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Novel Fuzzy Logic Controller Based Multivariable Energy Management Strategy for Standalone Dc Micro Grids

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Abstract***: Due to substantial generation and demand fluctuations in stand alone green electricity control schemes are becoming crucial for the electricity sharing and voltage regulation functions. The classical power management strategies rent the maximum energy factor monitoring (MPPT) algorithms and rely on batteries in case of possible extra or deficit of strength. However, so as to recognize constant present day-constant voltage (IU) charging regime and growth the life span of batteries, electricity control strategies require being more flexible with the power curtailment feature. The paper proposes a method for the hybrid solar photovoltaic and winds energy device in Battery management for stand-alone applications. Battery charging manner is nonlinear, time-varying with an enormous time delay so it is difficult to achieve the best energy management performance by using traditional control approaches. A fuzzy manipulate approach for battery charging or discharging utilized in a renewable power generation system is analysed in the paper. To improve the life cycle of the battery, fuzzy control manages the desired state of charge (SOC). A fuzzy logic-based controller for use for the Battery SOC manipulate of the designed hybrid system is proposed and in comparison with a classical PI controller for the overall performance validation. The whole designed device is modeled and simulated the use of MATLAB/Simulink Environment.***

Keywords: MPPT, FUZZY, SOC, SIMULINK.

I. INTRODUCTION

Economic, industrial and social development of any nation requires energy. The significant energy sources are petroleum derivatives, which have been over-used prompting awful impacts, for example, air contamination and annihilation of nature. Consuming of petroleum derivatives discharges destructive gasses, which have extreme results on the living spaces and likewise influence human well-being [1]. They are the energy source that is non-renewable as they are gotten from pre-memorable fossils and are not anymore accessible once utilized. Their source is constrained and they are being exhausted at a speedier rate. Renewable energy era is a decent choice to secure nature and in addition an answer towards the constrained accessibility of non-renewable energy source.

The expanding energy demand, high energy costs, and in addition concerns over environmental impact, well-being and environmental change, have pulled in numerous analysts and communities for moving into elective energy examines. Several examinations are done for making utilization of renewable energy sources (e.g. the wind, solar and biogas) which are standalone [2], [3]. Between these, the two most promising renewable power generation technologies are the wind and solar energy. Normally, the wind or solar power is utilized by o-grid remote areas where mains power supply is inaccessible. The standalone power frameworks disservice utilizing renewable energy sources in which their accessibility is influenced by day by day and seasonal examples which bring about troubles in managing the output power to the load [4]. For instance, fluctuating everyday wind speeds and solar irradiation cut-o around evening time and cloudy days prompts the wind and solar frameworks with low unwavering quality in providing the load in a day throughout. Since both solar and wind power is accessible constantly in a day throughout, month or year, selective breeze or solar power frameworks cannot be utilized on standalone reason to the electrical installations that require power to be constantly ensured. A good other option to this is the hybrid energy frameworks utilization [1]. These hybrid frameworks having major limitation and that is the control necessary for optimal productivity [5]. A scientific model is required by the conventional control algorithms for the dynamic framework is controllable. Then, a numerical model is utilized for constructing a controller. In numerous down to earth situations, generally, it is not possible to obtain a controlled framework having a precise scientific model. Manmade brainpower (AI) control offers a method for managing problems that are hard to model by executing phonetic, non-formal control laws gotten from master knowledge [6].

Fuzzy logic control frameworks have advantages of recreating every single coveted element of human input, whereas the upsides of automatic closed-loop control advantages are maintained. The utilization of the fuzzy logic control is one the major problem is the trouble of choice and plan of enrollment functions for suiting a problem given [6]. A precise procedure to choose the kind of enrollment function and the scopes of factors in the discourse universe is as yet not accessible. Fuzzy controller tuning by error and trial is essential for getting a performance satisfaction. However, neural networks have the ability of recognizing the trademark components of a framework which is extricated from the input-output data. The neural network learning capacity is combined with the fuzzy logic framework control abilities to bring about a neuro-fuzzy inference framework [6].

Control of hybrid power frameworks has a tendency to be an intricate errand, given that such frameworks can't be precisely displayed as they are made out of an extensive number of factors. Different techniques for power management and optimization have been accounted for in writing. The current techniques have disadvantages as far as accuracy, flexibility, and efficiency. In this way, there is a requirement for building up a controller which will defeat these downsides. This exploration investigated methods for enhancing legitimate management and efficiency of power possess in a PV-Wind hybrid framework utilizing artificial intelligence systems.

This paper proposes an approach for the hybrid wind power and solar photovoltaic framework in Battery management for stand-alone applications. Battery charging process is non-direct, time-changing with a significant time delay so it is hard to accomplish the best energy management execution by utilizing conventional control approaches. A fuzzy control methodology for battery charging or discharging utilized as a part of a sustainable power era framework is examined. To enhance the battery life cycle, fuzzy control deals with the coveted state of charge (SOC). A fuzzy logic-based controller is proposed and utilized to the control Battery SOC of the planned hybrid framework and contrasted and an established PI controller for the execution approval. The whole composed framework is demonstrated and re-enacted utilizing MATLAB/Simulink Environment.

II. LITERATURE REVIEW

A Kerr and Cuevas [7] introduced another procedure, which can decide the mutt rent {voltage (I{V) characteristics of PV modules based on simultaneously measuring the open-circuit voltage as an element of a slowly varying light intensity. They have also given a detailed theoretical analysis and interpretation of such quasi-steady-state open circuit voltage (VOC) measurements.

Borowy and Salameh [8] gave a rearranged show with which the maximum power yield could be calculated for a PV module once solar radiation on the PV module and ambient temperature were found.

Zhou et al. [9] introduced a novel simulation display for PV array performance expectations for designing applications based on the I-V bends of a PV module. Five parameters are acquainted with an account for the intricate reliance of PV module performance upon solar radiation powers and PV module temperatures. The authors presumed that this simulation display is basic and especially helpful for architects to calculate the actual performance of the PV modules under operating conditions, with constrained data given by the PV module manufacturers.

Yang et al. [10] created one model for calculating the maximum power yield of PV modules according to the theory of equivalent circuit of solar cells by utilizing eight parameters which can be recognized by relapse with the Amoeba Subroutine or Downhill Simplex Method from experimental data. The accuracy of this model was validated by experimental data with great wellness.

Zamani and Riahy [11] exhibited another method for calculating the power of a wind turbine by considering wind speed variations. The rate of wind speed variations is assessed by the energy pattern factor (EPF) of actual wind, and the performance of rotor speed and pitch angle controllers is evaluated by another factor, named wind turbine controllability (Ca). By utilizing the EPF and Ca, the power bend is altered by considering the extra power that is captured by the controllers. The mathematical formulation of turbine display considering the variation of wind speed is portrayed next.

Nguyen et al. [12] introduced a model analogous to the flooded sort and examined the dynamic behavior of the phone amid discharge as for icy cranking amperage and save capacity. In general, these models are unpredictable as far as the articulations and number of parameters utilized.

Broad SOC determination methods have been presented by **Sabine Piller et al.** [13]. It presumed that the most utilized demonstrating strategy at this time for all systems is ampere-hour numbering method because it is the most direct and transparent method and easily actualized with satisfyingly accurate outcomes for short-time applications, especially if utilized as a part of the range of low to medium SOC. The lead-acid battery is utilized as a part of this proposition for energy storage. The segment underneath portrays the mathematical formulation of lead acid battery display based on its state of charge.

Onur et al., [14] outlined proportional-integral (PI) controller and a fuzzy logic controller (FLC) that could settle the voltage sufficiency to a steady estimation of 380 V and 50 Hz for loads provided from a wind/battery hybrid energy system. The nature of the power created by the wind turbine is influenced by the consistent and erratic varieties of the wind speed. In this way, the voltage-balancing out controllers were coordinated into the system with a specific end goal to keep the voltage size and recurrence consistent at the heap terminals, which requires steady voltage and recurrence. A fuzzy logic-based controller was utilized for the voltage control of the planned hybrid system and contrasted and an established PI controller for execution approval. The whole composed system was displayed and mimicked utilizing MATLAB/Simulink GUI (graphical UI) with the majority of its subparts the cost to execute a system. Fueling fuel cells is as yet a noteworthy issue since the creation, transportation, dispersion, and capacity of hydrogen is di clique [44].

Another examination by **Yerra et al** [15] proposes a hybrid energy change system joining photovoltaic and a wind turbine as a little scale elective wellspring of electrical energy where customary era is not handy. The hybrid system comprises of photovoltaic boards, wind turbines, and capacity batteries.

III.SYSTEM MODEL

Development of PV-wind Hybrid Power System Model

In power applications and system configuration, displaying and reproduction are fundamental to upgrade control and improve system operations. In this section, the models for the primary parts of the proposed hybrid power system are created and approved. It incorporates wind turbine power system, photovoltaic power system, battery storage, dc-ac converter, and dc-dc converter. Moreover, the MATLAB Simulink circuit piece models for each system appear in a separate segment.

System Description

Displaying of the PV-Wind hybrid system is completed utilizing MATLAB Simulink. The Solar-Wind Hybrid Power System (SWHPS) comprises of a few units, PV power and wind power units as essential energy sources, battery bank unit as helper energy source, dc-air conditioning and dc-dc converters, control, and a load unit. The capacity of controller unit is to guarantee the power administration, which is conveyed by the hybrid system to fulfill the load request and to charge the battery. The capacity of the dc-dc converter is to change the unregulated DC voltage to deliver controlled voltage. The inverter unit is utilized to change over the DC produced power from renewable energy sources to nourish the load with the required AC power. The intemperate charge from the battery will be dumped to the dump load unit. The dump load for this situation is the battery stockpiling which would then be able to be utilized to supply power to the load if there should arise an occurrence of deficient power created by essential sources. Squares, for example, photovoltaic model, the wind demonstrate, dc-wind conditioning converter display, the energy stockpiling model, and dc-dc converter show are incorporated independently before joining with a total hybrid system. The square outline portraying the system theoretical structure appears in Figure. The scientific models portraying the dynamic conduct of each of these segments are talked about in next segment.

Development of optimal power management algorithm

The problem considered by MPPT techniques is to automatically find the optimum voltage (V M P) or current (IM P) at which a PV module should operate, under a given solar irradiance and temperature. Perturb and observe method is the most commonly used technique because of its simplicity and ease of implementation [15]. It requires two inputs; measurement of the current (Ipv) and measurement of the voltage (V pv).

The P&O algorithm operates by periodically perturbing (incrementing or decrementing) the PV array terminal voltage or current, and comparing the PV output power with the previous one. On the off chance that it is positive, the control system moves the PV array operating point in the same direction; otherwise, it is moved in the opposite direction. In the next perturbation cycle, the algorithm continues in the same way.

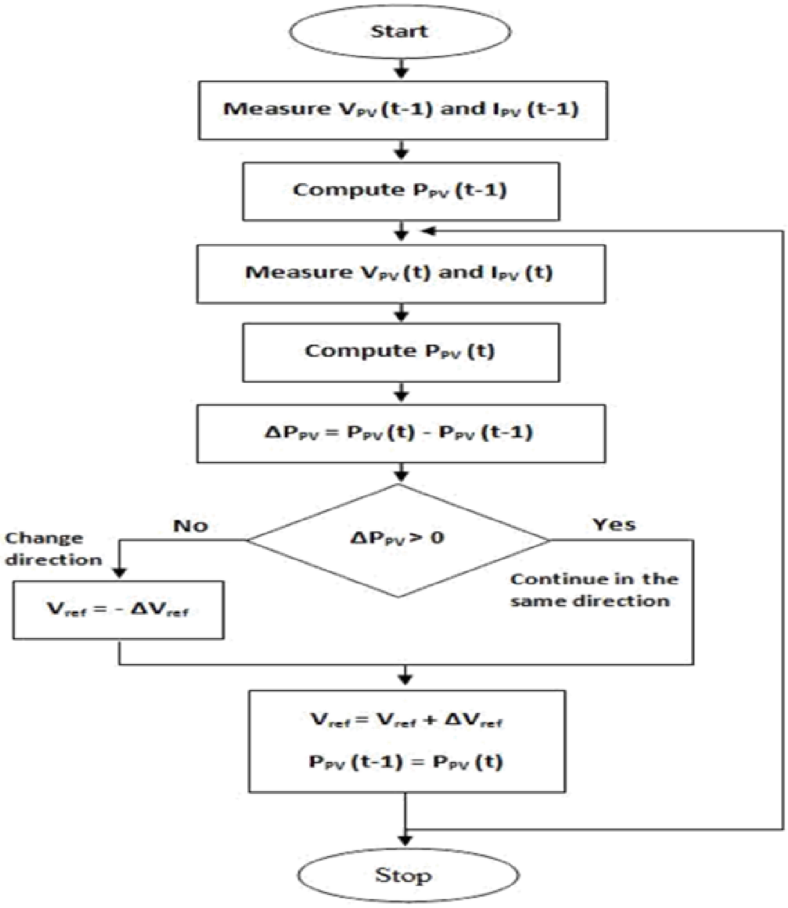

Figure 1: P&O algorithm flow chart

IV. EXPERIMENTAL RESULT

V. TABLE 5.1: SIMULATION ENVIRONMENT

Wind		Battery	
Power	8.5e3 W	Voltage	300V
Speed	12 m/s	Initial SOC	60%
Maximum Power	0.8	Maximum Capacity	7
Rational	1 P.V	Normal Discharge current	353.38
		Resistance	6.25

PV		Simulation	
Base Power	100e6	t	300-600V
P2 Tolerance	1e-4	V_{iv}	26.3V
Frequency	50 Hz	Nominal voltage	48.0V

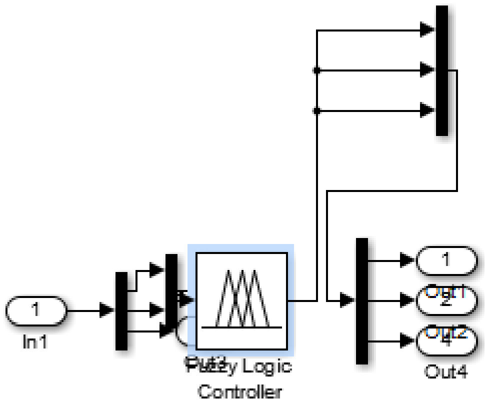

Figure 2: Fuzzy interface for Simulink

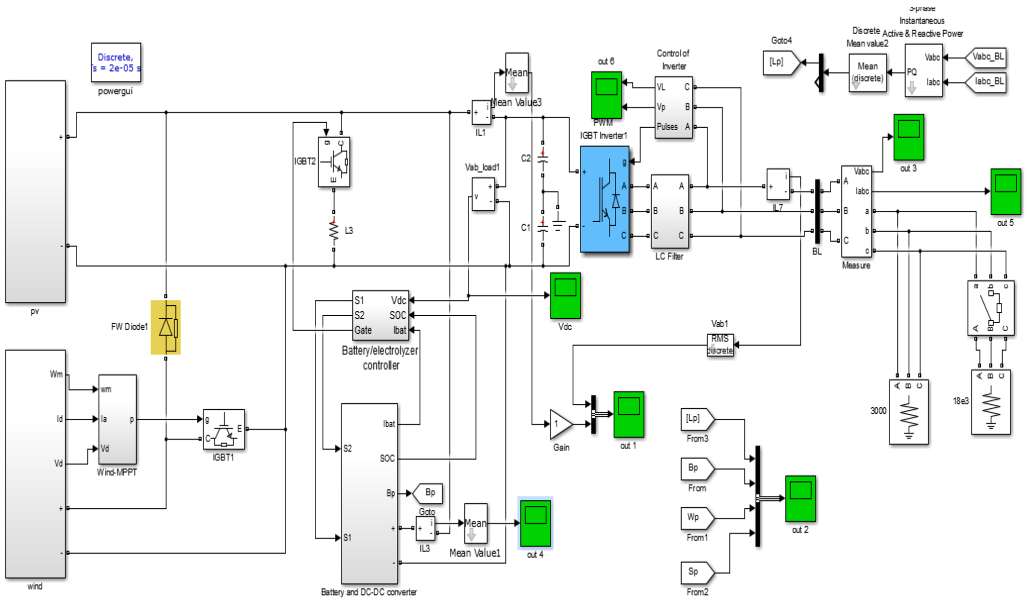

Figure 3: Simulink use for experiment

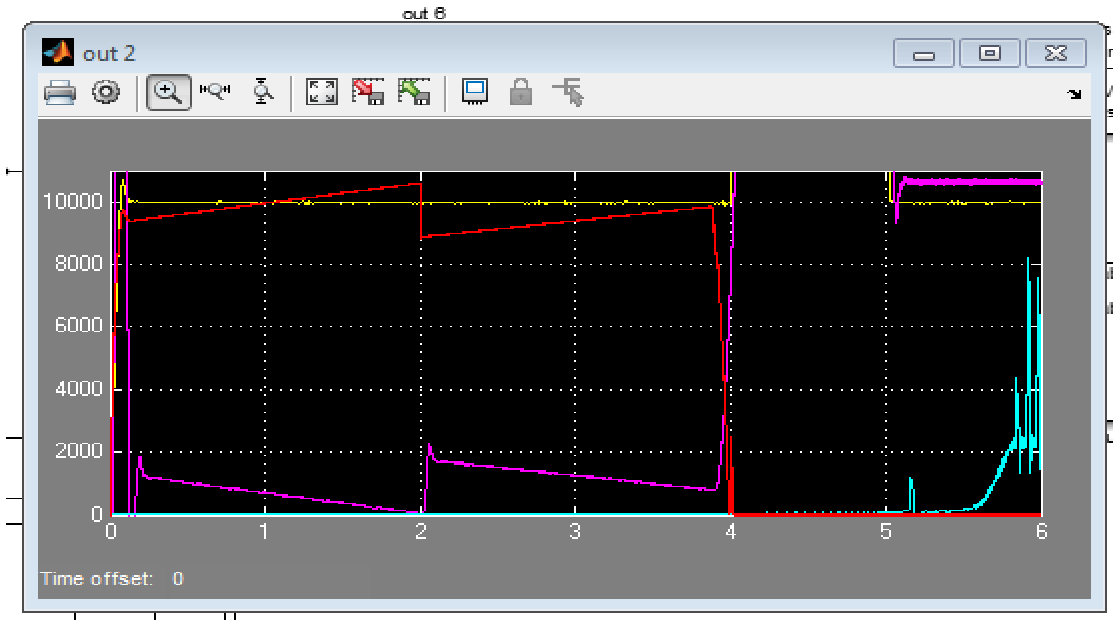

Figure 4: Angles of PV, wind and battery power

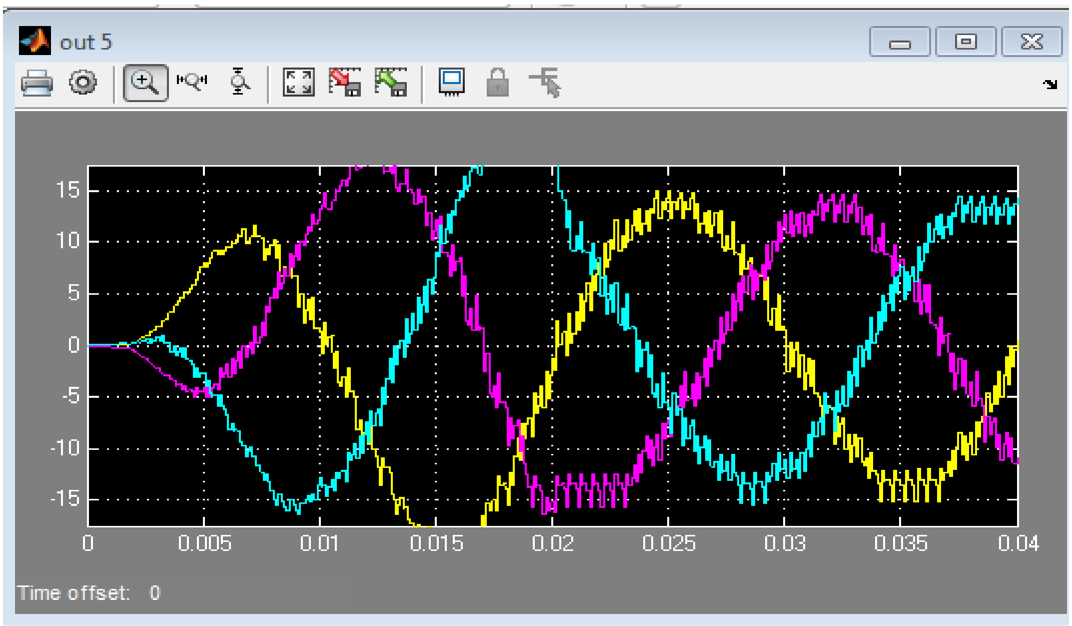

Figure 5: Angles of PV, wind and battery power

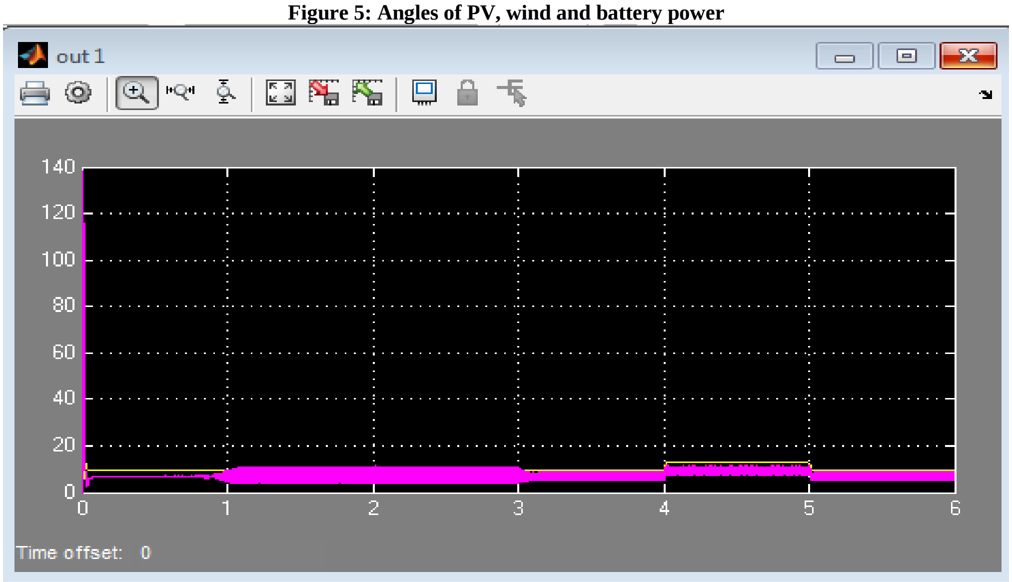

Figure 6: Gain by fuzzy logics

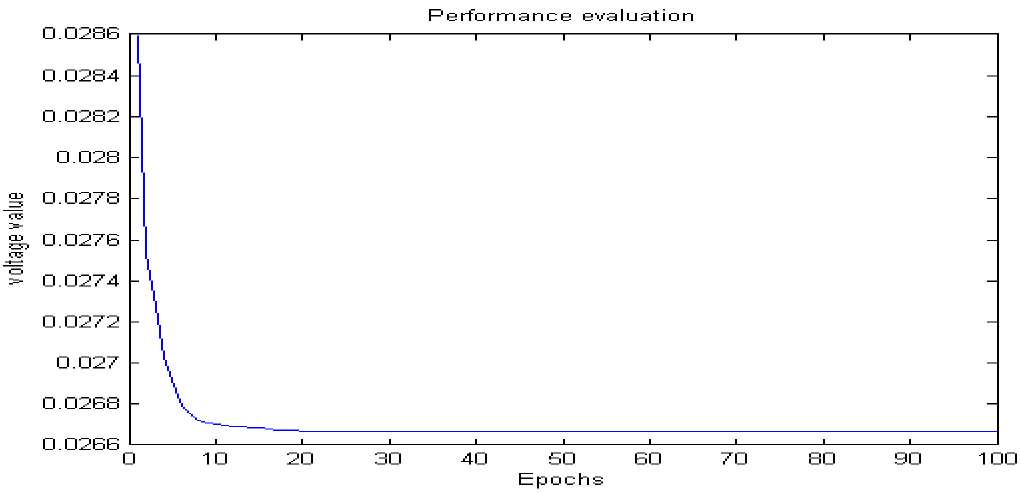

Figure 7: Fuzzy rules optimization

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