Designing of Control Scheme For Hybrid Power System Using Fuzzy Logic Controller

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Abstract:
The development of renewable energy sources is a critical topic in 21st century. With growing problems of global warming and other environmental issues, researcher from all over the worlds have shown their interest in developing alternative energy resources i.e solar and wind for electric power generation. The objective of this paper is to introduce an innovative hybrid power energy system powered by solar and conventional power system which controlled by Fuzzy controller. Additionally, In Solar energy a maximum point tracking (MPPT) system is designed by fuzzy logic controller and tracked optimal power point. According to current revolution of communication in power system, FSK (Frequency Shift Key) based power line communication scheme is tested over this new hybrid power system. This proposed Fuzzy MPPT algorithm is implemented using MATLAB/ Simulink. From these simulation results, it is definite that this fuzzy model delivers superior power tracking performance in any weather conditions compared to already existing models.

Keywords *Maximum Power Point Tracking, Renew-able Energy Resources, Power line Communication*

I. Introduction

The demand of energy is increasing because of growing population and living way of people is going to be efficient. In addition, the harmful and serious effects on environment of petroleum products resources are also a big issue. Renewable energy resources are an option to full these energy requirements and have capabilities to overcome the burden on power system. Solar energy is more reliable but have some issues like climate changes that badly effect the solar power. To overcome these effects on solar energy, researchers proposed some maximum power point tracking algorithms and schemes but there found bundles of drawbacks of each algorithm. After the rapid changes of temperature and irradiation, these algorithms have no capabilities to track Maximum power point. There is need of an efficient MPPT scheme that can meet and resolve all these climate concerns. One method of open circuit voltage (V_{OC}) of PV panel and one issue with this method is to measure V_{OC} the power converters should shut down for some instant after each measurement there will be power losses. One more problem is the MPP voltage that is not able to measure continuously and also depend on approximation of one constant term, that's why it cannot say that is real. One more method that is based on short circuit (I_{SC}) and measurement of I_{SC} is a problem at running time of solar system because this configuration requires an extra device to short the converters for some instant. It is also problematic situation to measure I_{SC} after some time [1] and is caused of power losses. Perturb & observe and incremental conductance algorithms which observes if there is an increment in power then perturbation should be on same path but power is decreased then then perturbation should be on opposite path. Although these both are not bad options but it is not possible for both schemes to obtain maximum point at rapid change in power. The other problem of these two methods is the oscillations of voltage and current around the MPP in the steady state. [2] - [6]. The already exist algorithms for MPPT are worked on same purpose, but cannot able to judge the rapid changes in voltages are current.

As was earlier mentioned that MPPT algorithms are very essential for PV applications. The reason is the MPP of a solar panel is varied with variation of irradiation and temperature, so by using of MPPT algorithms it can obtain the maximum power from a solar panel. PV panels are generated DC power and supplied their electrical power to grid or home but AC power is needed for that purpose. Inverter is a device which can convert DC power into AC power in[7] to get maximum power from solar array MPP tracking algorithms are designed. Despite all these algorithms different inverter configuration is also very important [8]. To decide that what configuration is exact suitable for the solar panel MPP because there is continuously environmental variation. One important reason of inverter configuration is different MPP of each panel, so it is necessary to choose a best suitable configuration [9].

The distributed power generation systems based on RES like solar energy, wind energy and micro-turbines are called a hybrid renewables power system. According to [10] there is need to overcome the dependency to conventional energy power system. The distributed generation system integrated with various RES are allowed to attain higher efficiency and better performance. There are many methods of integrating different RES to a hybrid system. These methods are dc-coupled, ac-coupled, and hybrid-coupled [11]. In this hybrid system, various RES are integrated to a DC bus over associated power electronic devices like rectifiers or DC-DC converters. The DC bus voltage is converted to AC and DC loads is directly connected to DC bus. The generated voltage, current, and apparent power of each renewable source are measured and then decided the priorities of energy resource.

However, because of this huge size of power network and big investment that has been done over the years, then a

small significant change can be very much expensive and also needs an extra intention. The complexity is also increased by integration of huge amount of energy generation through renewable. After the integration of these alternative resources with conventional power system, it is required a communication setup to facilitate these complexities as well as to ensure its smooth operations, to overcome security concerns and facilitate the interconnected operations of supply side generators to end customers. Power line communication is an example of smart grid application but faces difficulties in communications networks like noise on channel is a very unfamiliar characteristics and that level of noises may be excessive. Moreover, the electromagnetic compatibility is also an issue in interfacing of PLC circuits with electrical power lines then there are required coupling circuits that can merge communications equipment's with power lines.

After studied the detailed scenarios, the goals of this paper are an efficient MPPT algorithm for solar arrays with their proper adjustments and a communication link between these suggested models. A fuzzy logic based optimize algorithms is referred to track maximum power. Finally, the main purpose is to develop a model with integration of these alternative resources and Power line communication is used as communication link with frequency shift key modulation schemes.

II. Layout of Hybrid Power System Model

A hybrid power system that is controlled and optimized with FLC as shown in Figure 1. There is modeled a solar panel and then by fuzzy logic scheme the MPP is optimized. Solar panel is constructed under these parameters like open circuit voltages, short circuit current, optimum voltages and optimum current. Then Fuzzy Logic Controller with Rule viewer is selected to design FLC based hybrid power system. That is fixed the panel voltages as per battery required and also meet optimum current. The panels configuration is developed that is made of different arrays in string structures to feed power converters. After merged these sources a FLC is placed to select the power source according to its loads as shown in Figure 1. To fulfill the need of communication between power system and end load, the power line communication setup is tested.

A. MPPT of Solar Panel

This proposed configuration where it is suggested that each PV panel have its own inverters and therefore MPP is also connected to each panel and from this configuration each panel have its own MPPT. Although this configuration is very expensive but very optimize configuration. In addition, it is very useful for large size of solar panels.

There are two inputs of FLC based MPPT as shown in figure.2. One is irradiation (S) and second one is Temperature. The reason of taken these two input is that both have continuously variation and the parameters of controller are depended on both these two inputs. The parameters of input are given below. Irradiation are changed continuously that's why it has four input variables of different ranges. There are input variables of S are given with their different ranges and similarly temperature is changed continuously therefore five input variables of different ranges are taken. The output and rules are set by rule editor. PV array is constructed over Table.1 parameter.

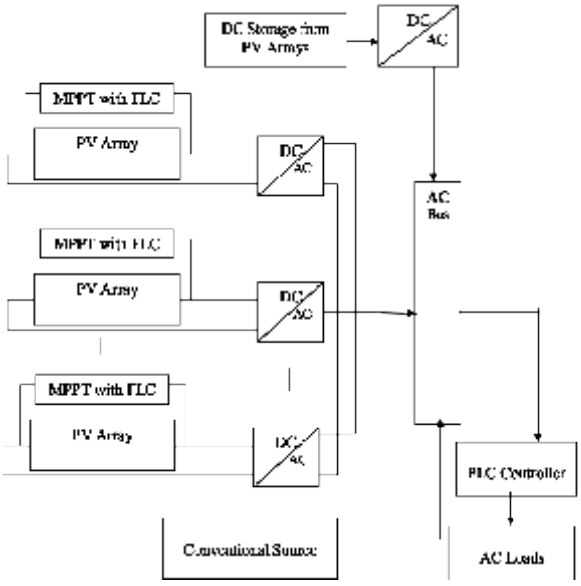

Fig. 1. Model Layout of Hybrid Power system

TABLE I
PV PANEL PARAMETERS & RATINGS

Sr.no	Parameters	Ratings
1.	Maximum Power	240 watts
2.	Optimum Power Voltage (Vmp):	30.72 volts
3	Optimum Operating Current (Imp):	7.81 amps
4.	Open Circuit Voltage (Voc):	36.60 volts
5.	Short Circuit Current (Isc):	8.36 amps
6.	Temperature Coefficients of Isc (%)	°C: +0.04
7.	Temperature Coefficients of Voc (%)	°C: -0.35
8.	Temperature Coefficients of Pm (%)	°C: -0.45
9.	Temperature Coefficients of Im (%)	°C: +0.04
10.	Temperature Coefficients of Vm (%)	°C: -0.35
11.	Temperature Range:	-40°C to +85°C
12.	Tolerance Wattage	+/- 3%
13.	Surface Maximum Load Capacity	5400Pa
14.	Cell Efficiency (%):	16.77%
15.	Module Efficiency (%):	14.78%
16.	Standard Test Conditions	1KW/m,25+/-2°C

These are rules when all climate changing is set as input. Then the output action can set by rules where zero means that is situation when there is need to power ON devices. Zero= 0, Check =5-7 Volts, rated= 30.72 volts are observing parameters. The action on zero output will be turn OFF devices that will be at night time or when the sun is not available. The output action check means that is condition when panels placing is not adjusted well so action will be any alarm. So, that panels placing is needed

to adjust. The output action rated means that power is available and just need to track MPP and battery will be charged at fix voltage constant. The rules are clearly shown that Vm always be tracked continuously then output is attached with PWM generator that is further connected with MOSFET. Then output will remain optimized at every possible situation whenever sun is available. The voltage level is controlled by controller that is connect with DC converters. This power system based on solar power with integration of conventional power and to meet with the challenges of climate changing that effects to solar power there is a FLC based MPPT algorithm is designed. This algorithm is placed to overcome the drawbacks of others MPPT algorithms. Although all these schemes are in used for different application of solar energy but FLC that is suggested in this model more attractive and more optimizing technique to obtain MPP. This not only feasible for the change in power due to changing in PV voltages and PV current as well as PV power and also very suitable for the sudden change in irradiation. It is clear that there is a need of DC-AC inverter to utilize DC power of solar array in useful purpose because most of the loads are founded AC loads. Each PV array has its own MPP so it is impossible to optimize all panels at same MPPT. Therefore, a need of inserting an individual MPPT for each panel and arrangement of inverters, both can see in figure1. Here, it can observe that the FLC algorithm based MPPT for each panel is placed. Although this is a very expensive way but also a very optimize method to operate each panel at MPP. The results are discussed further in details.

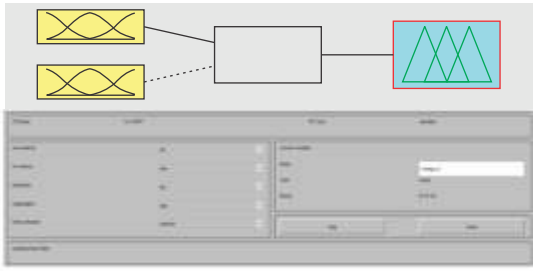

Fig. 2. Two inputs of FLC based MPPT

B. Fuzzy controller for Hybrid Power Station

This attained AC power from this above configuration is linked to the AC bus bar. The objective of this proposed model is to introduce an innovative energy system for consuming renewable energy. To increase reliability of electrical power there is an option of conventional energy resources. So, AC bus is powered by solar energy, conventional energy and DC storage bank. The one more FLC is placed to facilitate the selection from input powers. There are some conditions to operate FLC on desired purpose and simulation results of this controller are also discussed in detail in next section and condition are:

- If load is higher than the production of power from RES, then controller will switch ON the conventional supply in order to operate the load.
- If load is less than the production of power from RES, then the controller will switch on the supply of RES system as well as store the remaining power in dc bank.
- Of load is equal to the production of electricity from RES then both supply conventional supply (for store power) as well as solar system will on to continue the supply of electricity.
- Is there is no solar supply from RES as well as no supply of conventional supply then there is a backup supply of electricity as a dc battery (storage system) to continue the supply of electricity.

C. Power Line Communication of Proposed Hybrid Power System

Most of the power systems that are developing for upgradation, they are using power line communication to achieve this purpose. PLC have provided an option to use same power line for dual purpose. That is a major point of power systems of using electrical infrastructure for data communication. The main problems are the different values of their different parameters. For example, power system ratings are high power, high voltages and low frequency but in PLC there are low power, low voltages and very high frequency. It is impossible to do direct communication through power lines, there are needed some line matching unit or coupling unit to engage information with power lines. In addition, there is further two topologies to deal with this compatibility problem based on power line voltage that are low voltage coupling circuit and high voltage coupling circuit. Each are used inductive coupling or capacitor coupling but the different is only to implement according to their voltage level. There is digital communication through PLC, so there is tested FSK techniques to make sure that PLC is also applicable.

III. Simulation and Results

All these models test over MATLAB Simulink. Then Fuzzy Logic Controller with Rule viewer is selected to design FLC based hybrid power system. Solar panel is constructed according to table 1 parameters ratings.

TABLE II
PV PANEL RESULTS WITHOUT MPPT

Sr.no	Parameters	Ratings
1.	Irradiation	1000 W/ m2
2.	Temperature	25 Co
3.	Power	14.4 Watt
4.	Current	0.4 ampere
5.	Voltage	36 Volt
6.	Efficiency=	6%

A. MPPT Results

It can observe that whenever irradiation is decreased then sudden change in current of PV array as well as sudden

change in power. Voltage variation is very problematic to charge the battery because batteries need continuously constant voltage of rated value at which battery is charged efficiently. So without using MPPT algorithm, it is impossible to track even ten percent of rated power as shown in figure.2. Observed result from Figure are shown in Table II.

TABLE III
PV PANEL RESULTS WITHOUT FLC BASED MPPT

Sr.no	Parameters	Ratings
1.	Irradiation	1000 W/ m2
2.	Temperature	40 Co
3.	Power	14.4 Watt
4.	Current	0.4 ampere
5.	Voltage	36 Volt
6.	Efficiency=	6%

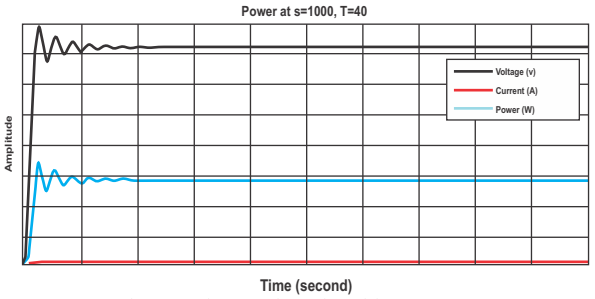

Fig. 3. Solar Panel results without MPPT

It is fact that with FLC Based MPPT, the power is optimized to 92%. That can see in Figure under these parameters. T= 25 Co and S= 1000 W/ m2 Then the results are: P= 220 Watt Voltage = 30.72 Volt, Efficiency= 92% as shown in Table III as well as Figure 4.

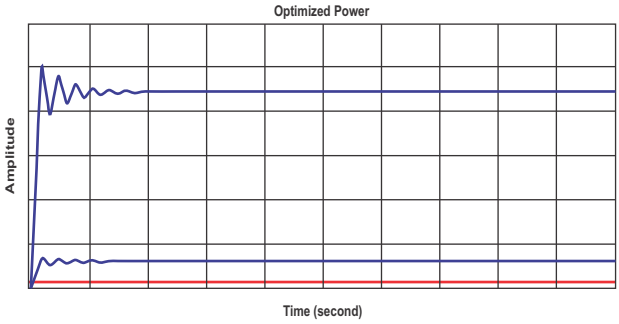

Fig. 4. Solar Panel results with FLC based MPPT

B. Fuzzy controller for Hybrid Power Station

To Move towards power line communication, there is developed FLC controller for selection of power according to load. This controller read loads measurement and then decide how much power is required from RES. Inputs of FLC are solar and conventional generation and their ranges are adjusted in such way every possibility can be adjusted as shown in Figure 5. After getting the input and output ranges there is constructed rules according to load values. These results are shown at one instant of power systems where some power is getting from solar and remaining power is obtaining from conventional source according to load measurements. The surface view is shown in 6.

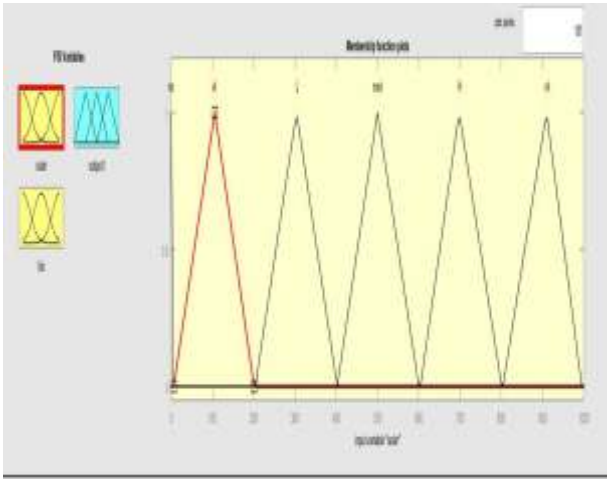

Fig. 5. Solar and conventional generation Inputs of FLC

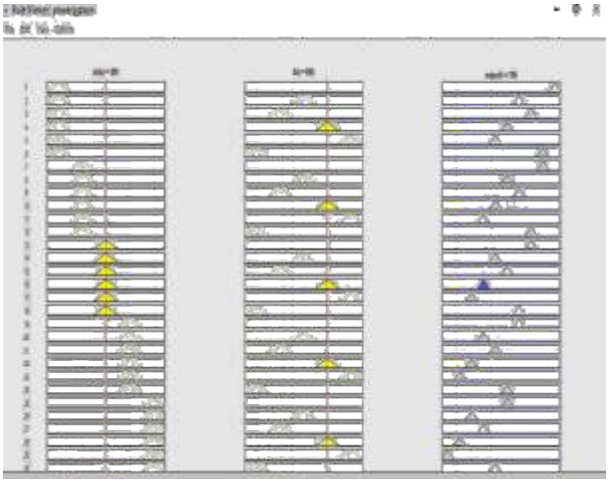

Fig. 6. Results at one instant of Hybrid Power System

C. Testing of Power Line Communication using FSK

A digital data from MATLAB Simulink library is taken where binary number as input. That can see in Figure 7. (plot of input). Then it modulated on Simulink that is shown in Figure.7 (Modulated Signal) where the modulated signal generated of almost 1200c00 hertz. The carrier signal is sine wave from signal generator. Now next task is to couple this modulated signal with power lines. Then this FSK modulated signal with noise is coupled with power lines as shown in Figure.7 (Coupling signal). That have frequency of 50 hertz and amplitude of 220 volts because AC power line is designed on same parameters. High pas filter is used and other coupling is provided at receiver end to connect with demodulator that is shown in Figure.8 (Demodulated signal) Band limited white noise and random noise, there is an option to select that which noise we want to insert. In Simulink we can change manually with the help of switch. This time random noise is selected.

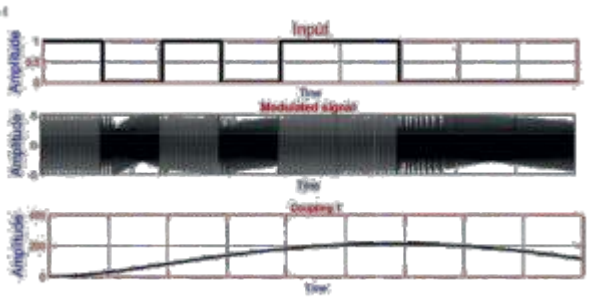

Fig. 7. PLC results of Input, Modulation and Coupling

Then a coupling circuit is provided to couple demodulator with power line, it's just like coupling provided to modulator. There are low pas and high pass filter are inserted in cascade with cut of frequencies 10000,100000 hertz respectively. It is desired band that is required to demodulator that is shown in Figure.8 (coupling). Further that signal is converted into digital data where there are provided 9 pulse to logic operator.

Logic AND operator is used and input of logic operator are FSK input and pulse. Pulse is generated through unit step function. It compares with FSK where its high then AND operator send logic high otherwise low. That is shown in Figure.(output plot). The demodulator is shown in Figure8. That is constructed over the features of FSK modulator. The modulated signal, both coupling, demodulator and out results are shown in Figure.8. These results are shown a communication link for hybrid power system using Power Line Communication that is tested over AC line of hybrid power system.

IV. Conclusion

This hybrid power system is merged through solar energy and conventional power system to increase the reliability of electrical power and it is a forwarding step to utilize renewable energy with small scale energy systems. Panel's selection, panel's adjustment, MPPT of PV array and its utilization with their suitable application are key parts of this research. In addition, there is also inserted a FLC on AC bus to facilitate in the selection of energy resources according to their loads. All results of proposed schemes are shown then briefly discussed where it is found that without MPPT algorithm it is not possible to optimize MPP. The deficiencies of different MPPT schemes are discussed and then FLC based MPPT shows that it is not only optimized and also resolve the issues that were found in previous schemes. At the end simulation test of PLC is successfully tested over AC bus bar of hybrid power system.

V. Future Work

This proposed methodology is validated for Low Voltages. These schemes can applicable for medium voltage and high voltages and more flexible for different RES based power system and power distribution units. It can more enhance towards smart metering, load management and home automation. There is also need to improve semiconductors devices more efficiently.

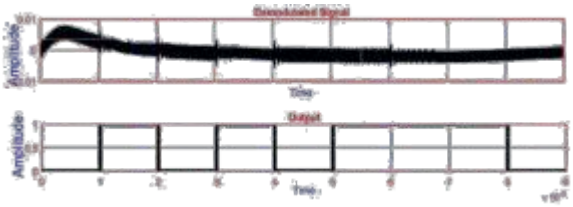

Fig 8. Results of Demodulation and output

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