators under varying speed and loads in order to maintain the load voltage almost constant. Therefore, an attempt has been made to design a generalized fuzzy logic controller for isolated

hybrid scheme employing solar and wind (three phase and single phase self-excited induction generators) energy conversion system.

7. REFERENCES

[1] Chiang, H.C., Ma, T.T., Cheng, Y.H., et al.: 'Design and implementation of a hybrid regenerative power system combining grid-tie and uninterruptible power supply functions', IET Renew. Power Gener., 2010, 4, (1), pp. 85–99.

[2] Bae, S., Kwasinski, A.: 'Dynamic modeling and operation strategy for a microgrid with wind and photovoltaic resources', IEEE Trans. Smart Grid, 2012, 3, (4), pp. 1867–1876.

[3] Daniel, S.A., Pandiraj, K., Jenkins, N.: 'Control of an integrated wind turbine generator and photovoltaic system for battery charging'. Proc. British Wind Energy Conf., 1997, pp. 121–128.

[4] Rajan Singaravel, M.M., Arul Daniel, S.: 'MPPT with single DC–DC converter and inverter for grid-connected hybrid wind-driven PMSG–PV array', IEEE Trans. Ind. Electron., 2015, 62, (8), pp. 4849–4857.

[5] Subashini, N., Dharmalingam, V., Uma, G.: 'Design and implementation of a linear quadratic regulator controlled active power conditioner for effective source utilisation and voltage regulation in low-power wind energy conversion systems', IET Power Electron., 2015, 8, (11), pp. 2145–2155.

[6] Aguilar, O., Tapia, R., Valderrabano, A., et al.: 'Design and performance comparison of PI and adaptive current controllers for a WECS', IEEE Latin Am. Trans., 2015, 13, (5), pp. 1361–1368.

[7] T. L. Kottas, Y. S. Boutalis, and A. D. Karlis, "New maximum power tracker for PV arrays using fuzzy controller in close cooperation with fuzzy cognitive networks," IEEE Trans. Energy Convers., vol. 21, no.3,pp. 793-803,Sep.2006.

[8] G.B. Chung and J.H Choi, "Application of fuzzy PI control algorithm as stator power controller of double – fed induction machine in wind power generation systems," J. Power Electron., vol 9, no. 5, pp. 677 – 685, Sep. 2009.