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Article Title: ANN Based Maximum Power Point Tracking Under Uniform Irradiance And Partially Shaded Conditions

ANN Based Maximum Power Point Tracking under Uniform Irradiance and Partially Shaded Conditions

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ABSTRACT

Solar photovoltaic (PV) systems are becoming more and more popular since they immediately transform solar radiation into ecologically beneficial and sustainable electrical energy. It significantly lowers the system's power output. To address this, continuous duty cycle variation methods that track a maximum power point under partial shading conditions have been proposed. In these schemes, proposed Luo converters are attached to the PV module to enable the highest output voltage under any given circumstance. A novel technique for Artificial Neural Network based Maximum Power Point Tracking (ANN-MPPT), which track Maximum Power Point (MPP) in the presence of further local maxima, has been integrated into the proposed system. The proposed technique tracks MPP by continuously varying a duty cycle of the converters without using expensive parts like signal converters and microprocessors, making the system more compact. Consequently, using the MATLAB 2021a/Simulink programme, we will do a number of numerical simulations to verify the proposed controls.

Keywords: Photovoltaic (PV), Artificial Neural Network, Luo converter, Maximum Power Point (MPP).

1 Introduction

In recent years, scientists have paid a lot of attention to photovoltaic (PV) generating electricity in an effort to lessen the inherent environmental pollution connected with conventional electric generators [1]. Without raising the cost of implementation, P&O algorithm provides for the resolution of P&O issues and increases its effectiveness, particularly during rapid weather changes [2]. The steady state oscillations are reduced but the system becomes slow with modest perturbation step sizes. Thus, the degree of the perturbation must be carefully determined to both decrease steady state oscillations and boost response time [3]. The Hill Climbing system includes changing a duty cycle of the power converter. Also, it is appropriate for a battery charger in which a quick dynamic response is not required [4]. The HC algorithm disrupts the systems by altering a duty cycle of the DC-DC converter, then evaluates an effects on output power generated by PV components [5]. DC voltage are stabilised by using a variety of constant voltage controllers [6]. Fuzzy logic control, however, has been proven to outperform the traditional PI method in a number of areas, including active power provided to grid, grid current, and tracking the MPP for solar arrays [7]. A variations in load demands, battery charge and PV power generation are detected by fuzzy logic controller. When PV power is very high, a battery can be charged and the load is fed [8]. However, the MPPT controller expands on the P&O technique's simplicity while also eradicating the steady state oscillations they cause by adaptively altering a reference voltage perturbation step size C utilising a fuzzy logic controller [9]. Using regulated energy storage units became important because of the irregular operation of these sources, which causes changes in voltage and frequencies [10]. The efficiency of the model is increased by using a LUO converter, which is utilized in this suggested system to increase the PV system's output voltage. The list below demonstrates how the paper is organised: Section I gives a description of the introduction. The recent works are described in Section II. The proposed model and description are explained in Part III. The results are presented in Section IV. In Section V, the conclusion is presented.

2 Recent Works

A. Wang et al [2019] [11] have introduced a unique Event Triggering Mechanism (ETM) along with a new and advanced technologies adaptive control method to lessen communication burden. It needs to be emphasised that the suggested technique only updates the adaptive characteristics and the control signal at the triggering time instants, further minimizing the system's resources as well as its energy. It has been demonstrated that a proposed event-triggered robust adaptive control approach guarantees that all of closed loop system's outputs are semi globally limited and that a system's outputs propagate to a bounded area surrounding the origin.

M. A. Ghasemi, et al [2020] [12] have proposed an intelligent sampling approach that is based on a fractional open circuit voltage technique, where the tracker takes initial samples from the power voltage characteristics of the solar array. As a result, the search area is less, and the global maximum power point can be discovered with greater speed and accuracy. A maximum power point tracker also suggests a method that requires estimating module voltage at its peak power.

Y. Mahmoud et al [2020] [13] have aimed to create a quick modelling strategy for PV systems that are partially shaded. By utilising three proven criteria that control the creation of power peaks in partially shaded PV systems, the recommended approach can quickly detect a power peak of these systems without modelling the entire power curve. A MPPT successfully ensures operating on global maximum power peak, enhances a dynamic performance of power extraction, and eliminates fluctuating steady state power losses.

C. Li et al [2020] [14] have presented STATCOM controllers .When previous stability-related studies are not directly related to an instability in presence of STATCOMs because of some unique characteristics of STATCOMs, a d-q frame impedance based stability study is used to explore an instability. Also, a topology of power systems or the locations of STATCOMs, the total number of linked STATCOMs was the significant contributor to stability because of high impedance of STATCOMs around a frequency range of interactions.

Y. Jeon et al [2020] [15] have exhibited better harmonic performance with low capacitance STATCOM technology, which intentionally operates with large voltage ripples on the dc-link capacitors. A harmonic performance gain of this system is removed, though, when running at reactive current levels below the rated capacity of the capacitor. However, the suggested method uses both conventional dc-dc converters and a CHB multilevel converter to regulate voltage ripples on the dc-link capacitor independently of its operating point.

3 Proposed Work Explanation

The proposed converter (Luo converter) is used to increase a converter output voltage while maintaining it constant throughout the system. A single phase inverters is utilized to convert DC voltage to AC voltage. The inverter uses PWM signals to transform the DC voltages into AC voltages during the grid connection operation. A simulation system is assessed under both uniform and non-uniform irradiation settings, and results are shown. In Figure 1, the proposed block diagram is given.

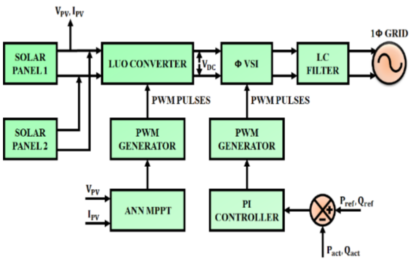

Figure 1: *Proposed Block diagram*

3.1 PV System

A sustainable and dependable energy source that is always available is the sun. By photovoltaic, the energy that the sun emits is directly captured for the purpose of generating electricity. Photovoltaic (PV), which uses the photovoltaic effect to turn sunlight into energy, is one of the key solar power techniques.

3.2 Luo Converter

By using a Luo converter, the voltage generated by PV is increased. With few ripples and great efficiency, this converter produces a maximum output voltage.

Figure 2 shows the circuit for Luo converter. This circuit consists of a switch (S), a diode (D), coupling capacitance ((C_1) that serves as a storing element, an inductance (L_1) that transmits energy from an input side to an output side, and a low pass filter comprised of inductance (L_2)) and capacitance (C_2)).

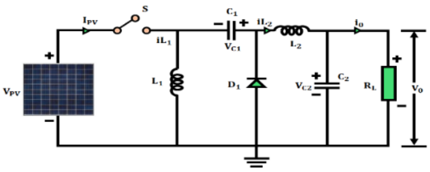

Figure 2: Luo *converter's circuit*

3.3 ANN Based MPPT

ANN based MPPT technique is created to track the maximum power of the PV module under changing weather conditions. According to Figure 3, the proposed ANN based MPPT controllers comprises of a two layer feed forward network.

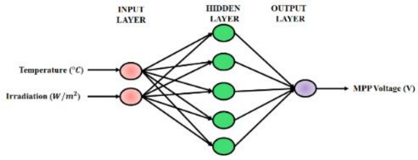

Figure 3: *Structure of ANN*

3.4 Control of Single Phase Inverter and Grid

Two stage converters are used in a rectifier fed inverter system. This study describes inverter side control. To determine duty cycle, one uses the rectifier side control and Voltage control is necessary for the majority of inverter applications.

3.5 PI Controller

The proportional integral controller, sometimes known as a feedback controller. It operates the plant that must be regulated using the integral of that value and a weighted sum of error. Basic block of PI controller is presented in Figure 4. PI Controllers have been used to regulate practically every process currently in use, from motion control to aerospace, and from slow to quick systems.

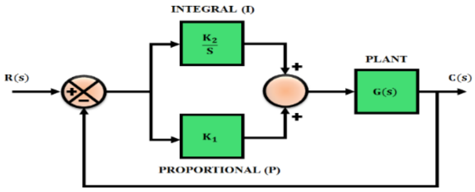

Figure 4: *Basic block of PI Controller*

3.6 PWM Generator

The switch found in the Luo converter produces and applies the pulse width modulated signal. An average power reduction is really divided into discrete pieces by the PWM generator. The PWM generator's primary mission is to generate pulse width modulated gate pulse signals which are transmitted to the switch inside the Luo converter.

3.7 LC Filter

The fundamental component of grid current is taken to be zero based on this rule. The voltage of the filter's inductor is then have zero as its basic component. As a result, the voltage across an inductor is defined as:

$$V_L = V_{inl} - V_g \quad (1)$$

Phase voltage is dependent on switching frequency f_s, which is greater than grid frequency F_N.

$$\Delta I_{pp} = 2I_{rpm} = \frac{\frac{V_{dc}}{2} - V_{av}}{L_f} \cdot \frac{d_1}{f_s} \quad (2)$$

Where I_{pp} and I_{rpm} are peak-to-peak value and maximum value of the ripple in current flowing through a filter inductor.

4 Results and Discussion

The following outcomes are attained as a result of implementing the planned work in MATLAB simulation.

Figure 5: *Simulation Diagram*

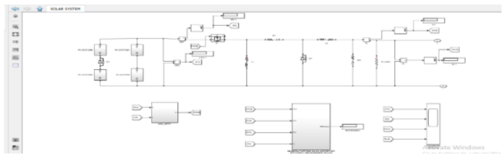

Figure 6: *Simulation Diagram for solar with Luo converter*

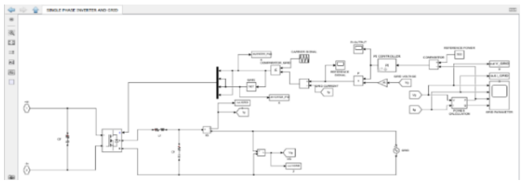

Figure 7: *Simulation Diagram for single phase inverter*

Case (1) Under Normal Operation without Partially Shaded Condition

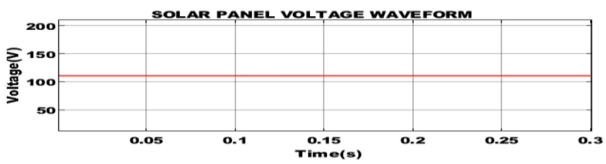

Figure 8: *Solar panel voltage waveform*

The figure 8 represents the solar panel voltage waveform under normal operating condition.

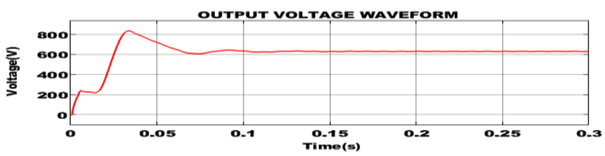

Figure 9: *Output voltage waveform*

The figure 9 represents an output voltage waveform under normal operating condition.

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Case (2) Under Partially Shaded Condition

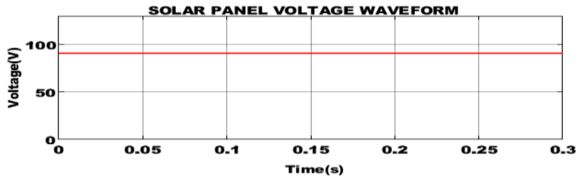


Figure 10: *Solar panel voltage waveform*

The voltage waveform of a solar panel under partially shadowed conditions is shown in figure 10.

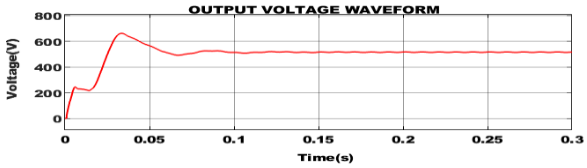
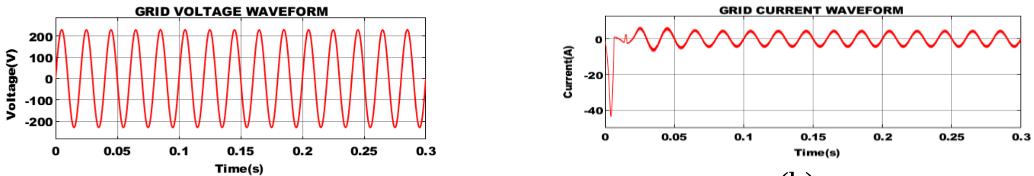


Figure 11: *Output voltage waveform*

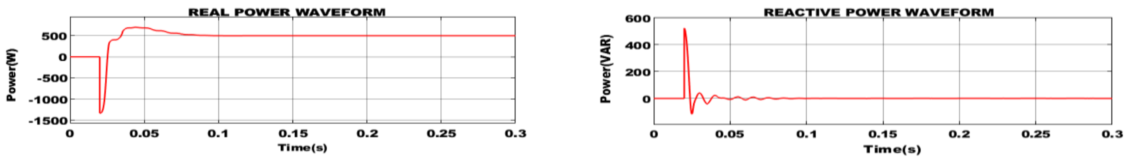
An output voltage waveform is shown in partially shadowed condition in figure 11.



(a) (b)

Figure 12: *Waveforms representing (a) Grid voltage and (b) Grid current*

Figures 12(a) and 12(b) show the grid voltage and current waveforms, respectively.



(a) (b)

Figure 13: *Waveforms of (a) Real power and (b) Reactive power*

Real and reactive power have values of 500W and -60VAR, respectively, as shown in Figure 13. Figure 14 includes the waveforms that show power factor.

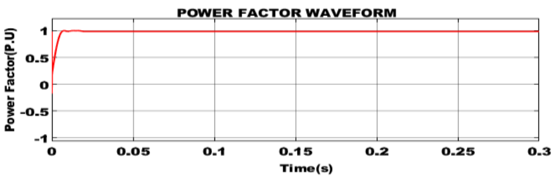


Figure 14: *Waveforms of power factor*

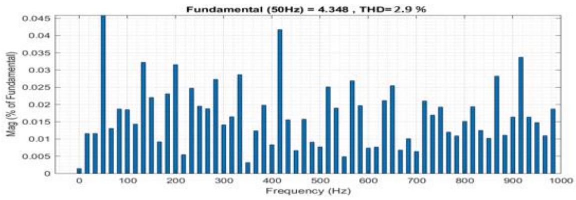


Figure 15: *THD result of the grid current*

The grid current's THD results are displayed in Figure 15. A thorough procedure for controlling single-phase solar inverters connected to the grid.

5 Conclusion

Due to the fluctuating environmental circumstances, tracking the module's MPP in solar PV systems is difficult. Due to the many peaks in the power voltage characteristics that occur under partial shading, the tracking method also becomes more difficult. So that a high performance and excellent results are presented by ANN based MPPT controller. A PI controller is used to coordinate its operation with that of the single phase grid. The proposed technique is effective in maintaining a dependability and stability of the output voltage system in partially shadowed conditions, according to the MATLAB simulation results. For the purpose of testing its efficacy, a simulation model of the solar system is developed in MATLAB.

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