Journal of Electrical Engineering and Automation (ISSN: 2582-3051)
www.irojournals.com/iroeea/

MISO CONVERTER BASED CONTROL OF SOLAR PV SYSTEM

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Abstract

The solar photovoltaic (PV) system penetrates the global renewable energy source due to the direct energy conversion process and environmentally friendly nature. The irradiance mismatch undergoes major difficulties in the PV converters, and this algorithm has been performed under Maximum Power Point Tracking (MPPT). To solve MPPT problems, conventional soft computing methods are frequently employed. In this study, Multiple Input Single Output (MISO) converters are used to compare the Perturbation & Observation and Artificial Neural Network methods. The converter is set up as a single-inductor buck converter with numerous input ports connected to two PV panels. The output voltage and current from the solar cell are sent into the buck converter. In order to attain maximum power for various irradiances, the reference voltage and current are sent to the MPPT controller, and the duty cycle created is supplied to the MISO buck converter. The proposed system is established in MATLAB/ Simulink to evaluate the effectiveness of the system.

Keywords: Artificial Neural Network (ANN), Multi Input Single Output (MISO) Converter, irradiance mismatch.

1. Introduction

Due to their abundance, silence, and environmental friendliness, photovoltaic (PV) cells are extensively used in their market. There are many sustainable energy sources available, including solar, wind, hydro, and tidal. The two renewable energy sources with the highest global growth rates are solar and wind power. PV cells are used for energy exchange, which emits no pollutants.

DOI: https://doi.org/10.36548/jeea.2023.1.006
Received: 01.03.2023, received in revised form: 01.04.2023, accepted: 16.04.2023, published: 26.04.2023

The demand for energy is rising quickly every day. However, the existing base load plants cannot meet the demand for electricity. Therefore, during high loads, these energy sources can be used to close the gap between supply and demand. In remote locations where conventional power generation is impractical, this type of small-scale standalone power-generating device can also be used.

The most popular method of using solar energy is PV power generation. An object called a solar photovoltaic transforms incident photon energy into electrical power by absorbing it. Due to a single solar cell's limited output power, many solar cells must be coupled in parallel and serial for forming a basic photo voltaic component unit.

The study makes use of the Multi Input Single Output (MISO) converter, which enables the usage of two solar PV panels. One of the main issues with the system in the two screens is the irradiance mismatch. The PV array can generate the most electricity while also making the best use of it thanks to the usage of Maximum Power Point Tracking (MPPT) algorithms. When the Maximum Power Point (MPP) is partially shadowed, it is challenging to follow since the array's P-V characteristics have many peaks. The MPPT approach based on Artificial Neural Network (ANN) algorithm is utilized to get the most power out of the panel. The duty cycle to the gate input for each individual switch is determined by the result of each algorithm. The output voltage is then processed to the load after performing the buck converter arrangement with a single inductor.

When compared to the MPPT technique based on the Perturbation & Observation (P&O) algorithm, the ANN algorithm tracts the most power.

2. Maximum Power Point Tracking Methods

An electronic control system that can compel the utmost power from the system is known as a maximum power point tracking system. The movement of the modules is altered, turning them to face directly towards the sun, without the use of a single motorized component. By adjusting the electrical operating point of the modules, the MPPT control system, a fully electronic system, can give the utmost permissible power.

Regardless of changes in weather and load, the output power from solar cells and wind turbines must be produced with optimum efficiency by operating constantly at the highest point of power (peak power point). To put this into practice, MPPT technology is used to guarantee maximum power transmission while the system is in operation and tracks the maximum power production from variations in weather conditions. An electronic component known as the MPPT is primarily used between the PV, wind, and load.

In the Power Vs Voltage characteristic of PV modules, it can be seen that there are single maxima, or maximum power points. These units are wired up to the specific voltage and current that are offered. The overall module efficiency is quite low, averaging roughly 12%.

Therefore, it must be run at the crest power point to supply the load with the maximum amount of power regardless of the constantly shifting environmental circumstances. With more electricity, the solar PV module can be used more effectively. To get the highest power, which is then sent to the load, a DC/DC converter next to the PV module matches the impedance of the circuit and the PV module. Impedance matching is done altering the duty cycle of the switching elements.

There are several algorithms that can be used to determine the maximum power point of a PV module and a wind energy system. They are as follows:

- INC algorithm
- P&O algorithm
- Hill climbing
- Parasitic capacitance
- peak power tracking (Voltage-based)
- peak power tracking (Current-based)

ISSN: 2582-3051

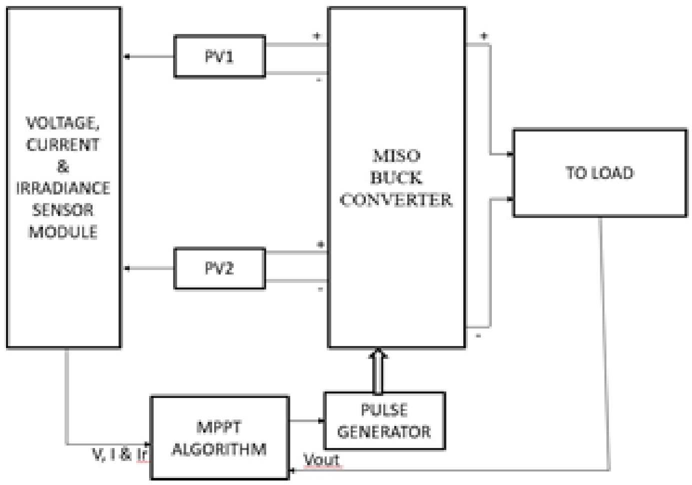

Figure 1. Block diagram for a PV system's MPPT implementation

3. Algorithm for Perturb and Observe

The most widely used technique is the perturb and observe method because it is easy and straightforward to use. It needs two inputs: measurement 32 of the current (Ipv) and measurement of the voltage (Vpv). Every MPPT algorithm has benefits and drawbacks.Due to its simplicity, the method is widely used. The device operating voltage will then be perturbed in this algorithm. By varying the DC-DC converter's value duty cycle, voltage can be perturbed.

On the right side of MPP, the power grows as voltage lowers, but in left side MPP, power increases as voltage increases. This is observable when analysing the characteristics. The main concept behind the P&O algorithm in tracking MPP is as follows. The P&O technique may also result in a lot of oscillations near the MPP, which slows down the system's response. In order to eliminate power fluctuation and maintain stable load voltage, a different controller has been used in conjunction with P&O. The linear PI, non-linear passivity-based controller, and feedback controller are a few of these controllers.

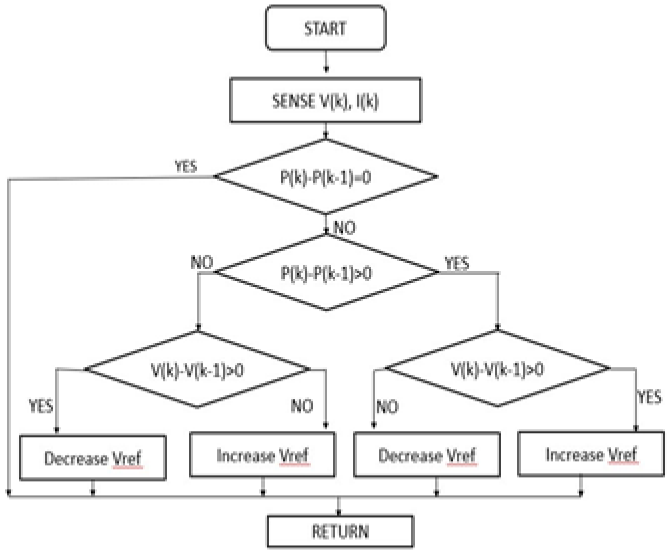

Figure 2. Flowchart of P&O

4. Artificial Neural Network Algorithm

ANNs and fuzzy logic control are two examples of Artificial Intelligence (AI) methods that fall under the category of soft computing. Simpleness and a fairly quick response are beneficial characteristics that ANNs possess, which aid in their success. In-depth system understanding is not necessary for ANNs. They can determine and assess the connection between inputs and outputs by reading and examining the system's prior data and analyzing the system's behavior using previously registered information. Furthermore, the user doesn't need to be an expert in advanced mathematics because Neural Network (NN) is relatively significant in terms of getting the best answers. Both numerical and analog data can be used with NN, which can also handle complex systems.

To accurately estimate the maximum power point in renewable systems, many maximum power point monitoring methods have been developed. Most existing MPPT algorithms struggle with slow tracking, incorrect tracking, and oscillations amid rapidly changing weather conditions, which lowers utilization efficiency. This research introduces an ANN-based MPPT control technique to address these issues because it significantly enhances system performance and efficiency compared to other traditional approaches. By using a multi-layered NN and ANN based tracking for maximum power point, the levels of temperature and irradiance are evaluated using the photovoltaic array. In a quickly varying ecological circumstances for both constant as well as the instance that are transient, a multi-layered feed-back neural network is employed. The MPPT is commonly implemented using a multilayer technique to minimize the training set in order to enhance the nonuniform irradiance on the PV modules. Because MPP is not dependent on time or trade property, it may be tracked without a time increment by detecting changes in PV characteristics. The irradiance and the temperature problems of the photovoltaic array faced in standard MPPT is addressed by the introduction of an ANN-based MPPT.

Because tracking time is substantially faster than P&O systems, especially during rapid weather changes, this method eliminates the time reliance and trade-off. The mean square error was created to enhance network precision and performance. In multi-layered neural network maximum power point locus is roughly determined to find the optimal peak operating point by evaluating the temperature and the irradiance of the photovoltaic arrays. It makes use of a fast, simple MPPT method that continuously controls the output voltage of the PV panels and the output voltage of the wind system to provide a good reaction to abrupt changes in irradiance levels and to improve tracking efficiency

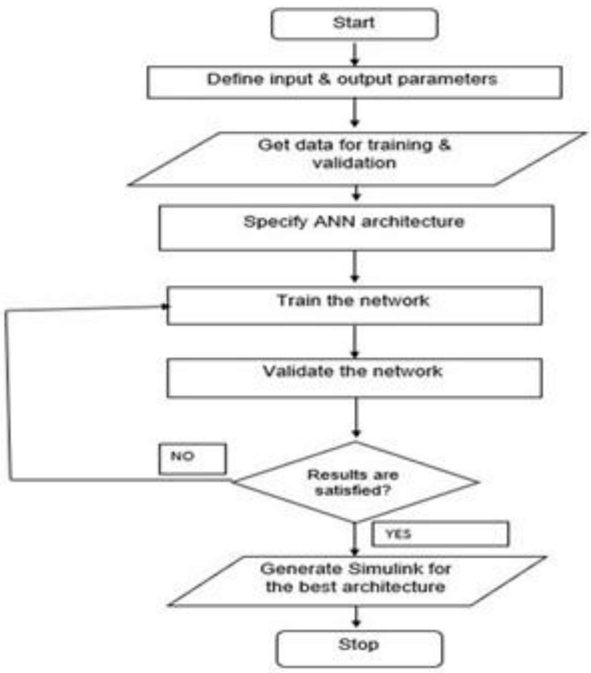

Figure 3. Flowchart of Artificial Neural Network Algorithm

5. Miso Buck Converter

In this work, the buck MISO DC/DC converter is proposed. The multiport converter put-forth uses a single diode and a single inductor as its output and active switches at the input ports, such that the number of photovoltaic panels in a string and the switches are equal [1].

Each active power electronic switch's gating is directly controlled by the suggested ANN algorithm of the MPPT approach. Each matching PV panel's output voltage is adjusted to make sure that the MPP is extracted in line with the specific relative irradiance level of each panel. As a result, the maximum power of each PV module is exactly extracted without taking into consideration the other panels in the string and in accordance with its relative circumstances. The three converter outputs of the system are created from the sum of the peak powers of all the modules.

The outputs D1 and D2, which are obtained from the MPPT algorithm, are what the proposed system regards to be under system control. Continuous conduction of the mode of the converter operation is performed under PWM-pulse width modulation that is unchanging [1]. The converter output voltage gain is given in its general form as, when using the continuous conduction mode and a duty cycle control scheme, where each switch is modulated at the same frequency but may experience different ON times.

$$V_0 = \sum_{k=1}^{N} V_{ik} D_{eff-k}$$

The switches effective-duty cycle is represented as D_{eff-k} [1].

Modes of Operation

Both the average inductor voltage and the average current through the capacitors are equal to zero during steady-state operation. The converter current and the voltage gains are determined using the second balance of the voltage and current observed in the inductor and the capacitor [1]. When Vi1>Vi2, a two-input converter is used for simplicity. Therefore, there are only two possible outcomes: D1>D2 or D1<D2.

CASE 1 (D1>D2)

When connected to PV1 output, S1's ON time in this instance is longer than S2's (connected to PV2 output). Three different operating modes will be present when the continuous conduction mode is taken into account. The converter inductor voltage, switching states, time interval, PV capacitor currents, and switching states are all displayed.

Table 1. D1>D2 converter operating state

MODE	TIME INTERVAL	SWITCHING STATES	V_L	i_{C_1}	i_{c2}
I	$(1 - D_1)T_S$	Diode ON, S1 and S2 OFF.	$-V_0$	Ipv_1	Ipv_2
II	$(D_1 - D_2)T_S$	S1 ON, S2 and Diode OFF.	$V_{i1} - V_0$	$I_{Pv_1} - I_L$	I_{Pv_2}
III	D_2T_S	S1 and S2 ON, Diode OFF.	$V_{i_1} - V_0$	$I_{Pv_1} - mI_L$	$I_{Pv_2} - (1 - m)I_L$

CASE 2 (D1<D2)

The ON time of S2 (connected to PV2 output) is longer in this instance than it is for S1 (connected to PV1 output) [1]. There will be different modes of operation when taking the continuous conduction mode into account. The converter inductor voltage, time interval, switching states, PV capacitor current, and all of these are displayed [1].

Table 2. D1<D2 converter operating

MODE	TIME INTERVAL	SWITCHING STATES	V_L	i_{C_1}	i_{c2}
I	$(1 - D_2)T_S$	Diode ON, S1 and S2 OFF.	$-V_0$	Ipv_1	Ipv_2
II	$(D_2 - D_1)T_S$	S1 ON, S2 and Diode OFF.	$V_{i2} - V_0$	I_{Pv_1}	$I_{Pv_2} - I_L$
III	D_1T_S	S1 and S2 ON, Diode OFF.	$V_{i_1} - V_0$	$I_{Pv_1} - mI_L$	$I_{Pv_2} - (1 - m)I_L$

6. Simulation and Result

There are a few characteristics of the photovoltaic model's design that are discussed. P-V and I-V characteristics make up the two different types of properties of the PV module. Solar irradiance and temperature both affect these characteristics.

P-V features of the photovoltaic module illustrates how the temperature and amount of solar radiation available will affect the maximum power output of a PV system. Power falls to decrease after a period due to a decrease in power as well as an increase in voltage. The power value automatically rises if the voltage and current values do as well.

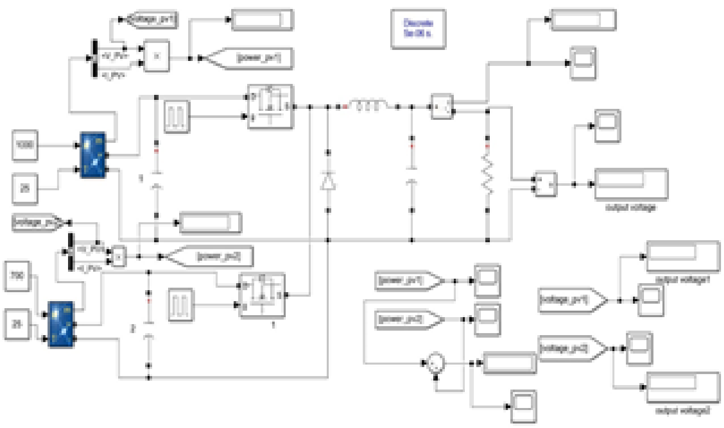

Figure 4. Simulation for P&O

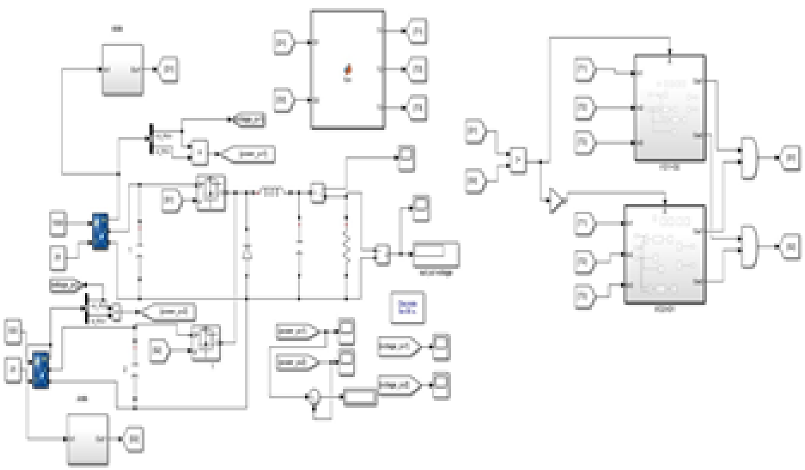

Figure 5. Simulation of ANN

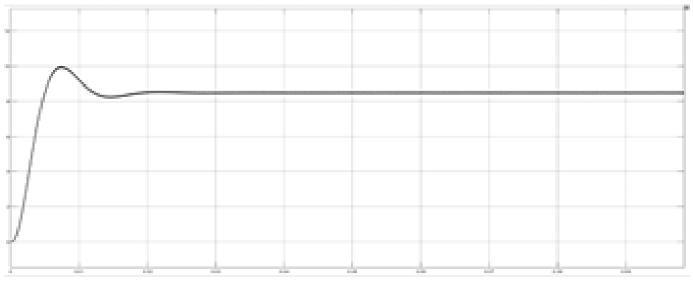

Figure 6. P&O output voltage

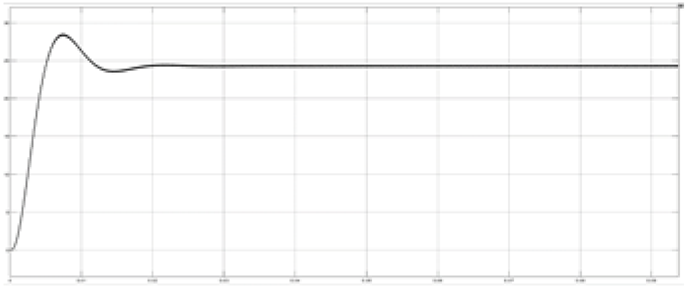

Figure 7. P&O output current

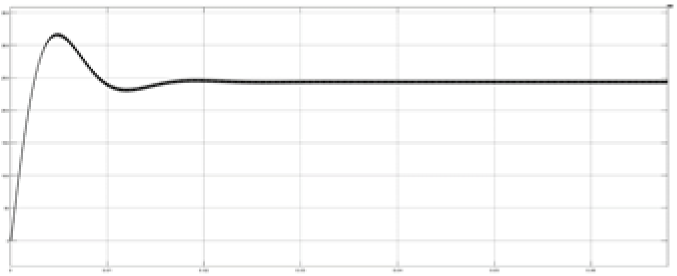

Figure 8. Power output for P&O

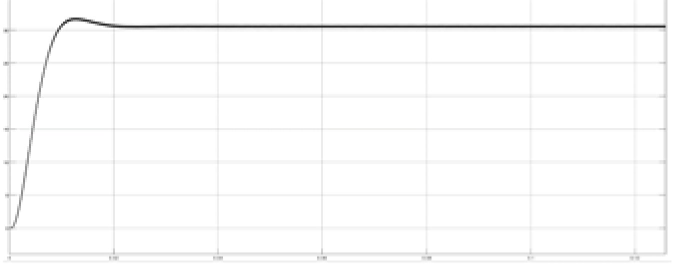

Figure 9. Voltage output for ANN

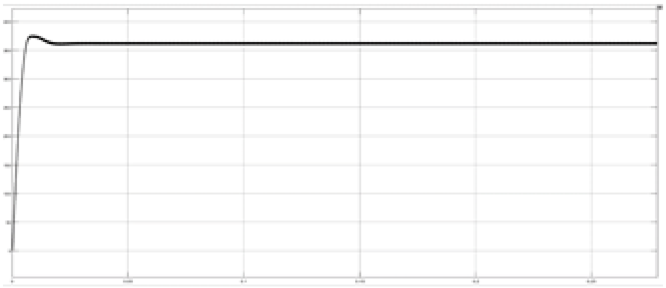

Figure 10. Power output for ANN

Voltage 1, Voltage 2, the total output voltage, and the total output current are compared.

Table 3. Comparison of the P&O method for output parameters and the ANN MPPT algorithm method

PARAMETERS	P&O ALGORITHM	ANN ALGORITHM
VOLTAGE OF PV1	16.53	28.03
VOLTAGE OF PV2	6.02	27.51
TOTAL OUTPUT CURRENT (A)	24.67	30.55
TOTAL OUTPUT VOLTAGE (V)	8.45	10.69
TOTAL OUTPUT POWER (W)	246.3	361.1

7. Conclusion

In this research, the maximum power point tracking (MPPT) controller of the system is presented as a Multi Input Single Output (MISO) converter using Perturb & Observe (P&O) and Artificial Neural Network (ANN)-based techniques. The advantages of the suggested topology include high voltage gain, decreased current stress, and rating of the power switches. A wider variety of switching duty cycles are offered in the converter that is being presented, which is worth mentioning. A control system that is more adaptable can therefore be used. The P&O and ANN-based MPPT techniques are utilised to evaluate the system using a solar system that has a MISO buck converter topology and only one inductor.

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