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A Review on Solar based Hybrid Power System with MPPT Controllers

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Abstract: *An exercise of power effectively of renewable energy is more important in the present scenario. This paper proposes a detailed review on Hybrid power system (HPS) with solar in addition with MPPT controllers. Standalone solar power system is the best choice for a rural area to supply uninterrupted power. Maximum Power Point Tracking (MPPT) is ordinarily involved in photovoltaic (PV) systems to maximize the output power from PV arrays regardless of the weather changes. Quick reaction and high tracking accuracy are two essential design requirements in MPPT control.*

Keywords *- FLC, HPS, MATLAB MPPT, PV.*

I. Introduction

In the past decade oil crisis is more noticeable because of the economic dependency on the fossil fuels. Due to this significance the need of new sources for the energy is more necessary. The renewable energy source is the only solution for the problem like environment pollution which is the main reason for the global warming. Since they are everlasting one and have environment friendly nature due to these reasons the research on utilizing these energy is increasing now a days. But the technology has not yet reached its standard to be considered as a competitive for the fossil fuels. The energy analysis of solar energy, battery and Diesel power is reviewed in this paper. The main advantage in the use of renewable energy is its inexhaustible source of energy and eco friendly in nature and its main disadvantage is the lack of consistency. To meet out this drawback a hybrid standalone system may be designed to utilize the solar energy effectively and also to reduce the pollution produced by the Diesel generator.

II. Literature Review

2.1 Back ground of Hybrid System

Yang et al. (2004) analyzed the energy management system which is applied in experimental equipment. The hybrid generation system controlled by the fuzzy energy management system at the appearance of random variation of wind speed and solar radiation supplies with stable electric power [1].

Zhenhua Jiang (2006) discussed about Photovoltaic (PV) solar energy, a system which is extensively used as a vital alternative energy source. Hybrid systems composed of fuel cells and batteries can be incorporated with PV power systems to afford uninterrupted high-quality power. In this system, the organization of the hybrid power system is described and control strategies for power management of the hybrid power system are discussed. The proposed hybrid power system is then confirmed by numerical simulation [2].

Ahmed & Miyatake (2006) proposed a hybrid energy system with a combination of both solar photovoltaic and wind turbine as a small-scale alternative source of electrical energy where conventional generation is not practical [3].

Li Wei (2009) describes a system combining photovoltaic (PV) and fuel cell (FC) hybrid energy system for stationary applications. The system comprises solar panels and a FC system working in parallel, an electrolyses system, power manager unit and storage tanks for the compressed hydrogen. The model is developed and functioned on MATLAB/Simulink and also mathematical and electrical models developed for the proposed system [4].

Vanden Eynde et al. (2010) reported on the modeling and simulation of a stand-alone photovoltaic (PV) plant with maximum power point tracking (MPPT) aspect and dedicated battery storage. The overall plant consists of the PV module, battery bank, MPPT module, controller, inverter and a resistive load. The load is provided by both the PV and the battery bank [5].

Raju et al. (2011) analyzed stand-alone power system with PV power generators and fuel cell which form a valuable energy source. The model is built up using basic circuit equation of the photovoltaic (PV) solar cells including the effect of constant solar irradiation and temperature. The experiment result shows the proposed approach to the development of Hybrid Alternative Energy System using MATLAB software to demonstrate its feasibility and performance [6].

Kumaravel & Ashok (2011) proposed a DC linked hybrid solar photovoltaic/wind energy system for stand-alone applications. Solar and wind energy are used as primary energy sources and battery unit is considered as storage to meet the primary load demand. An overall power management strategy is conceived and applied for the proposed system to manage power flows among the different energy sources, the storage unit and loads in the system. A simulation model for the hybrid energy system has been developed using MATLAB/Simulink [7].

Majumdar et al. (2012) discuss unconventional technologies for producing electricity which is under current research focus. Among many renewable alternatives which have the potential to address these concerns, Photovoltaic Cells (PV) could be considered a feasible solution. Photovoltaic Cells capture solar radiation and convert it directly into electrical energy. A Shockley Diode equation based model was selected to model solar arrays. A battery bank was modeled with parasitic model. The cost of generation of power by this method is higher than the conventional fossil fuel generation [8].

Moritz Hill & Rollie Armstrong (2012) discussed about a PV/Diesel Hybrid Power-Case Study. The project called Zimbi is done for a Chromites mine factory by CRONIMET and it is located at 250 KM NW of Johannesburg, South Africa. The installed plant capacity is for 1 MW PV power with 1.6 MVA Diesel power at the cost of 2.66 million dollars for PV plant and the cost of saving is also analyzed. The achieved Diesel saving is around 450,000 lit/year, before installing PV power plant it was around 1.9 million lit/yr. The saving of running cost of Diesel is around 0.5 million dollars/yr (Previously it was 2.18 million dollars/yr). Carbon emission is also very much reduced due to minimal usage of Diesel [9].

Krieger, EM & Arnold, CB (2012) analyzed Battery charge efficiency across a range of input powers as an important performance parameter in variable charging systems. An equivalent circuit theory is used to model the inherent trade-off between battery charging power and energy stored and it is compared with the existing Ragone model for discharge power and energy. An additional parameter is included to account for undercharge and under discharge of the battery due to premature arrival at the battery's voltage limits. At a given power, energy efficiency is predicted to be higher for charging than discharging when only accounting for energy dissipated by internal resistance. The model is expected to help to inform operational parameters for battery charging for variable power sources [10].

Priolkar & Doolla (2013) focused the system on combination of solar photovoltaic, mini hydro, diesel and battery energy storage system. Sources such as mini hydro and solar photovoltaic are clean, environment friendly and have ability to complement each other. The analysis of proposed hybrid system is carried out in Matlab/Simulink package [11].

Guishi Wang et al. (2014) proposed a system of power smoothing strategy for a 1-MW grid-connected solar photovoltaic (PV) power plant. A hybrid energy storage system (HESS) consisting of a vanadium redox battery and a super capacitor bank is used to smooth the fluctuating output power of the PV plant. The PV plant including the HESS has been modeled using MATLAB/Simulink and PLECS software environment [12].

Patterson et al. (2015) explored the modeled performance and cost viability of a hybrid grid-tied micro grid that makes use of the combination of solar photovoltaic (PV), batteries, and fuel cell (FC) systems. The proposed concept emphasizes that each community home is equipped with more solar PV than is required for normal operation [13].

2.2 Back Ground of MPPT Technique

Eftichios Koutroulis et al. (2001) discussed that the Maximum power point tracking (MPPT) was employed in photovoltaic (PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and irradiation conditions and of the load electrical features. An innovative MPPT system has been developed, consisting of a Buck-type dc/dc converter, which is controlled by a microcontroller-based unit. The main difference between the method used in the proposed MPPT system and other techniques used in the past is that the PV array output power is used to directly control the dc/dc converter, thus reducing the complexity of the system [14].

Yeong-Chau Kuo et al. (2001) explored a new MPPT controller for a photovoltaic (PV) energy conversion system. Using the slope of power versus voltage of a PV array, the suggested MPPT controller allows the conversion system to track the maximum power point very rapidly. As opposed to conventional two-stage designs, a single-stage configuration is implemented, resulting in size and weight reduction and increased efficiency [15].

Dong-Yun Lee et al. (2003) discussed an advanced MPPT converter with current compensation method for small-scaled PV-applications. The intended method applied maximum power point tracking (MPPT) by variable reference current which is continuously varied during one sampling period. Therefore, the intended MPPT converter with current compensation method increases the power transferred to the load above 9%. As a result, the utilization efficiency of Photovoltaic (PV)-module can be increased [16].

Zhenhua Jiang & Roger A Dougal (2004) discussed about a novel multi objective control algorithm for standalone PV power systems that can track out the maximum power point of the solar array while limiting the charging/discharging current and voltage of the battery under different insolation and load conditions [17].

Sridhar et al. (2010) suggested modeling and simulation of photovoltaic model. Considering the temperature and sun's irradiance, the PV array is modeled and its voltage current features and the power and voltage features are simulated. This enables the dynamics of PV system to be simply simulated and optimized. It is observed that the output features of a PV array are manipulated by the environmental factors and gives low conversion efficiency. As a result, a maximum power tracking (MPPT) technique is needed to track the peak power to maximize the generated energy. The maximum power point in the power–voltage graph is recognized by an algorithm called perturbation & observation (P&O) method or Hill climbing. This algorithm will identify the appropriate duty ratio in which the DC to DC converter should be operated to maximize the power output [18].

Ferdous et al. (2012) presented the importance of MPPT for effective operation and power extraction from a PV module. Among the various existing MPPT algorithms, the open voltage (OV) based algorithm is chosen to design the proposed MPPT circuit developed in their paper [19].

Sandeepan Majumdar et al. (2012) considered Jadavpur University Salt lake Campus as an electrical energy consumption site which was powered entirely by solar power and impact of Maximum Power Tracking was studied for the same system. The load of the system was forecasted using regression analysis [20].

Karanjkar Dnyaneshwar et al. (2014) explained a new fuzzy adaptive proportional-integral-derivative (PID) control strategy with an online set-point tracking being reported for maximum power point tracking (MPPT) in solar photovoltaic (PV) system. The range of the membership functions of the fuzzy logic for online PID parameter tuner has been optimized with the help of relay feedback tuning method. The suggested MPPT controller has been designed with online set-point adjustment approach using current, radiation and temperature sensors [21].

Lihua Wang et al. (2015) explored a novel stepped-up chaos optimization algorithm for maximum power point tracking (MPPT) scheme in photovoltaic system to attain the maximum efficiency. Comparatively the proposed technique is sharper than traditional chaos methods [22].

III. Conclusion

The concluding remarks obtained from the review are as follows:

- Wide research has done in the topic of Hybrid Power System and MPPT controllers.
- Many researchers have used solar as the major source of power in renewable based Hybrid Power System.
- For simulation, MATLAB Simulink software package is widely used.
- Although PI controller is normally used for battery charging, Fuzzy logic controller shows better performance.

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