Multidisciplinary Journal for Applied Research in Engineering and Technology (MJARET)

Vol.1 Issue 2, Month – September – 2021, Pages: 26-28

Design and Analysis of a Grid-Integrated Residential Solar PV System

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Received: 01 September 2021 / Accepted: 26 September 2021

Abstract:
Controlling the single-phase PV system improves system performance, safety, reliability, and controllability while interacting with the energy grid. The primary goal of this research is to create an Artificial Neural Network (ANN) vector control method for a single-phase solar inverter. The ANN controller is trained using approximation dynamic programming to obtain optimum control. To evaluate an ANN-based solar PV system, models of PV system behaviour for grid integration and maximum power extraction from solar PV arrays in a genuine residential PV application, as well as the development of an experimental solar PV system, are employed. The findings show that an ANN-controlled PV system outperforms a typical vector-controlled PV system in terms of performance.

Keywords— MPPT control, ANN vector control and PV system integration

1. Introduction

More than 900 MW of solar photovoltaic (PV) installations are projected to be built in the worldwide market for grid-connected residential systems in 2018. A domestic solar power system that is linked to the electrical grid. According to current forecasts, the worldwide market for grid-connected household solar photovoltaic (PV) installations would exceed 900 MW by 2018. Power electronic converters are used in grid-connected residential solar PV systems to capture solar energy and integrate it into the grid. A PV array is made up of a number of solar cells that are linked in series and parallel. Maximum power extraction from a PV array and dependable grid integration are two of the most important components of a solar PV system.

The output of a PV array is heavily influenced by temperature and sun irradiation. Every every one of these

The P-V curve represents a single point, known as the maximum power point (MPP), at which the PV array generates its maximum output power under optimal solar radiation and temperature conditions. A maximum power point tracking (MPPT) strategy, which is conducted by manipulating the DC-DC converter attached to the PV array, may be used to determine the MPP's position. An MPPT algorithm must be capable of reliably identifying and maintaining an MPP under steady-state irradiance circumstances, as well as monitoring an accurate MPP under rapidly changing conditions, if a solar PV system is to be managed by one.

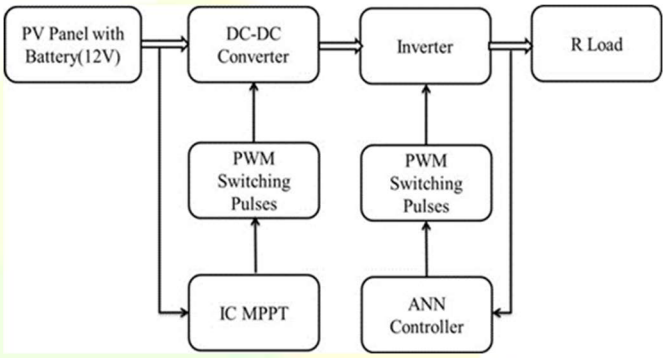

Figure 1.1 Basic Block Diagram

2. SYSTEM DESCRIPTION

2.1 Artificial neural networks

An artificial neuron network is a computer model that is based on the structure and functionality of biological neural networks, for example (ANN). Because neural networks adjust depending on input and output, the ANN's structure changes - or learns in certain ways - as data travels through it. Artificial neural networks (ANNs) and other nonlinear statistical data modelling methodologies are used to simulate or find patterns in complicated input-output interactions. An ANN, often known as a neural network, is one kind of ANN.

2.2 DC-DC converter (Chopper)

Chopper quickly connects and disconnects from a source load. By continually flipping the power switch on and off, electricity is given sporadically to the

source. The ON and OFF phases of the chopper are referred to as the ON and OFF periods of the power switch, respectively.

Chopper technology is used in electric cars, wind turbines, solar panels, and DC motor regulators.

2.2 Photovoltaics (PV)

Photovoltaics convert light into energy by employing semiconducting materials that exhibit the photovoltaic effect, a phenomenon investigated in physics, photochemistry, and electrochemistry (PV).

To generate power, photovoltaic systems generally employ solar panels, each of which comprises a number of solar cells. PV systems may be installed on the ground, on the roof, or on the wall. A solar tracker or a permanent mount may be used to follow the sun's passage across the sky.

2.3 Maximum power point tracking

- MPPT is based on the idea of running PV modules at the highest feasible efficiency voltage in order to extract the most power out of them (maximum power point). To put it another way, the MPPT examines PV output, compares it to battery voltage, and then finds the ideal PV module power output for charging the battery. It can power a DC load when connected directly to the battery.
- MPPT is most effective in these situations.
- Days with a lot of cloud cover and chilly temperatures: MPPT is often utilised to extract the maximum power out of PV modules while they're running at lower temperatures.
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- MPPT may extract more current and charge the battery when the battery's state of charge is low.

3. ADP- ANN VECTOR CONTROL THEORY

To address the problem of decoupling inaccuracy, a new ADP-based ANN current controller is presented as a replacement for the PI-based current controller. The ADP-ANN controller's ANN component is referred to as a "action network" in this context. The controller's outer loop is identical to that of standard controllers. The design stages of the ADP-ANN controller are equivalent to those of a regular controller. To begin, we will need a dynamic model of the plant, comparable to that required by a standard controller. Second, just as a standard controller structure must be provided, a network structure must be provided... After then, the ANN is trained, which is similar to fine-tuning a typical controller.

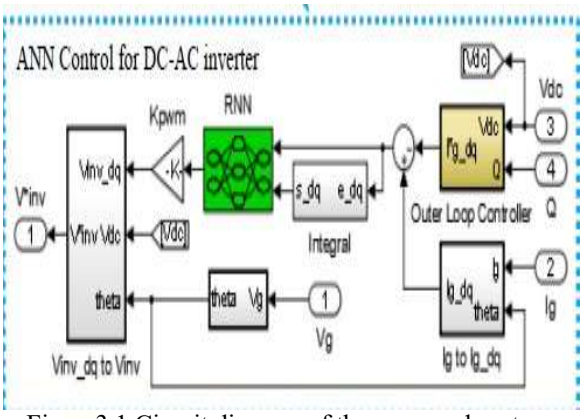


Figure3.1 Circuit diagram of the proposed system

Two PV grid integration instances were examined for the integration of MPPT and ANN controls: one for simulation and the other for testing hardware. The PV system features employed in the simulation are similar to those seen in a typical residential solar PV system. In the hardware experiment, which has a lower power ratio, lab-scale PV systems are employed.

4. RESULTS DISCUSSION SIMULATION DESIGN

The suggested simulation design is implemented in MATLAB SIMULINK. The output waveforms acquired are shown in the following figures.

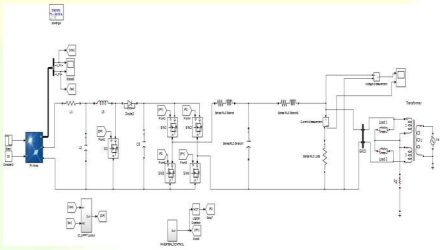
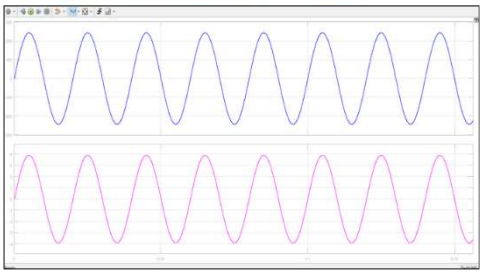


Figure 4.1 Simulation of proposed system

Simulating the recommended design is done using MATLAB SIMULINK. The output waveform may be seen in the figure below.



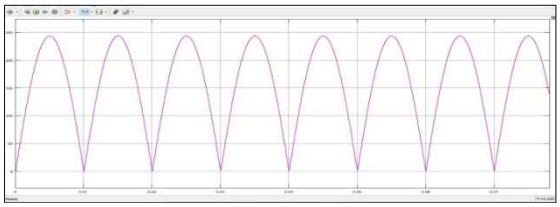


Figure 4.4 Output Voltage waveform of the inverter

Figure 4.6 Completely Assembled hardware

*5.***Conclusion**

Using artificial neural networks and adaptive dynamic programming, a single-phase home solar PV system with MPPT control and grid integration through an LCL-filter-based inverter is examined. The suggested artificial neural network controller uses approximation dynamic programming to provide optimum control. This method, which reduces harmonics and improves the system's capacity to adjust to changing circumstances, may be especially beneficial for small-scale domestic solar PV systems.

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