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Renewal energy based smart grid system using solar Energy by implementing MATLAB Simulink

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Abstract— *DC micro-grid systems that use solar energy from photovoltaic solar panels to obtain the required electrical energy are integrated with a power electronic converter. For efficient and maximum power utilization, the load impedance should equal the source impedance. In this article, a Dc to DC boost converter is designed, which helps to match the load impedance and the solar panel impedance, so that the maximum power can be transferred to the load for efficient use of solar energy. Perturb and Observe algorithms are used for maximum power point tracking to ensure maximum power utilization at different irradiance levels on solar PV arrays.*

Keywords: Solar Panel, pertub and observe, Maximum Power Tracking, micro-grid.

I. INTRODUCTION

The world's population growth has led to a sharp increase in global energy consumption. Solar energy from the sun is effective without polluting the environment. It does not consume the earth's resources and does not cause global warming. A solar panel is a device made up of multiple solar cells connected in series/parallel devices used to convert solar energy into electricity. Solar panels are used more and more every day. Because it has a built-in solar panel, all you need is sunlight to generate energy. The economic value of solar panels makes them a popular choice to avoid rising electricity costs. Although solar energy technology has been developed over the years, it is used more today than ever. The main reason for its increasing use is its reproducibility. The sun will always provide the Earth with more energy than humans consume.

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Although various MPPT techniques have been used in the past, the Perturb & Observe (P&O) algorithm remains the most widely used algorithm as it is the most widely adopted and preferred algorithm in the industry due to its simplicity and ease of implementation. The controller measures the power by adjusting the voltage using the P&O algorithm, and if the measured power is greater than the previous value, it adjusts in the same direction until there is no power increase. Common MPPT methods include disturbance and observation (P&O), incremental conductance (INC), and voltage source controller.

Objective

The main purpose of this paper is to implement a Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm with variable step size for a two-phase three-phase grid-connected photovoltaic (PV) system. A pre-stage boost circuit provides maximum power point tracking control. On the inverter side of the backstage, DC bus voltage stability and grid connection current regulation are achieved. A fixed step size is adopted when the distance is far from full power using the P&O variable step size algorithm point, the step size is halved each time the start point crosses a peak, until the last step is below the set limit. and the starting point remains constant at the maximum potential. Therefore, in this paper, we propose a technique to control MPPT parameters according to the illuminance level to reduce interharmonic emission without degrading the MPP tracking performance.

Other areas for further investigation are:

1. PV cell, module and array are simulated and the effect of environmental conditions on their characteristics is studied.
2. The maximum power point of operation is tracked for both the systems using the P&O algorithm.
3. Both systems are integrated, and the hybrid system is used for battery charging and discharging.
4. Solar array connect with Micro grid system.

II. METHODOLOGY

In this paper, a modified variable step size MPPT algorithm for grid-connected PV systems is proposed that overcomes the problems associated with classical P&O algorithms. A faster tracking speed with less steady-state oscillation is achieved using this method. It shows better dynamic response during any change in atmospheric condition. The proposed scheme is implemented using MATLAB/SIMULINK based environment. Comparison between Fixed Step Size MPPT Algorithm and Proposed Scheme provided. The effectiveness and improvement of the proposed algorithm have been demonstrated in transient, static and dynamic responses, particularly under rapidly changing atmospheric conditions such as ripples, overshoots and response times.

Common P&O MPPT Algorithm

The P&O algorithm is a commonly used MPPT algorithm. The structure is simple and easy to implement. The standard step P&O perturbs the PV voltage according to equation and calculates a new value of the PV array power P(k).

$$D(k) = D(k-1) \pm \Delta D \qquad (1)$$

Where ΔD= the fixed step size,

Power is comparison with the past perturbation cycle P(k-1). If power increases, perturbation is continued in the same direction otherwise the perturbation is stored. This cycle is repeated loop wise until the maximum power is reached (ΔP = 0) [12]. Figure shows the flowchart of the common P&O algorithm.

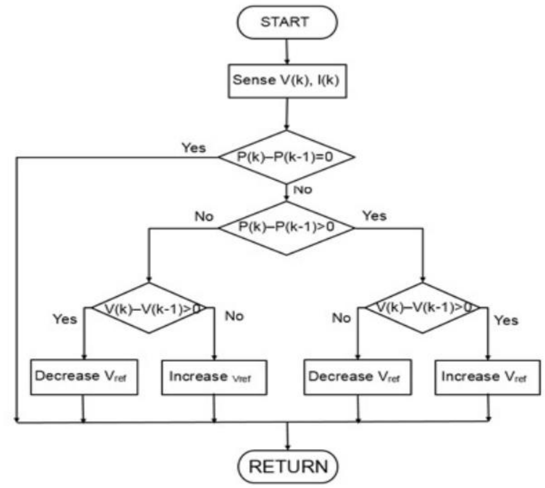

Figure 1: P&O MPPT Algorithm

Improved P&O Algorithm

A typical P&O algorithm uses a fixed step size, which is determined by accuracy and tracking speed requirements. Larger step size results in faster tracking but lower accuracy and smaller step size improves accuracy but slows MPPT. To obtain fast tracking speed with high steady-state accuracy, a step size MPPT algorithm is used where the step size varies with the slope of the P-V curve as shown in Eq.(2)

$$D(k) = D(k-1) \pm M * (\Delta P/\Delta V) \qquad (2)$$

The accuracy of this method is very high for a fixed value of solar radiation. If there is a sudden change in the Sun Radiating, the variable step size MPPT algorithm loses its accuracy and produces large oscillations. This is important This is because, for a step change in solar radiation, the PV power changes abruptly without much change in PV voltage. as Consequently, the step size from Eq. $M * (\Delta P/\Delta V)$, change suddenly. This causes large oscillations in the PV curve. To get a better response to sudden changes in the atmosphere Modifications for conditional, variable step size MPPT An algorithm has been proposed. MPPT controller Change in current with change in voltage (ΔI) and power. For a fixed insolation value, ΔV and ΔI will have the opposite sign. PV output current I is Components of the directly occurring photogenerated current Iph Proportional to insolation. If there is a sharp increase In the probe I will increase and ΔI will be positive. for someone If ΔV is also positive, then the next perturbation of the PV voltage, ΔV and ΔI are both positive and represent A sharp increase in insolation. Now about detection Rapid increase in insolation, MPPT controller Fixed step size of +0.05 to lower the PV voltage. this This is done because the PV array's MPP is at a lower voltage. For higher insolation values compared to that Low values of insolation. Similarly, if you investigate If there is a sudden decrease, both ΔV and ΔI become negative. this time, the MPPT controller uses a fixed step size of -0.05 and Increase the PV voltage. After this temporary period, The controller again uses a variable step size. proposed The system will prevent any undue vibration in the operating point. Steady-state vibration protection due to double grid Frequency voltage ripple in the DC link of the connected grid PV systems, modifications have been proposed. Equation (2) You can write it like this:

$$Vi = V_o * (1 - D) \qquad (3)$$

V_i is the PV voltage and V_o is the dc link voltage. If there is a voltage ripple Δvo present in the dc link, the net dc link voltage becomes $V_o + \Delta_{vo}$. If we add a small ripple(Δd) to the duty cycle as well, equation becomes

$$Vi = (V_o + \Delta_{vo}) * (1 - D - \Delta d) \quad (4)$$

Equation (4) can be further simplified as

$$Vi = Vo *(1-D)+(1-D)*(\Delta vo)-Vo *(\Delta d)-(\Delta vo)*(\Delta d) \quad (5)$$

To get a ripple free PV voltage, the ripple component of equation (9) must be zero. Therefore,

$$(1 - D) * (\Delta vo) - Vo * (\Delta d) - (\Delta vo) * (\Delta d) = 0 \qquad (6)$$

From equation (6), we get

$$(\Delta d) = \{(1 - D) * (\Delta vo)\} / (Vo + \Delta vo) \qquad (7)$$

Thus, by adding a small ripple Δd to the duty cycle generated by the MPPT controller, PV voltage oscillations due to DC bus voltage can be avoided.

III. Battery storage management

A typical PV solar farm is idle at night, and the bidirectional inverter used to supply the PV DC power to the grid as three-phase AC power is unused. The point where the solar farm is connected to the grid is called the point of common connection (PCC). In Figure, VS and IS represents the voltage and current at the secondary of the distribution transformer; VPCC and VL denote voltages at PCC and load terminal, respectively, and IPV is the current delivered by the PV solar panels. AC current is drawn/delivered by the solar farm inverter and the DC current flowing through the storage battery are represented by ISF and IBatt, respectively.

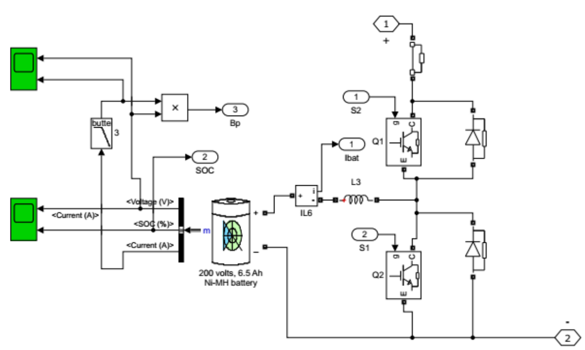

Figure 2: Simulink of Battery Storage System

IV. Solar Array

A photovoltaic array (PV system) is a set of blocks consisting of several PV cells in succession or in parallel. The power generated by a single module is not sufficient to meet the requirements of industrial applications, so the modules are connected to form rows to deliver loads. In a row, the connection of blocks is identical to the cells in a block. B.V. The modules in series are usually connected in series to achieve the desired voltages first; Individual modules are connected in parallel to allow the system to generate more current.

Solar cells / arrays have unique properties that cannot be followed by any other power source. In order to evaluate the transient and steady-state performance of the converter, it is necessary to develop an electromagnetic model of the solar panels, which will represent the solar cell properties as best as possible. The solar system has two distinct functions. It acts as a voltage source before the maximum power point, and as a current source after the MPPT. This model has provided excellent performance for a variety of operating conditions.

In this system we use MPPT control for MPPT measurement. We use the P&O method to measure the MPPT of solar energy. The MPPT method assumes automatic detection of current IMPP or voltage VMPP, in which a PV is detected. The series must obtain the maximum output power PMPP under the given temperature and randomness. Most MPPT methods respond to variations in both randomness and temperature, but some are more accurate if the temperature is approximately constant. Most MPPT methods respond automatically to variations in order due to aging, although some are open-cycle, requiring periodic fine-tuning. In our environment, the module is usually connected by a power converter that can differentiate the amplifying current from the PV series to the load.

DC-DC Boost Convertor

V. Solar with Grid System

The DC power from the photovoltaic array is converted to grid-compatible AC by a grid-tie inverter, and the AC power is fed into the building's main power supply. Additionally, a cooling system can be installed to prevent the panels from overheating. Excess electricity not used in the building is exported to the power grid. Additionally, a grid-tied PV system has no moving parts, is silent, produces zero emissions during use, and is fully scalable from small to large in a fully modular system for expansion.

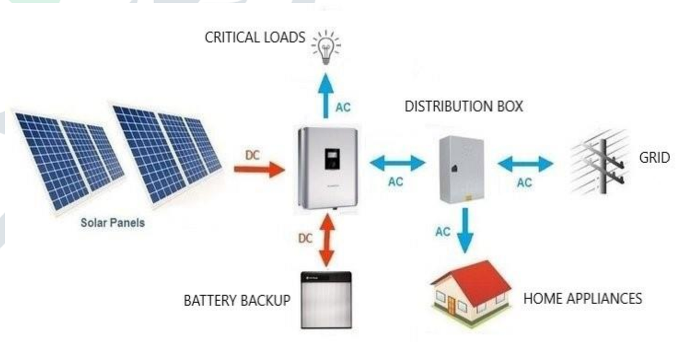

Figure 3: Solar Array integrated with Power grid system

A grid-tied PV system consists of solar panels; Inverter/charge controller interconnection wring with battery bank. In the grid we use PWM invertor and VSC controller for control the voltage and current fluctuations, It's also help to redusce the harmonics losses.

VI. System Design and Implementation

A MATLAB model is developed for the renewable energy-based distribution system and MPPT tracking. The figure shows the MATLAB model for the distribution system. In this system, an ideal three-phase source feeds a nonlinear load. The PV power stored in the battery after supplying to the inverter which generates three-phase power to the load. In the load section, we use VSC to control voltage fluctuations.

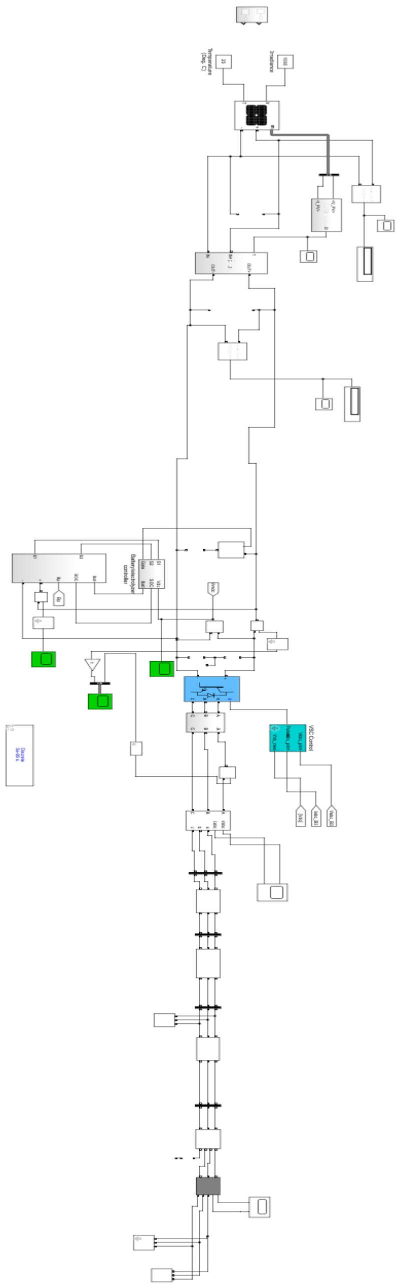

Figure 4: Solar with grid Simulation diagram

VII. RESULT AND DISCUSSIONS

The results can be analyzed and discussed in terms of its capability to meet the required load demand of the area. The advanced methodology has been applied to simulate a standalone hybrid PV system in MATLAB/SIMULINK environment. The result is presented.

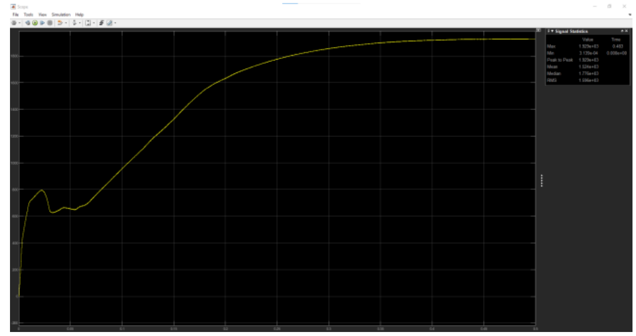

Figure 5: PV voltage after DC-DC convertor

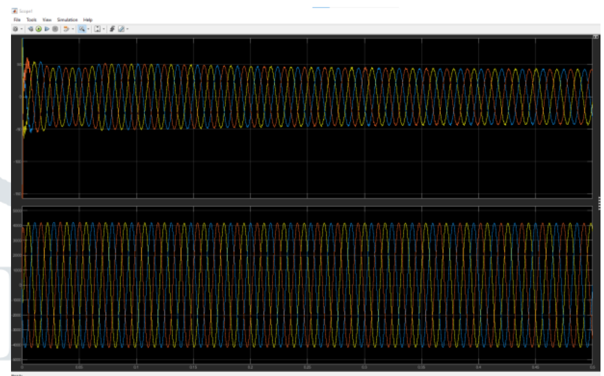

Figure 6: Voltage and Current graph in load side distribution network

Simulation results of PV module

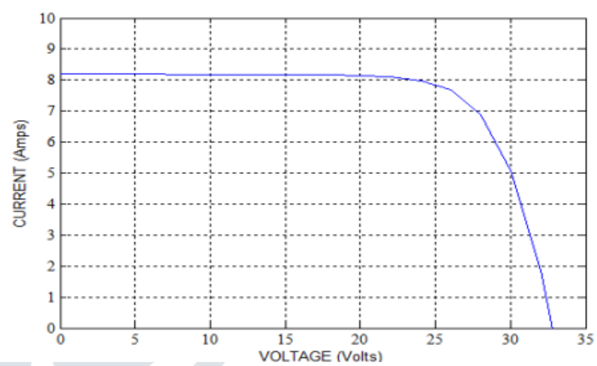

Figure 7: V-I curve of PV module

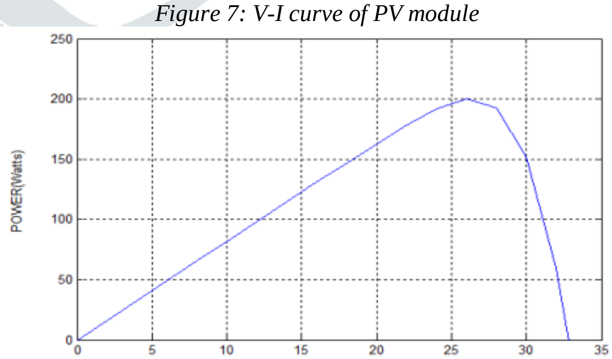

Figure 8: P-V curve of PV module

we can observe that during charging state of charge (SOC) of the battery is gradually increasing and also during charging current is negative. We can observe at 40% SOC battery voltage is around 26 volts, as state of charge of battery is increased battery voltage exceeded its nominal voltage.

VIII. CONCLUSION

This paper is mainly used to build the proposed simulation model for the solar power generation system, and it is performed together with the P&O technique for peak-peak power tracking. The purpose of the thesis, namely to develop an efficient and optimal system, is achieved. The maximum power point tracker must match the load to the maximum power available from the high-efficiency PVG (PV generator). This is achieved by consolidating P&O. Algorithm of MPPT controller. The duty of the boost converter is controlled by the above algorithm. A typical method is implemented in a Matlab/Simulink environment. Many countries of the world are located in tropical and subtropical regions where the intensity of sunlight can reach up to 1000 W/m2. Influence of environmental parameters ie. Temperature and irradiance changes can also be observed in the simulated properties. A boost converter is used to boost the PV array output with a perturbation and observe a technique to control the duty ratio of the boost converter switch.

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