Performance Analysis of Hybrid MPPT Controller for PV Boost Converter

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Abstract - *This study examines the Perturb and Observe (P&O) and Incremental and Conductance (I&C) MPPTs, both of which use neural network (NN)-based artificial intelligence techniques to improve their output. The purpose of the DC-DC converter is to control the PV module's output voltage in buck or boost mode as necessary. The DC-converter is designed using a single switch unidirectional architecture, with gate pulses regulated by an MPPT algorithm based on neural networks. The P&O and I&C algorithms with and without the NN approach are compared. To validate the suggested topology, the results are acquired using MATLAB program for Simulink.*

Key Words: Maximum Power Point Tracking (MPPT), incremental and conductance (IC), constant voltage, perturb and observe (PO), neural networks (NN), DC-DC converter.

1.INTRODUCTION

During the past two decades, solar has astonishingly gotten deep into the main stream power system. Solar irradiation, which fluctuates on an hourly, daily, monthly, and annual basis, is the source of solar energy. Therefore, it is not possible to generate power continuously from sunlight. However, by monitoring the highest generation at the instantaneous irradiance, the output from the sola-cell may be maximized at any given time. Maximum Power Point Tracking (MPPT) is used to accomplish this [1]. When PV production peaks at a location known as the Maximum Power Point (MPP), which is constantly shifting in relation to temperature and solar radiation, MPPT aids in tracking the output. MPP is a point on the PV/VI curve that represents a particular PV module's peak voltage, current, and power. There are many different topologies for building MPPT controllers in the literature; the most widely used ones include hill climbing, incremental and conductance (IC), constant voltage, perturb and observe (PO), and others [2–5]. All of these topologies are widely used and customary. By using any clever techniques, the efficiency of the traditional topologies may be multiplied by many. Intelligent methods, such as neural or fuzzy, aid in the quick and precise monitoring of MPP [6–8].

The intelligent MPPT hybrid approach based on neural networks (NN) is presented in this paper. With the aid of an algorithm that facilitates quick convergence of the MPP at the specified irradiance, NN is intended to calculate the voltage and current at MPP. The DC load is powered by the DC-DC converter, specifically the boost. In order to precisely convalesce the MPP under a variety of operating situations, the output from MPPT is used to create the converter's proper duty cycle. When the hybrid MPPT algorithm is used, the duty cycles provide PWM for the converter's switches and achieve smooth fluctuations with regard to varied irradiations. A compact DC system with 250 W of power and input-to-output voltage fluctuations between 30 and 80 V is built. In order to determine which strategies converge quickly to determine the maximum voltage and current at the moment of irradiation variance, results are compared under varying irradiance and performance is examined.

2. NEURAL NETWORK BASED HYBRID MPPT

A highly effective technique for improving PV system performance and guaranteeing smooth operation in varying weather conditions is MPPT. In order to build the duty-cycle of the DC-DC converter to follow the MPP, MPPT is used to track the MPP [9].

Using the NN-algorithm to adjust the fluctuation in MPP voltage and current may significantly improve the MPPT's convergence speed and quick adaptation. In order to supply the gating of the switches of the PV-boost converter, this study develops a hybrid NN-based IC and PO method [10]. ANN is used because of its high degree of convergence flexibility and dependability. The NN determines the voltage and current at MPP for each operating point with a specified temperature and irradiance. The PO algorithm determines the proper duty cycle for the DC-converter's switches based on the estimated parameters. In a variety of climatic conditions, this will perfectly recover the maximum power and be in line with the MPP. The conventional PO and IC approaches are then compared with the proposed approach. A proportional-integral (PI) controller is used to ensure that the capacitor voltage balance is maintained. Figure 1 displays the full schematic design of the suggested architecture. NN is often used for MPPT control since it doesn't require a physical model or intricate mathematical computations. It can also manage the large nonlinearities in the P/V characteristics of the PV panel [11-13].

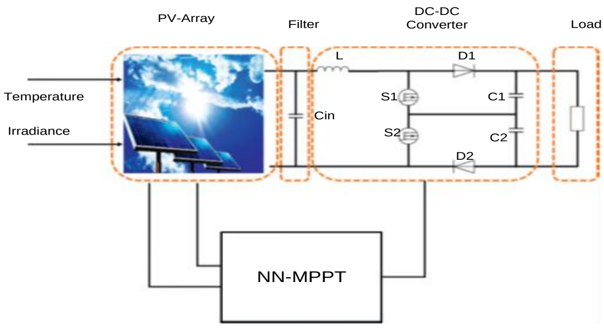

Fig -1: Schematic diagram of the Proposed hybrid MPPT topology

3. SIMULATION MODEL

The user-defined PV module, whose parameters are shown in Table 1, and the simulation model, which is displayed in Figure 2, are used in MATLAB program to generate the simulation results. The findings are based on variable irradiance ranging from 200 to 1000 wb/m2, which is changed in increments of 200 over a period of 0.2 seconds at each division. The temperature in this experiment is maintained at 25°. However, the system under investigation can also be examined under different temperature circumstances.

The MPPT-controller, whose primary function is to create the PWM control for the DC-converter's switches, receives the PV's output. Performance study is done in this work for both static loading situations and dynamic environmental conditions. Three cases are examined:

(i) Conventional PO technique;

(ii) NN-PO technique; and

(iii) NN-IC technique.

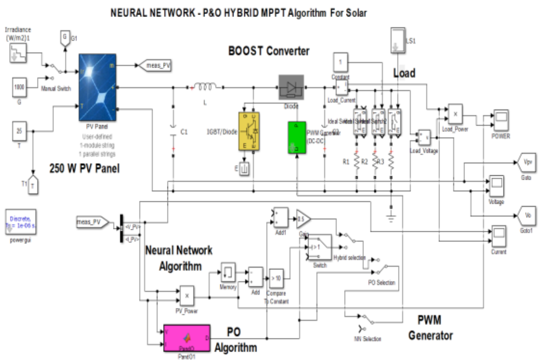

Fig -2: Simulation Model

Table -1: Sample Table format

S.No.	*Parameter*	*Value*
1	PV Power rating	250 V
2	Per module cells	60
3	Series resistance Rs (ohms)	0.237
4	Series resistance Rs (ohms)	240.6
5	Isc	8.66 A
6	Voc	37.3 V
7	Vmp	30.7 V
8	Imp	8.15
9	Switching Frequency	10 KHz
10	C1, C2	100μF
11	L	3mH
12	Ki	0.3
13	Kp	0.6
14	Filter Coefficient	100

4. RESULT DISCUSSION

In this section results for the proposed neural network based MPPT algorithm is discussed. Figure 3 displays the Vmp (max. volt. at any input radiance and temperature) as determined by NN under different irradiance. It is evident that under the various operating circumstances, the Vmp value of the module, which is 30.7V, is maintained by the Vmp acquired from NN. Figure 4 displays the duty cycle in this scenario. Figure 5 displays the output power at the PV module's terminal under the specified operating circumstances. Figure 6 compares the voltage at the PV terminal for conventional P&O MPPT, NN-P&O and NN-IC. The graph shows that even though NN was trained for Vmp, it also influences the output at the PV side when it is fed into the MPPT algorithm. Figure 7 displays the output voltage that was acquired from the DC-converter side. It is evident from the graphic that the Dc-converter increases the voltage by more than double the input voltage. The output terminal voltage is around 80V, which varies between 80V and 40V depending on the input irradiance, whereas the input voltage is approximately 32 V. Similarly, DC-converter side output current is presented in figure 8.

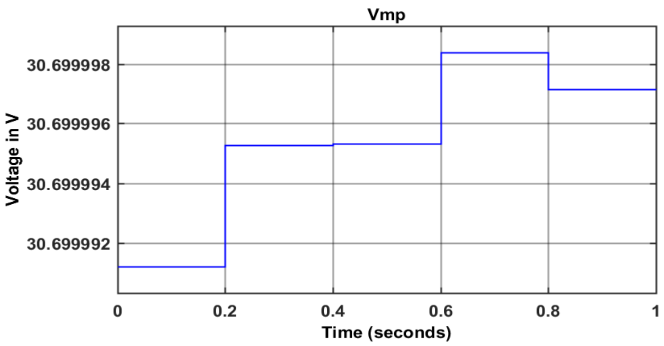

Fig -3: Max. voltage obtained at NN output

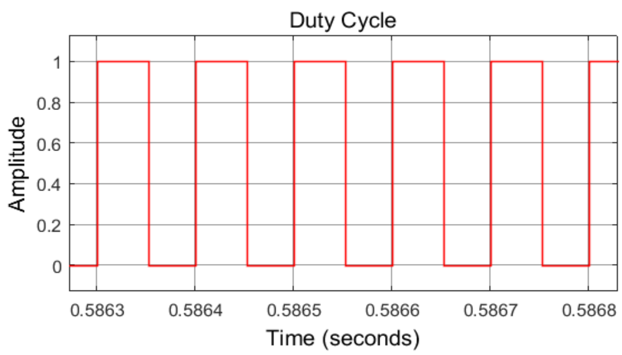

Fig -4: Duty cycle under variable irradiance

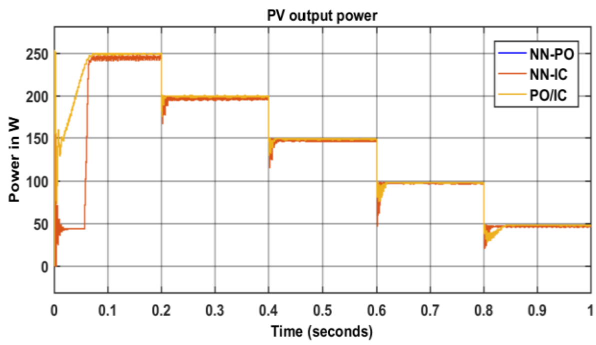

Fig -5: PV output power comparison

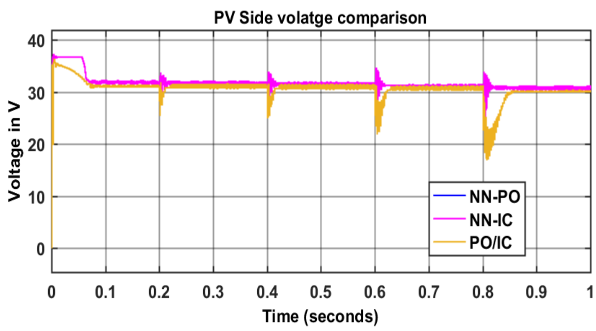

Fig -6: PV output terminal Voltage comparison

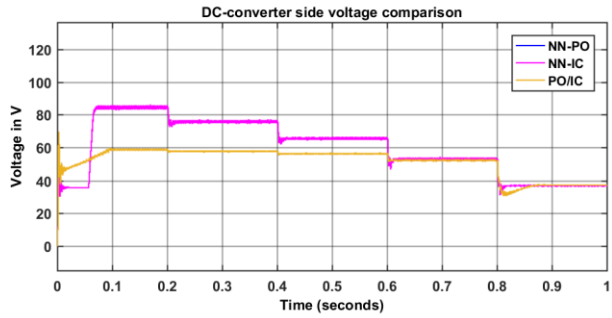

Fig -7: DC-Converter output terminal Voltage comparison

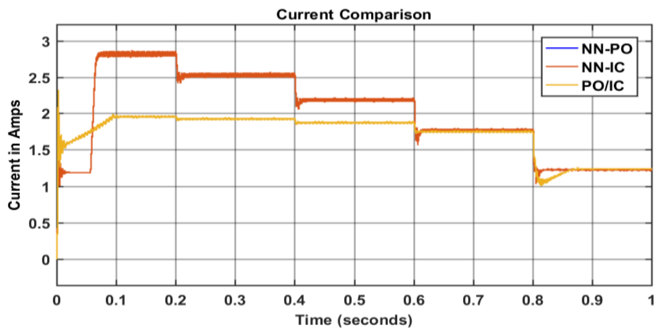

Fig -8: DC-Converter output current comparison with NN-MPPT

NN based MPPT algorithms has high degree of accuracy. It tracks the MPP and feed to the MPPT algorithm to design the duty-cycle for the switches of the DC-converter. The Duty cycle designed using NN based MPPT algorithms is shown in figure 9 and the one without the NN is shown in figure 10. It is evident that, duty cycle is stable with NN, while with conventional topologies it has fluctuations which affects the performance of the system.

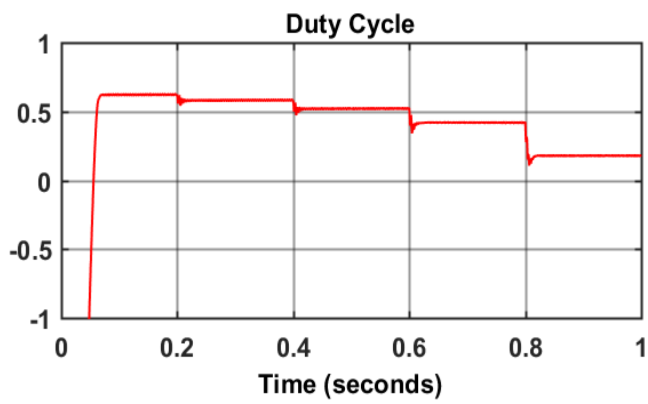

Fig -9: DC-Converter switches duty cycle with NN-MPPT

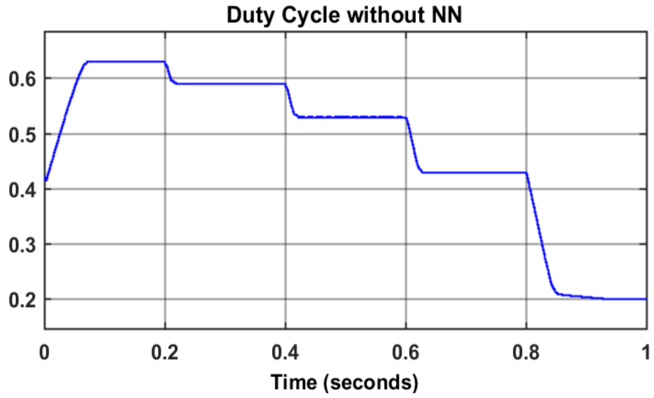

Fig -10: DC-Converter switches duty cycle without NN-MPPT

5. CONCLUSIONS

The solar irradiance that strikes the PV plate determines the output across the sun. Just as the irradiances vary in nature, so does the solar power's production. The PV array's greatest point of voltage and current generation at any given time is tracked using greatest Power Point Tracking (MPPT). This aids in getting the most power possible from the sun at any irradiance level.

Intelligent algorithms can be used to secure this tracking method. The purpose of this research is to use a neural network trainer to create an MPPT controller that is both accurate and precise. The MMPT algorithm's result analysis has been shown both with and without a NN trainer. In contrast to the traditional topologies, the comparative study demonstrates that the output from NN-based MPPT is more accurate and exact.

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