



Enhancing PV Inverter Performance Using ANN-Based Control Technique

Mohammad Ordouei¹, Azamossadat Nourbakhsh^{*2}, Ali Sahib Jebur³

Department of Computer, South Tehran Branch, Islamic Azad University, Tehran, Iran¹

ORCID: 0000-0002-0391-0638

Department of Computer Engineering and Information Technology, La.C., Islamic Azad University, Lahijan, Iran²

Corresponding Author^{*2}

Department of Computer, South Tehran Branch, Islamic Azad University, Tehran, Iran³

Abstract: Due to the significant advantages, it offers as a pure, renewable energy that is free of issues related to waste and fuel, there has been a growing interest in using solar energy to generate electric power using photovoltaic panels over the course of the past few decades. There is a need for smart controllers to convert the direct current generated from photovoltaic cells towards alternating current through inverters, the most prominent of which are the Model predictive control (MPC). MPCs are adaptable devices with multivariable control methodology provide best powerful execution than direct control. In this paper we propose an efficient controller for adjusting Photovoltaic micro-grid power system using ANN technique to overcome problems of floating energy and enhancing the overall all system performance efficiency as a proposed technique. The suggested model should have the abilities to cancelling the losses and disadvantages effect provided by LC filters and other limitations in controlling techniques. The required software which have been chosen to employ the proposed technique relays upon utilizing MatLab2020 simulation program.

1. INTRODUCTION

Small networks that are activated through transformers that form the network by the switch that is connected to infinite distribution power resources (DERs) or clean energy sources have made significant progress in recent years as smart technologies and artificial intelligence algorithms have spread throughout all aspects of life. Lately, energy contraptions authors have hoped to examine info based systems as decisions to model-based technologies [4,5]. A couple of benefits nitty gritty in the composing are the reliability enhancement (sensor decline) [5,6], too minimization of hardware necessities [7,8]. One man-made cognizance (AI) data based approach is neuro-fuzzy control, against it is a half to 50% of fuzzy reasoning utilizing artificial neural networks (ANN) [9,10].

Aims

Design and Implementing of a model predictive controlled MPC for Photovoltaic micro-grid power system using ANN technique.

- 1- The suggested inverter : as mentioned above the suggested inverter is combined from two types of inverters and we will discuss the two types also will explain the suggested inverter and as follow :

3.1- Perturb And Disturb (P&O) Controller

This is the utmost usual kind of boost controllers available for MPPT technique. Some MPPT techniques are available in P&O and IP&O. The P&O approach is the utmost easy, that travels the operating point towards the maximum power point periodically to ascend or descend the PV cells voltages. A typical P&O controller is presented in Figure1

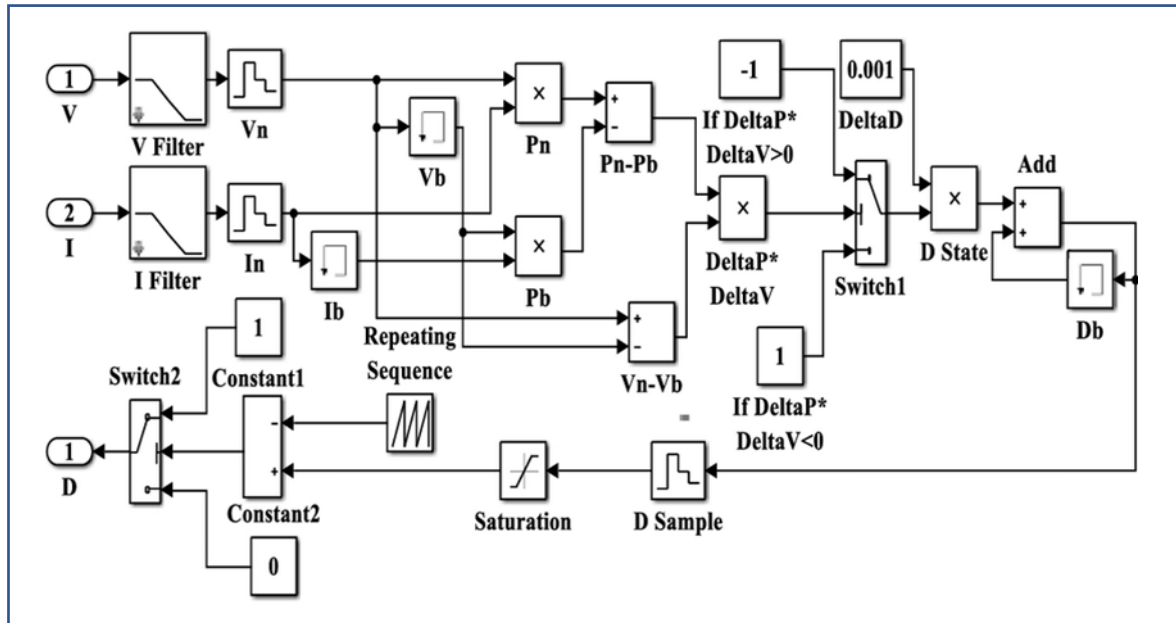


Figure1 A typical P&O controller circuit diagram

This technique, a slight disturbance was presented to produce the power alternation of the PV module. The photovoltaic resulting energy is periodically computed and correlated to the last energy. If the resulting energy is increased, the similar operation continues otherwise the disturbance is inverted.

3.2- Artificial Neural Networks (ANN) Controllers

Artificial neural networks controllers, are powerful data-driven modeling equipment which are broadly utilized in the dynamic modeling as well quantification of nonlinear systems, because of their global approximation abilities with their flexible structure which permits capturing complicated nonlinear performances [11,12]. Artificial Neural Networks (ANNs) are biologically inspired computer softwares analyzed to simulate the approach that the human brain processes data. ANNs collect their knowledge by discovering patterns and relationships in data and learned (or are trained) along practice, not along automation.

Figure 2 presents common ANN controller for PV power system [13,14]

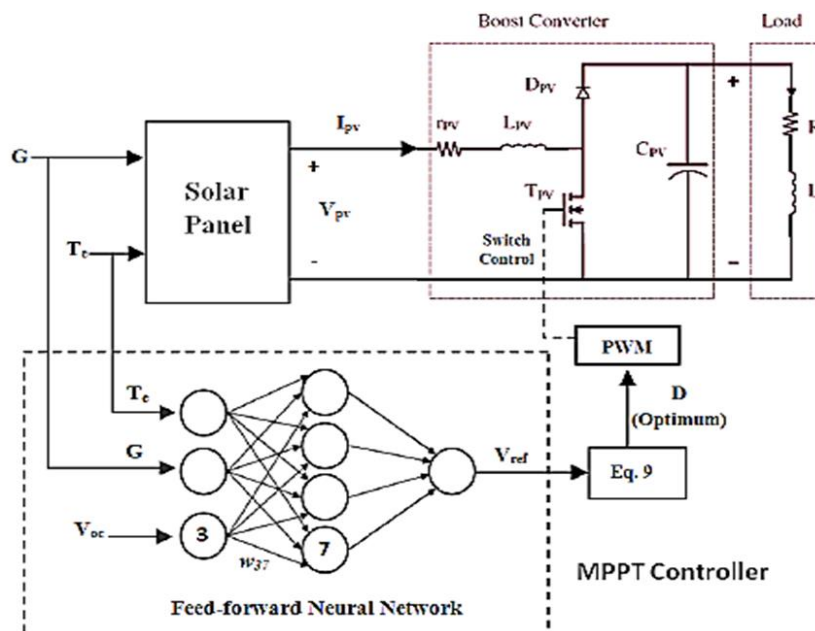


Figure2: The suggested block diagram model implemented in the project



Intelligent control obtains computerization along simulation intelligence. ANN is part of the advanced control techniques. It is utilized for control of the system attached to the three-phase photovoltaic grid with such ANNs. They have been successfully applied in advancement, for associative memories, pattern recognition, and numerous other fields [15,16]. ANN is utilized in such system because it has several benefits such as: NN Artificial kinds of artificial intelligence is part of the advanced control categories also, furthermore no force is required for system description, NN contains input layer, output layer and number of hidden layers as displayed in Figure 3. Input layer It is based on controlling the current that includes of two axes (d axis and q axis). The outcome layer expressed by control signal axis.

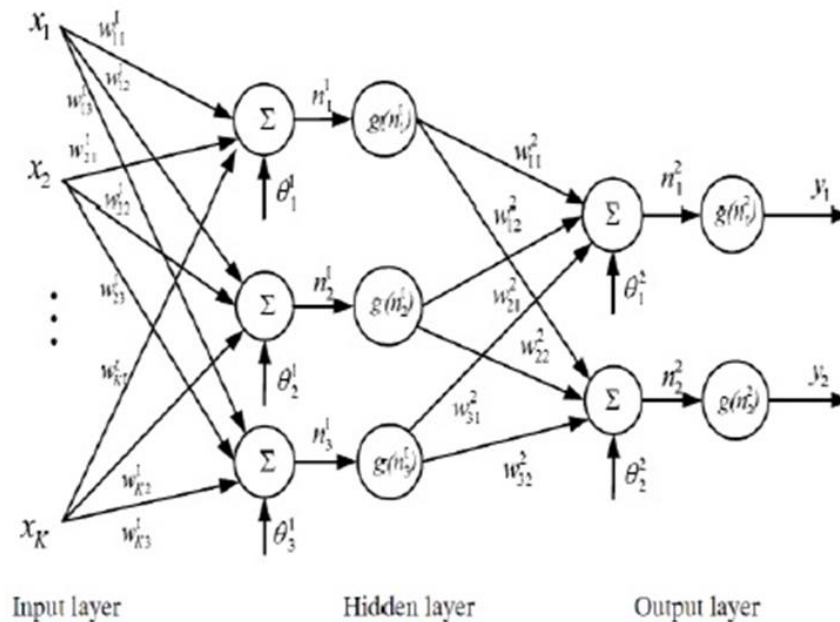


Figure3: Schematic diagram of Neural network internal model [7].

The hidden layer in ANN architecture includes of numerous neurons ordered in layers. Every neuron in a layer is attached to each part of the neurons of the incommong layer. Figure 2.18 illustrates a block of the developed feed-forward neural network [17,18]. It consists of 10 hidden layers and one result layer. The information layer to this network is the turning reference frame current error in the d-axis component. The result layer in Figure 4 represents the control signal [19,20].

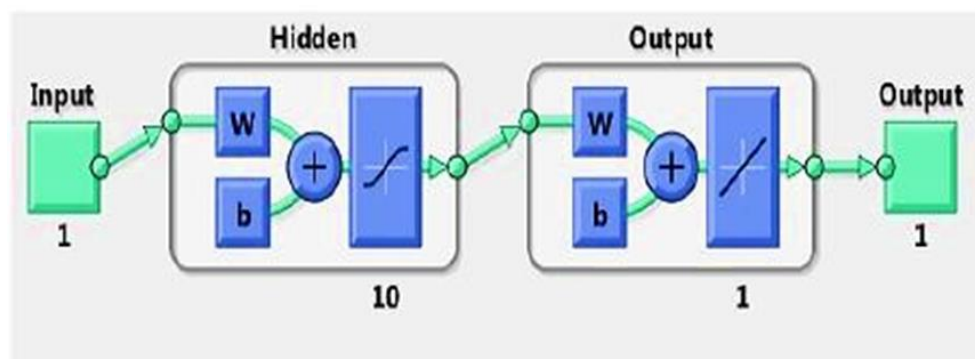


Figure 4

Since ANN controllers have been nominated to be chosen as the proposed model in this study.

3.3- The Hybrid (P&O) with ANN Controller Unit:

This is the essential unit in the simulated model, which is responsible of the optimum or maximum power tracking that might be obtained from the model. It consists of two main controllers, the perturb and observe (P&O) controller, and the artificial neural network (ANN) controller. Figure 5 presents the implementation model of this hybrid controller.

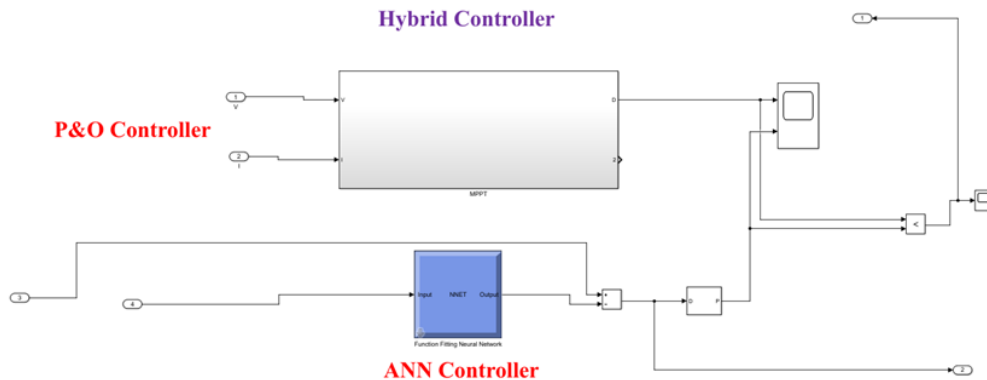
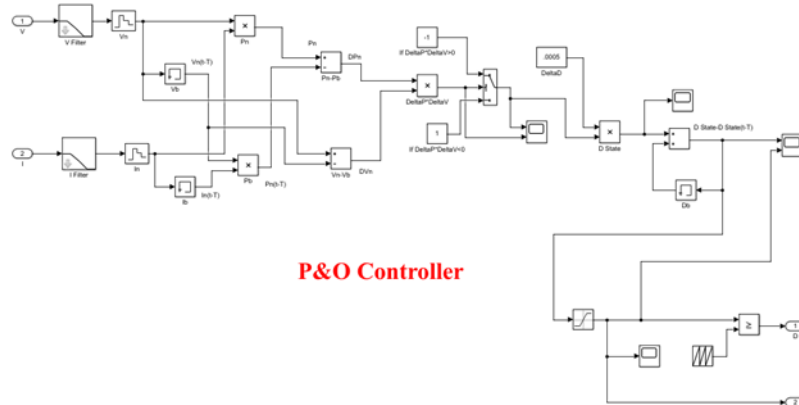


Figure 5 The implementation model of the hybrid controlling technique.

Each controller will act on the differential change in PV voltage and current to produce the differential change in overall obtained power. This differential change will be maximized until achieving the maximum power at the output of the model. Figures 6, illustrate the construction of the P&O controller and the ANN controller respectively.



Figures 6: The construction of the P&O controller technique nb e.

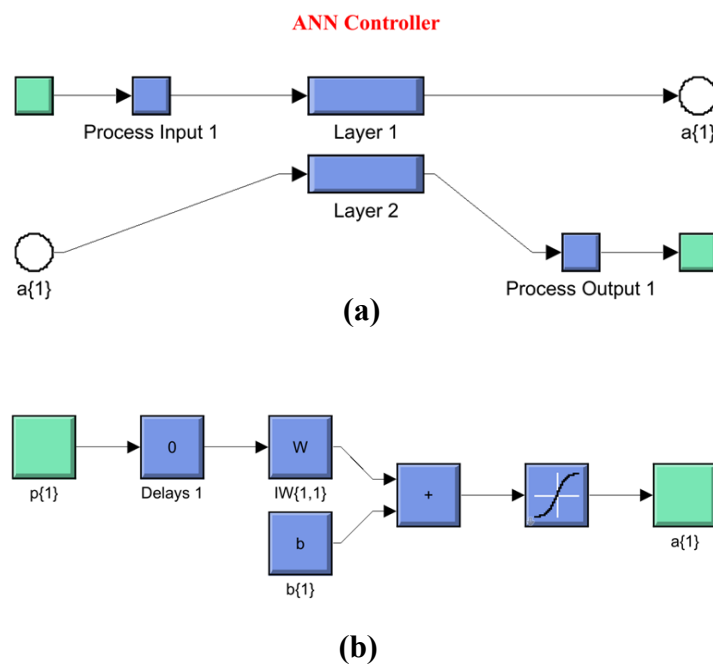
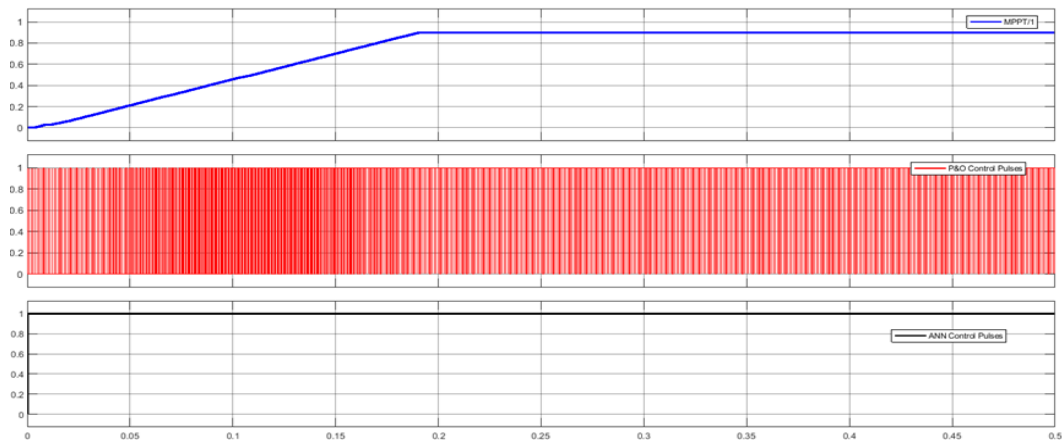


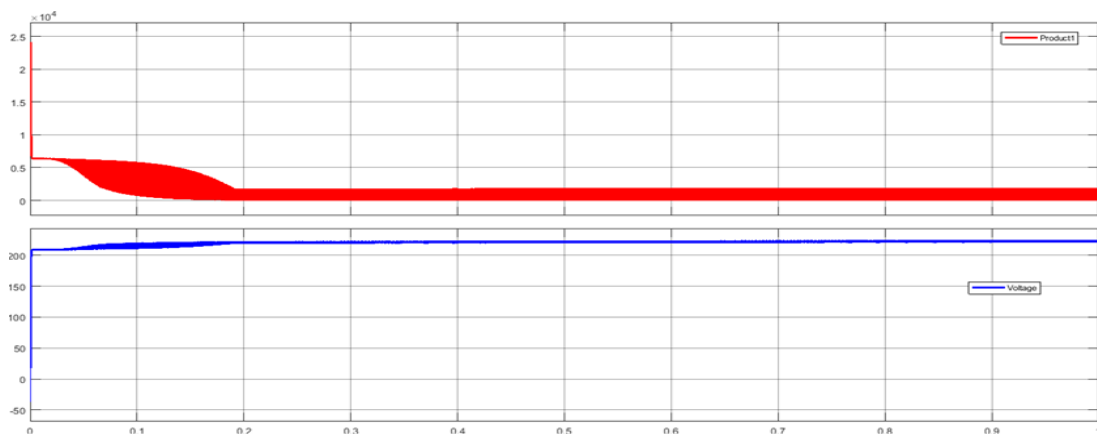
Figure 7: The ANN controller construction, (a) ANN internal layers, (b) ANN layer construction.



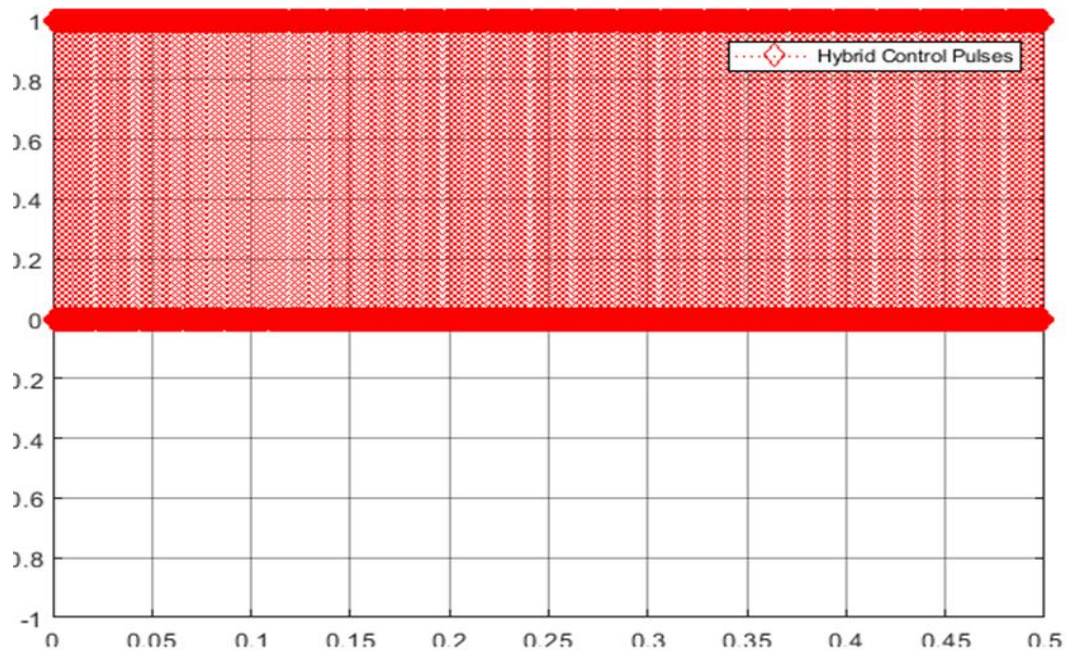
Such structure introduces a converted crossover greatest power point to ensure that photovoltaic (PV) displays under partial shade (PSC) conditions can always produce maximum power quickly and effectively. The strategy that comes next is called MPPT, and it involves applying a specialized neural network (ANN) to the modified perturbation and monitoring (MP&O). Instead of using expensive luminous intensity sensors straight away, the luminous intensity is turned on for each PV cluster unit, and the given points can be checked by using the cheapest voltage and current sensors. The ANN anticipates the optimal voltage areas for the Global Maximum Power Point (GMPP) by utilizing the backhanded light intensity. The combination of the P&O controller with the ANN controller will provide a better tracking to the overall power, since part of the very small differential change in the PV voltages and current those might not be sensed by the P&O controller will be detected by the ANN algorithm controller system.



The output signals from the P&O controller compared with the ANN controller.



The resulting signals from the ANN controller.



The final obtained hybrid controlling pulses.

Table 1 Comparison summary among the obtained results for the 3 techniques.

Control Technique	D.C. Current I(Ampere)	D.C. Voltage V(Volts)	MMPT P(Watt)
ANN	5	260	1200
P&O	9	400	3000
Hybrid	22	1150	21000



Table 2 : comparison summary of our suggested model with those presented by modern published studies.

Reference	Title	Implementation	Limitations
In 2019, Easley, M.; Fard, A.Y.; Fateh, F.; Shadmand, M.B.; Abu-Rub, H., et. al., [5], ; IEEE: Baltimore, MD, USA, 2019; pp. 3703–3709.	Auto-Tuned Model Parameters in Predictive Control of Power Electronics Converters	Modifications of finite set model predictive control are made for various applications, demonstrating how recurrent problems of finite set MPC can be solved. Issues of ambiguous cost function design and, for some applications, impractical computational burden are addressed. A variation of the finite-set MPC is proposed which removes ambiguity in the design phase of the finite-set MPC. Using hierarchical model predictive control, Solutions that enable real-time model alignment, fault-tolerant operation, and situational awareness of the transformer are presented. These improvements in predictive control can ensure that tomorrow's grid smart inverters are fast, aware and reliable.	The tracking performance required for each target is determined during design. Assuming multiple objectives, the designer must rank each objective and apply its associated cost tolerance (or acceptable error) to the objectives. Also complicated scheme with large computations & increased temperature.
In 2021, Khalilzadeh, M.; Vaez-Zadeh, S.; Eslahi, M.S., et. al., [6], IEEE J. Emerg. Sel. Top. Power Electron. 2021, 9, 327–334.	Parameter-Free Predictive Control of IPM Motor Drives with Direct Selection of Optimum Inverter Voltage Vectors.	The time derivatives of the armature current (slopes) are expressed as functions of the phase angles of the inverter's fundamental voltage vectors. The slopes are then predicted independently of the motor parameters and are used in selecting the optimal inverter voltage vectors. In addition, a method is used to avoid time-consuming evaluations of the cost function to determine the optimal inverter voltage vector. Through this method, reference current slopes are used to select the optimal direct voltage vector. As a result, the control performance under parametric uncertainties is improved and the control code execution time is shortened compared with the traditional predictive method. The effectiveness of the proposed method and its superiority over the conventional method and the recently introduced predictive current control method are confirmed by simulation and experimental results.	Complicated Structure with high cost. Also huge number of computations in order to select the optimum inverter voltage vectors
Our Suggested Model	PV system inverter Characteristics Improvement using ANN Controlling technique	By studying here, we present a superior way to eliminate the power of MPC to guide variant/fault combinations with a truly executable bounds evaluation. Moreover, we extend the proposed method to better working conditions through a new artificial neural network strategy. New predictable evaluation accuracy results of over 96% have been achieved in total harmonic distortions (THD) of normal MPC for apparent properties.	Little delayed testing against computations with acceptable complexity and medium cost.

The final obtained hybrid controlling pulses.



4. CONCLUSIONS

In this thesis, the effects of mixing two controllers on the boost converter PV cells system have been discussed and investigated using hybrid perturb and observe (P&O) with artificial neural network controllers. Since the ideal voltage at which the loads receive the most power with the fewest losses is known as the maximum power point tracking (MPPT). Three photo voltaic (PV) penal cells have been utilized as a constant DC power sources to provide partially shaded direct current to the system. The designed PV cells model has been simulated and examined with three types of boost controllers. The simulation results show that the hybrid combination of the P&O-ANN controller provides the best maximum power point tracking (MPPT) among the two other controllers. The proposed model produces MPPT power of 20 KW which is multiple times better than both the P&O technique and the ANN controller each individual.

REFERENCES

- [1] Easley, M.; Fard, A.Y.; Fateh, F.; Shadmand, M.B.; Abu-Rub, H. Auto-Tuned Model Parameters in Predictive Control of Power Electronics Converters; IEEE: Baltimore, MD, USA, 2019; pp. 3703–3709. [CrossRef]
- [2] Khalilzadeh, M.; Vaez-Zadeh, S.; Eslahi, M.S. Parameter-Free Predictive Control of IPM Motor Drives with Direct Selection of Optimum Inverter Voltage Vectors. IEEE J. Emerg. Sel. Top. Power Electron. 2021, 9, 327–334. [CrossRef]
- [3] Mehreganfar, M.; Saeedinia, M.H.; Davari, S.A.; Garcia, C.; Rodriguez, J. Sensorless Predictive Control of AFE Rectifier With Robust Adaptive Inductance Estimation. IEEE Trans. Ind. Inform. 2019, 15, 3420–3431. [CrossRef]
- [4] M. Ordouei and T. BaniRostam, Integrating data mining and knowledge management to improve customer relationship management in banking industry (Case study of Caspian Credit Institution), Int. J. Comput. Sci. 3 (2018), 208–214.
- [5] M. Ordouei and T. Banirostam, Diagnosis of liver fibrosis using RBF neural network and artificial bee colony algorithm, Int. J. Adv. Res. Comput. Commun. Engin. 11 (2022), no. 12, 45–50.
- [6] M. Ordouei and M. Moeini, Identification of female infertility in people with thalassemia using neural network, Int. J. Mechatron. Electric. Comput. Technol. 13 (2023), no. 48, 5371–5374.
- [7] M Ordouei, A Broumandnia, T Banirostam, A Gilani, Efficient energy management in a smart city based on multi-agent systems over the Internet of Things platform, International Journal of Nonlinear Analysis and Applications, pp. 1-8, January, 2023.
- [8]. Ordouei, I. Namdar. "Web Robot Detection Based On Fuzzy System and PSO Algorithm", IJCSN International Journal of Computer Science and Network, Volume 7, Issue 4, August 2018.
- [9] M Ordouei, A Broumandnia, T Banirostam, A Gilani, Providing A Novel Distributed Method For Energy Management In Wireless Sensor Networks Based On The Node Importance Criteria, Journal of Namibian Studies:History Politics Culture, 2023.
- [10] Kwak, S.; Moon, U.C.; Park, J.C. Predictive-Control-Based Direct Power Control With an Adaptive Parameter Identification Technique for Improved AFE Performance. IEEE Trans. Power Electron. 2014, 29, 6178–6187. [CrossRef]
- [11] A Moradi, M Ordouei, SMR Hashemi, Multi-period generation-transmission expansion planning with an allocation of phase shifter transformers, Int. J. Nonlinear Anal. Appl. In Press, (2023) 1–12.
- [12] M. Ordouei, A. Broumandnia, T. Banirostam and A. Gilani, Optimization of energy consumption in mart city using reinforcement learning algorithm, Int. J. Nonlinear Anal. Appl. In Press, (2022) 1–15.
- [13] M Ordouei, A Shams, M Moeini, ARTIFICIAL INTELLIGENCE ROUTING ALGORITHMS IN INTER-VEHICLE MOBILE NETWORKS, Vol. 10, Issue 08, pp. 8751-8757, August, 2023.
- [14] M Ordouei, B Jalali, A Tolouee, Enhancing Diabetes Diagnosis: A Comparative Analysis of Machine Learning Algorithms and Evaluation Metrics, Dandao Xuebao/Journal of Ballistics, Vol. 36 No. 1(2024).
- [15] M Ordouei, B Jalali, New Design and Clustering of Sensors to Optimize Energy in the Internet of Things Network ", IARJSET International Advanced Research Journal in Science, Engineering and Technology, vol. 10, no. 11, pp. 76-82, 2023. Crossref <https://doi.org/10.17148/IARJSET.2023.101111>.
- [16] A Nourbakhsh, M Ordouei, B Jalali, Proposing a New Framework for Optimizing Energy Consumption in Sensor Nodes Used in the Internet of Things, Power System Technology, Vol. 48 No. 1 (2024).
- [17] M Ordouei, A. Tolouee, Comparative Analysis of Evolutionary Algorithms for Optimizing Vehicle Routing in Smart Cities, Power System Technology, Vol. 48 No. 1 (2024).
- [18] M Ordouei, M Moeini, Identification of hepatitis disease by combining decision tree algorithm and Harris Hawks Optimization (HHO), International Journal of Advanced Research in Computer and Communication Engineering, Vol. 12, Issue 7, July 2023.



- [19] Zhang, Y.; Jiao, J.; Liu, J. Direct Power Control of PWM Rectifiers With Online Inductance Identification Under Unbalanced and Distorted Network Conditions. IEEE Trans. Power Electron. 2019, 34, 12524–12537. [CrossRef]
- [20] Abdelrahem, M.; Hackl, C.M.; Kennel, R. Finite set model predictive control with on-line parameter estimation for active frond-end converters. Electr. Eng. 2018, 100, 1497–1507. [CrossRef]