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IMPLEMENTATION AND ANALYSIS OF HYBRID SOLAR PV AND WIND ENERGY BASED MICROGRID

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***Abstract*— The hybrid energy system combines two or more sources of energy to produce and consume the energy efficiently, which results in a flexible source. Hybrid sources are made up of a combination of solar and wind energy. The end result will be superior because these two resources are complementary. Here, MPP is tracked by the fuzzy logic method and MPVRS based P&O technique. Maximum power is extracted from a two hybrid renewable energy sources such as wind and solar energy. Fuzzy & MPVRS based P&O algorithms are utilized in this MPPT approach to extract the highest wind and solar power output with less or no oscillation than other MPPT method. SEPIC converter is introduced to raise or reduce the output voltage level while the Z- Source inverter is used for conversion of dc to ac. Finally, the output power is transferred to the micro-grid. MATLAB is used to model solar, wind, battery, converter, inverter and creating rules for fuzzy algorithms. Finally, the extracted maximum power from two sources is given to the micro grid.**

Keywords*— *MPPT, Fuzzy algorithm, SEPIC converter, quasi-inverter, hybrid energy

I. INTRODUCTION

Micro grids are made up of interconnected loads and distributed energy resources such as energy storage devices and some active loads that work together as a controlled unit to meet the electric demand for a small area. Traditional energy sources are not environmentally-friendly and there will be significant power losses due to long-distance transmission. As a result, researchers and industries are now focusing more on renewable energy sources to generate alternative power. This paper proposes a Fuzzy Logic MPPT technique applied to a photovoltaic panel with a SEPIC converter under uneven temperature and irradiance. MPVRS P&O (modified power ratio variable step based perturb and observe) technique is used for tracking highest power from wind energy with permanent magnet synchronous generator. By using these two MPPT algorithms the maximum power is tracked and given to the micro- grid.

II. LITERATURE SURVEY

[1] For solar PV applications, this research proposed MPPT approach based on the BAT optimization algorithm and FLC. The results demonstrated that PV system efficiency is furnished with BAT-FLC MPPT algorithm is 99.8% when compared to other approaches. [2] A unique hybrid model of PV and wind power is designed in this paper. The collected findings indicate that the designed ICM-HCS-based ANFIS MPPT controller produced the highest power with the minimum oscillations. [3] The purpose of this study is to simulate and regulate a PV-wind micro-grid utilizing a quasi-inverter. The d-SPACE hardware was used to evaluate the grid system under various scenarios such as solar irradiation, wind speed, load cutting and removal, and so on. [4] This study provides speed sensor of wind but less MPPT technique for a changeable speed wind energy conversion system. This method has been demonstrated to be able of searching for MPP in real time. Detection of speed changes allows suggested method to operate in real time with shifting wind speed situations. The Q-learning technique has ability of recognizing MPP when the structure is uneducated, functioning at MPP with fluctuating wind speed. [5] The micro grid with the minimum converters is built on wind turbine driven DFIG in this paper. System has been modelled for a variety of circumstances, including varying speeds, insulation, and unbalanced load linked in PCC. A prototype was created to test the micro grid’s steady state and dynamic capabilities. [6] An experimental investigation of hybrid micro grid scheme is presented in this work. The network is a combination of renewable energy sources. Battery is used in an energy storage system (ESS). [7] A hybrid energy storage system with fuel cell as the primary source, battery as backuppower source is established. Proposed framework may modify the flop gain for both sources, allowing FC-battery to supply power output under various circumstances. As a result of the higher charging, discharging cycles the size of battery gets reduced while its lifetime is enhanced. [8] This research discussed an effective control technique for a bidirectional inverter in hybrid system. Suggested technique depends on voltage regulation capacitors using an ESS side buck-boost converter. [9] The FLC MPPT is introduced to increase performance of PEMFC systems. The benefits of the suggested technique include a fewer number of sensors used, quick MPPT withdrawal. [10] In this work, whale optimization algorithm with battery and fuzzy logic is used its efficacy is tracked. [11] Battery storage is commonly used in PV systems to diminish power oscillations caused by PV panel characteristics and solar irradiance. [12] The output voltage across load is the parameter considered when analysing the efficiency of the MPPT controller. [13] Under different weather circumstances, the performance of proposedsystem is evaluated in standalone and grid-connected modes.

[14] Since irregular character of renewable sources, power generation from them fluctuates. Power supply frequency deviates from the desired frequency, mismatched amid

generation and load demand. [15]. Non-clock gating technique is explained in this paper. [16]. Differential Evolution algorithm is dealt in this paper [17].Connectivity regulation is designed in such a way that it reduces the problem of partial shading [18]. The methodology used here provides excellent driving control to enhance PV potential extraction. The proposed grid-integrated PV system has been validated in practice with a MATLAB interfaced dSPACE, and the results accurately justify the proper design of control algorithms used with higher performance.

III. PROPOSED METHODOLOGY

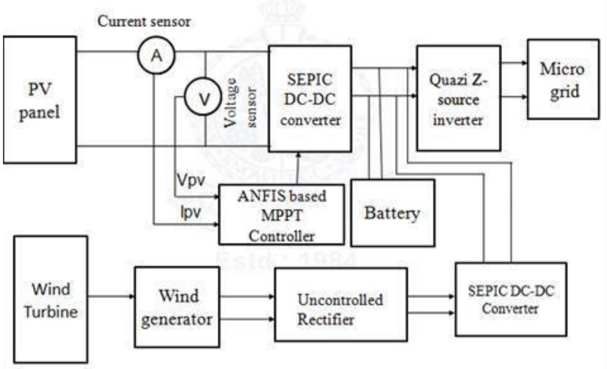

Fig1.Block diagram of proposed system.

The objective of the project is to track maximum power point of hybrid solar - wind using MPPT algorithm with SEPIC converter. In Fig 1, PV, wind turbine, battery and power electronic converter comprise a micro grid system. Equivalent circuit with single diode model for PV is utilized to analyse the proposed system because it has a high power extraction capability. To generate electricity, the wind turbines rotor is mechanically linked to generator. Battery is required to stable the fluctuations of PV and wind power introduced into the load. The block diagram explains about the hybrid system based solar PV and wind energy.

The current & voltage from PV panel is sensed by the current sensor and voltage sensor. These values are given to the Fuzzy based MPPT controller and the rules are framed for this technique. Then the duty cycle value is given to the SEPIC converter. Here, SEPIC converter acts as a boost converter and then output values are boosted up. Finally the output values are given to the quasi-z- source inverter for the conversion of dc output to ac output. The battery is connected to the inverter for the conversion of output.

The wind turbine speed is given to the wind generator. Here MPVRS based P&0 algorithms are used for tracking maximum power in the wind. Here the SEPIC converter output value is given to the quasi-Z-source inverter and finally all the output values are given to the load. Load is linked to the micro grid for the distribution of energy.

IV.SOLAR PV ARRAY

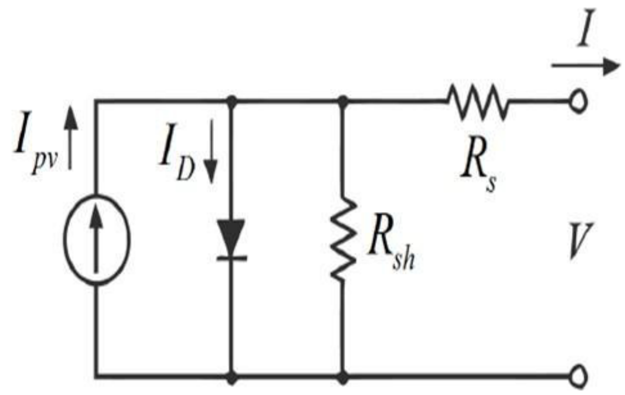

Fig 2.Equivalent circuit of PV module

Figure 2 depicts the equivalent circuit of PV cell. Cell photocurrent is represented by current I. Rsh, Rs are cell's shunt and series resistances. Since the value of Rsh is usually v large and that of Rs is very small, they can be ignored to simplify the analysis. PV cells are grouped into larger units known as PV modules, used to generate power in PV generating systems.

Table1: Parameters of solar system

1	Open circuit voltage	32.8 V
2	Short circuit current	8.2 A
3	Voltage at maximum point	25 V
4	Current at maximum point	8.01 A
5	Rated power	200.2 W

A. PV array modelling in MATLAB

1 Saturation Current

$$I_o = I_{rs}.(T/T_n)^3.\exp[q.E_{go}(1/T_n - 1/T)/(n.K)]$$

$\longrightarrow$ (1)

2 Reverse saturation current

$$I_{rs} = I_{sc} / e^{[q.v_{oc}/n.N_s.K.T]^{-1}}$$

$\longrightarrow$ (2)

3 Current through shunt resistor

$$I_{sh} = (V + I.R_s / R_{sh})$$

$\longrightarrow$ (3)

4 Photocurrent

$$I_{ph} = [I_{sc} + Ki.(T - 298)].[G/1000]$$

$\longrightarrow$ (4)

By using all these equations, the blocks are created in the MATLAB

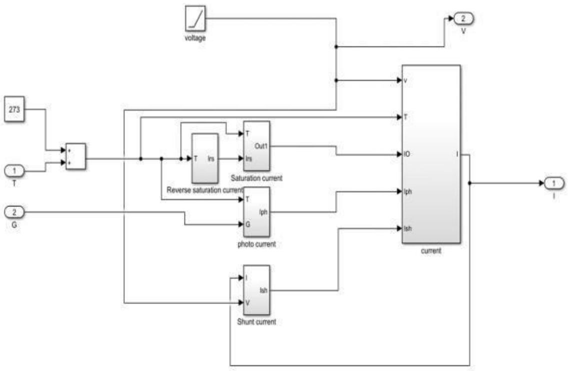

Fig 3. Interconnection of all the blocks

The blocks are interconnected to get the PV and IV curves as shown in fig.4 & fig 5

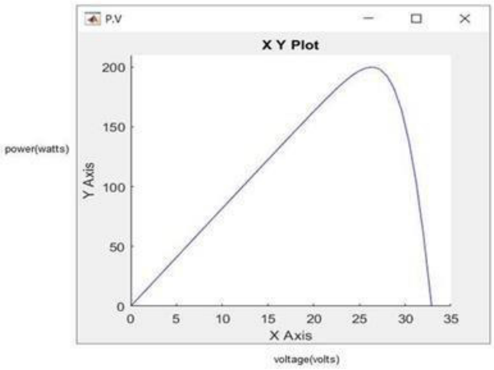

Fig 4. PV curve

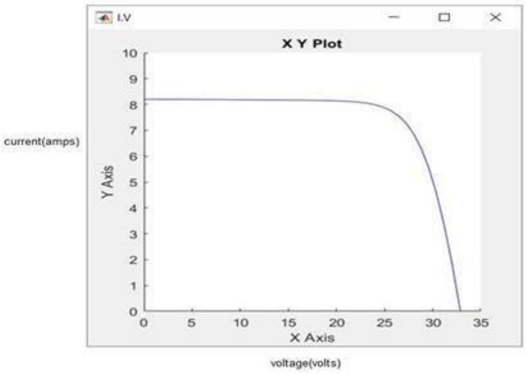

Fig 5. IV curve

Fig. 6 &7 shows output current, voltage and power of solar PV system

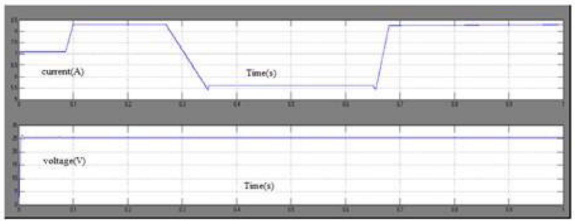

Fig 6. Output current and voltage curve

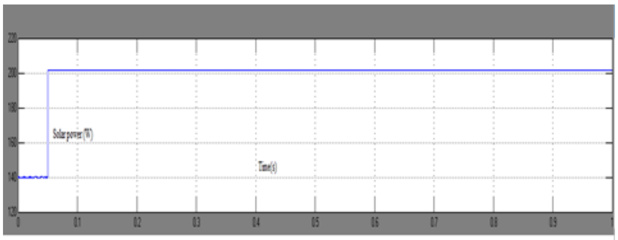

Fig 7. Output power

B. Wind Turbine

Wind turbine is a machine that converts kinetic energy into mechanical energy, which is then converted into electrical energy at the turbine shaft. Wind turbine power generation is primarily determined by wind velocity, with the rotors mechanically linked to a generator. The power coefficient (CPR) is function of tip speed ratio and blade pitch angle can be used to create a simple model. Wind energy is a renewable resource that produces no pollution. It can produce energy in remote areas where other forms of energy are unavailable. A wind turbine has a typical life span of 20 years with routine maintenance. When coupled with an energy storage device, turbine output power is changeable because of fluctuations in wind speed; Wind provides a steady power output.

C. Wind turbine modeling equations

1 Mechanical power output

$$P_{Mechanical} = 1/2 C_{PR} \pi R^{2}{}_{T} \rho_{a.d} V^{3}{}_{Wind} \rightarrow \quad (1)$$

2 Tip speed

$$\lambda_{T.S} = (\omega_{A.V} \times R_{T}) / V_{Wind} \rightarrow \quad (2)$$

3 Coefficient of performance

$$\eta_{gear} = \omega_{GM} \times R_{T} / \lambda_{T.S} V_{Wind} \rightarrow \quad (3)$$

$$\lambda_{T.S} = \omega_{G} \times R_{T} / V_{Wind} \times \eta_{gear} \rightarrow \quad (4)$$

The wind turbine is modelled by using the above equations.

D. Modeling of wind turbine

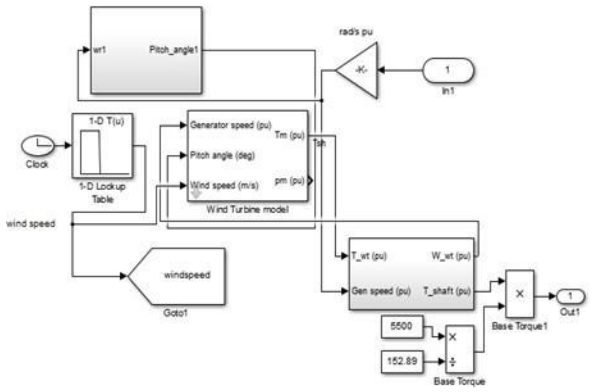

Fig 8. Wind turbine model

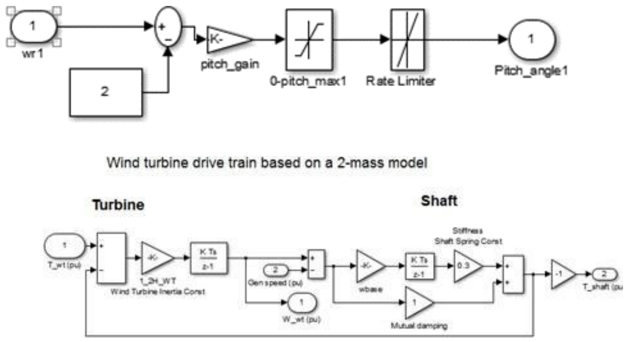

Fig 9. 2-mass model based wind turbine

For coupling generator and wind turbine, control of pitch angle at high wind speeds and desired power quality, two mass drive train models are established in fig 8 & fig.9. This control format is designed for grid side converters for achieving synchronized voltage on the grid. Here permanent magnet synchronous generator is used.

E. Designing of SEPIC converter

The single ended primary inductor converter acts as impedance adapter among Z-source inverter & PV module, providing high gain during working, improved voltage performance and a high voltage evaluation for lower/higher power necessities. A SEPIC converter is created when a boost converter is combined with an additional inductor and a capacitor. Unlike buck boost, polarity of the SEPIC is maintained positive. It allows output voltage to be superior than or lesser than or equal to its input voltage. The output of SEPIC is controlled by duty cycle of switch. It has several advantages compared to other converters. It possesses non inverting output and low current pulsating; and it is significant to track MPP for energy sources. It reduces the necessity for additional filter elements. Active power switch (IGBT), diode, two inductors (LA,LB) and two capacitors (CA,CB) are used and the values are shown in fig 10.

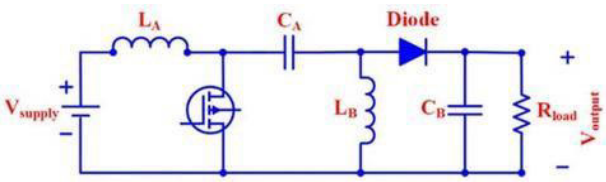

Fig 10: SEPIC Converter design

Table 2: SEPIC converter Parameters

S. NO	PARAMETERS	VALUES
1	Inductor 1 Inductor 2	0.42 mH 0.42 mH
2	Capacitor 1 Capacitor 2	3.5 ηF 3.5 ηF

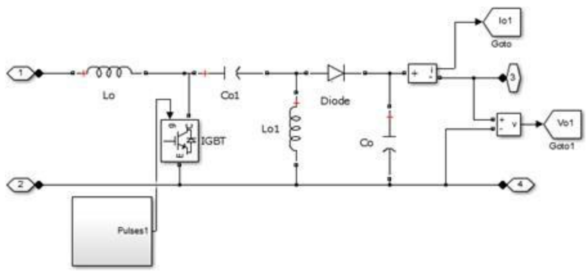

Fig 11: SEPIC converter simulation

F. Quasi-z- source inverter

This circuit is made up of two inductors and two capacitors are shown in fig 12. It has better buck/boost characteristics, is capable of regulating the phase angle output, is smaller in size, operates in continuous conduction mode, has less harmonic content, and it is more efficient with better power performance than other conventional inverters.

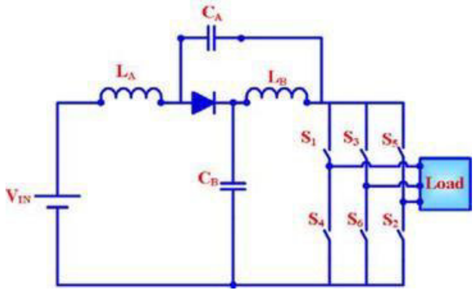

Fig 12. Quasi-Z-source inverter

Table 3. inverter parameters

S.NO	PARAMETERS	VALUES
1	Inductor 1 Inductor 2	3.5mH 3.5mH
2	Capacitor 1 Capacitor 2	1.2µF 1.2µF

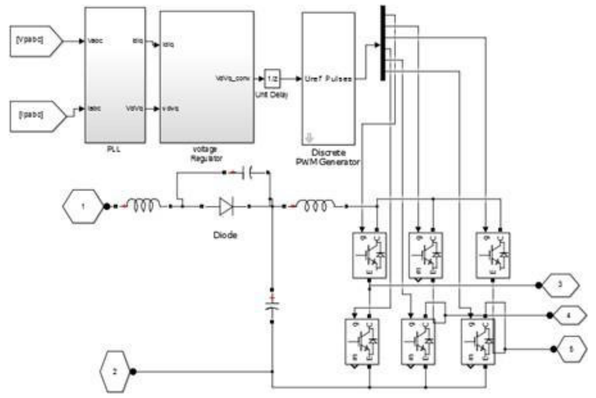

Fig 13. Quasi-z- source inverter simulation

G. fuzzy Algorithm

The Fuzzy-based MPPT algorithms are very accurate because they track the maximum power point without interrupting the circuit (or short-circuiting the PV module terminals), as traditional MPPT algorithms do. Fuzzy analysis is a technique for solving troubles that involve uncertainty and ambiguity; it is used in many fields, including engineering also applications in decision making, planning and manufacturing. Because of their ability to handle nonlinearity in the system, fuzzy logic-based intelligent MPPTs have gained popularity. Fuzzy MPPT (FMPPT) is found to be more apt for tracking MPP in PV System than conventional algorithms due to a lack of precise PV module modelling and uncertainty in PV system performance due to varying irradiance and temperature.

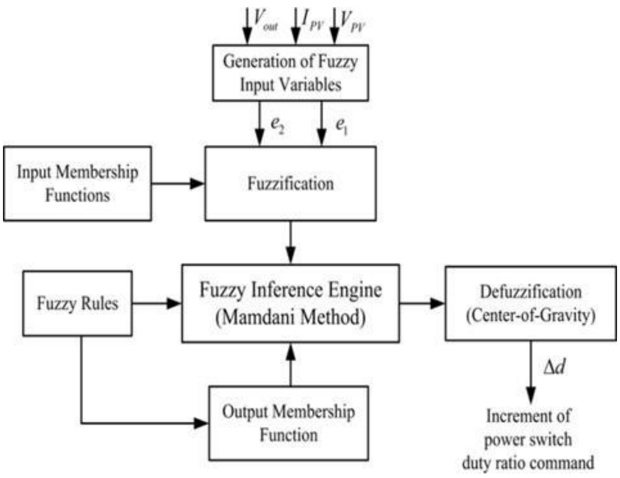

Fig 14. Flowchart of Fuzzy algorithm

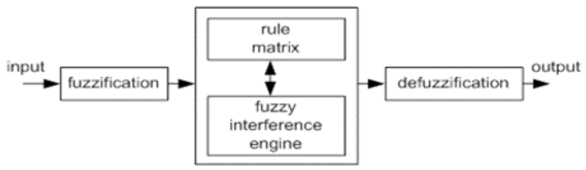

Fig 15. Fuzzy technique

Fig.14 shows two inputs are given to a Fuzzy interference engine. The Mamdani method is used for Fuzzification, rule inference & Defuzzification are the three functional blocks. In the projected work, FLC's input variables are error (E) , change in error (delta E) and the FLC's output variable is duty cycle change. The design considerations and effectiveness of the fuzzy MPPT algorithm are dependent on the input and output variables chosen. The FMPPT algorithm's output variable is typically a duty ratio command for adjusting the operating point of PV module to maximize power output. The slope of P-V curve and changes in this slope are the most commonly used input variables for FMPPT. The fuzzy membership functions and fuzzy rules are shown in Fig 15&16.

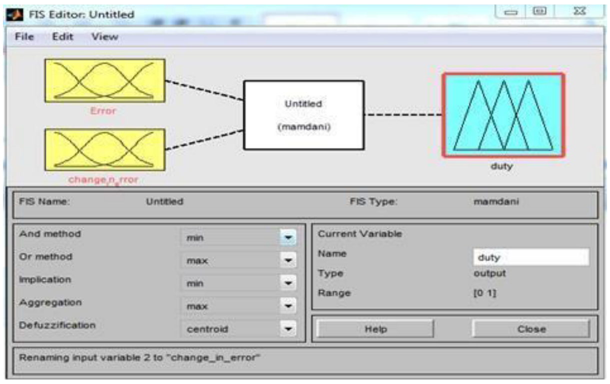

Fig 16. Mamdani technique

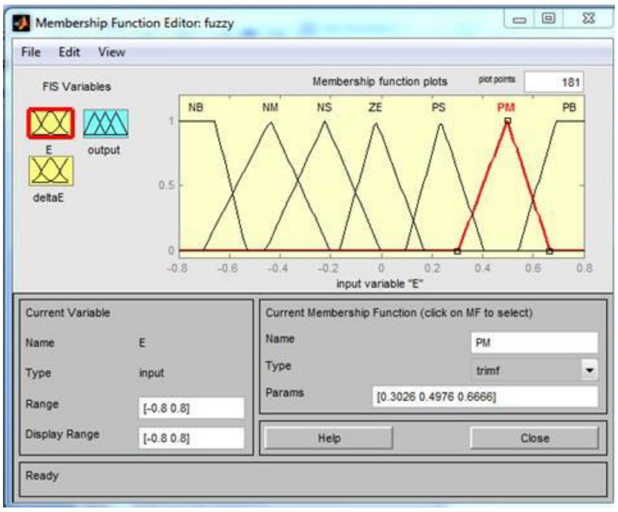

Fig 17. Fuzzy Membership function

NB – Negative Big, NM – Negative Medium, NS - Negative Small, ZE - Zero Error, PS – Positive Small, PM – Positive Medium, PB - Positive Big. These are the membership function plots shown in fig 17.

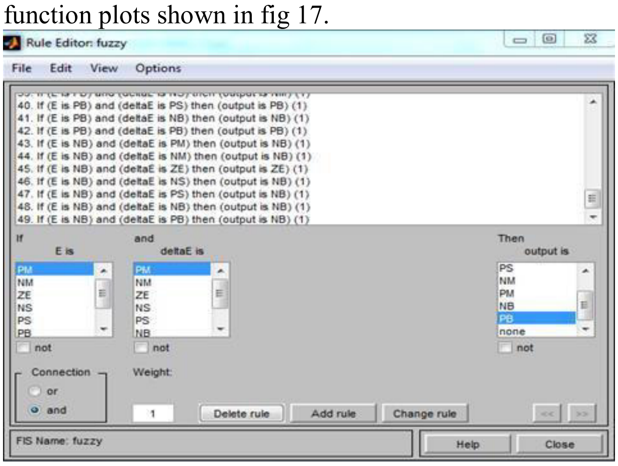

Fig 18. Fuzzy rules

The input variables E and deltaE also the output variable Duty cycle are converted into linguistic variables during the fuzzification process by assigning membership function values.49 rules are framed as shown in fig 18. These variables have fuzzy levels NB, NS, ZE, PS and PB. In this work, triangular membership functions are considered, which assume that for any given input, there is only one dominant fuzzy subset as shown in fig 19.

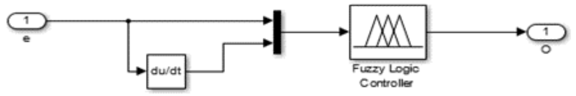

Fig 19: Implementation of Fuzzy block in solar PV system

H. MPVRS based p&o technique

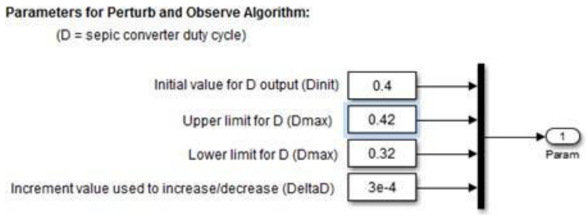

Fig 20. Parameters for perturb and observe algorithm

The proposed MPRVS-based P&O MPPT's accuracy was checked using the depicted varying operating conditions of wind. SEPIC controller functioning in the MPP region and provide best wind power tracked under sudden changes in wind velocity. The SEPIC converter's corresponding duty ratio is shown in Fig 20.

I. Battery

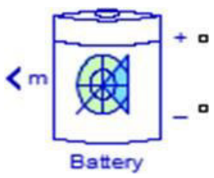

Fig 21. Battery

Battery is a necessary element of a hybrid system that offers a solution for irregular renewable energy sources. Here an electric circuit-based battery model is used, which provide superior dynamics for a state of charge mode. It is made up of an ideal voltage source and a series of internal resistances that are used to assess the battery's performance. It also serves as a storage device. It will be more useful for delivering power when solar and wind are unavailable. Here A rechargeable battery like nickel metal hydride battery (Ni–MH) is used.

J. Hybrid System Design

This system simulation consists of implementation of PV system, SEPIC converter, wind turbine and Z- source inverter and micro grid shown in fig 22.

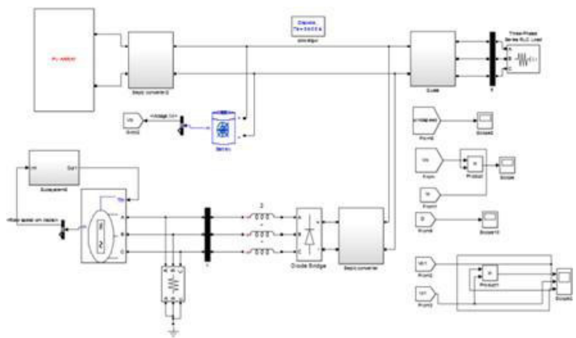

Fig 22. Simulation of hybrid system

K. Comparison between MPVRS and FUZZY

Modified power ratio variable step and fuzzy method comparison is shown in fig 23&24.

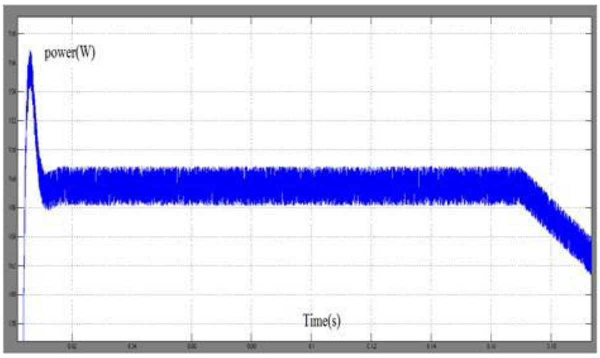

Fig 23. MPVRS P&O algorithm based solar output power

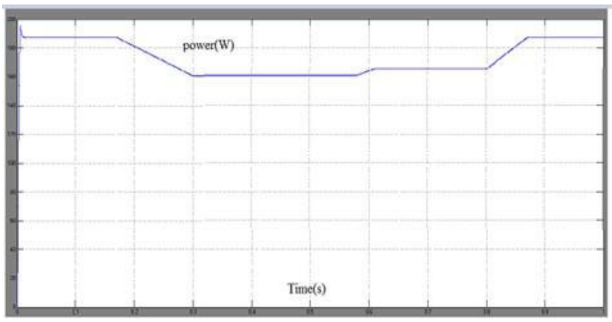

Fig 24. Fuzzy logic based solar output power

Table 4: Comparison between two MPPT techniques

PARAMETERS	MPVRS P&O	FUZZY
Output power	196 W	200 W
Current ripple	O.5 A	Nil

L. CONCLUSION

Unique hybrid model of PV and wind is designed and simulated using MATLAB/ SIMULINK. Based on the results, the fuzzy MPPT (FMPPT) is found to be more appropriate for tracking MPP in PV System than other conventional algorithms. It provides more accurate output and reduces ripples than other MPPT algorithms. This hybrid system has significantly enhanced results through highlighting as separate model for fuzzy logic method. It also serves as a broad platform for numerous initiatives in the field of renewable sources, interconnecting wide range of methods and applications. The growth of an intelligent Fuzzy Logic System (FLC) technique based on MPPT algorithm with SEPIC converter is described to improve the performance of photovoltaic panel when the atmospheric conditions change. The modeled wind turbine and PV panel were presented and developed in this work using MATLAB software. It has been confirmed that the Fuzzy-MPPT technique has the ability to improve not only performance but also tracking accuracy, speed, and system stability under various climatic conditions.

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