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Single Phase Water Pumping System using Adaptive Neuro Fuzzy Inference MPPT for PV system

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Abstract

The demand for water in India steadily increases as the population grows. Due to its numerous advantages, research in AC motor-based Water Pumping Systems (WPS) has recently got a lot of attention. Because of its natural abundance and ecologically beneficial properties, renewable energy-based solar photovoltaic (PV) generation is the ideal substitute for conventional energy sources. Maximum power extraction from the PV system is critical for increasing solar power generation efficiency. This proposed work presents a solar power system using Adaptive Neuro-Fuzzy Inference System (ANFIS) Maximum Power Point Tracking (MPPT) for pumping system. A MPPT controller based on ANFIS has been introduced in this research. This approach has the advantage of having a higher tracking accuracy. This tracker captures irradiance and temperature from the solar panel as inputs. This system uses a battery backup for energy storage purpose. The battery is recharged using the solar supply. In this system, Pulse Width Modulated (PWM) inverter is used, where it converts the battery voltage (DC), into AC voltage for running the pumping system. For validation, the proposed model is analysed using MATLAB/Simulink.

Keywords: ANFIS, MPPT, PV System, Boost Converter

1. Introduction

The globe is currently confronted with numerous issues, one of which is creating sufficient electrical power to meet humanity's needs. Electricity is being generated using traditional coal, gas, and nuclear power plants. As the world's population grows, so does their demand for electricity, and as a result, so does the generation of electricity. Massive usage of

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natural fuels like oil, coal, and gas pollutes the environment and has a significant warming effect on the planet. As a result, a recyclable renewable energy source such as wind or solar wave can be chosen for high step-up operation.

Solar energy is a renewable energy source that operates on the photovoltaic effect. The major component that converts solar energy into electrical energy is the solar cell. To build a solar array, solar modules are joined either in series or parallel, depending on the requirements. Unlike traditional energy sources such as coal, diesel, natural gas, and nuclear energy, solar cells deliver clean and pollution-free energy. Solar energy conversion is being carried out at high costs.

Under normal working settings, the efficiency of a solar array is quite low, and it drops even more with variable loads and climatic conditions. Different control algorithms such as Maximum PowerPoint Tracking (MPPT) are currently being utilised to boost the efficiency of solar arrays. The goal of all of these methods is to equal the source impedance to the load impedance so that the array can supply maximum power. The generation of peak power (PPeak) is primarily influenced by irradiance and temperature. As the amount of radiation increases, the peak power (Ppeak) decreases. Hence, power variation is mostly determined by temperature and irradiation amount. As a result, the MPPT algorithm can be used to track maximum power.

MPPTs are found in microprocessors, microcontrollers, and other devices in which a set of rules is written as a coded programme. Graphic programming, on the other hand, is simpler to comprehend and adapt. Matlab/Simulink and Lab VIEW are software programmes that collect data from the real world, process it, and provide an output signal that can be displayed or delivered to an output port as a control signal. The goal of this project is to develop and simulate a single-phase water pumping system using an MPPT solar and grid system. MATLAB software is used to implement the model.

2. Design Methodology

Figure 1 depicts the block diagram of the proposed system. The PV panel serves as the Boost converter's input source. The MPPT uses the temperature and irradiance of the solar panel as inputs. These numbers are then processed using the ANFIS algorithm, which produces an output that serves as the MOSFET's gate input. The main aim of the Boost converter is to convert lower-level input DC voltage to higher-level output DC voltage. The

converter's output is connected to the battery. The battery's output is supplied through an inverter, which converts the dc supply to ac power.

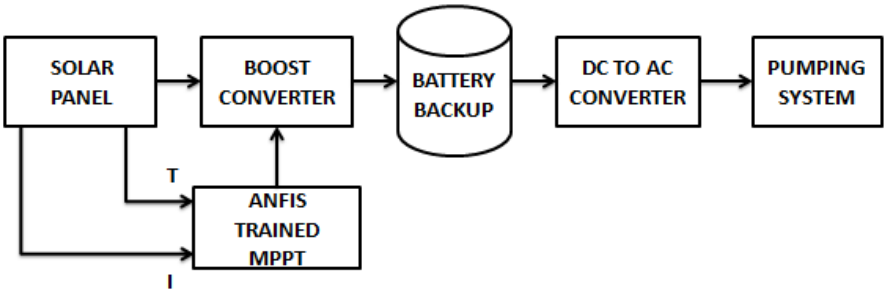

Figure 1. Block diagram of the proposed system

3. MPPT Algorithm

ANFIS (Adaptive Neuro-Fuzzy Inference) controller is a fusion of neural network and Fuzzy Logic. Large number of inputs are given to the neural network and based on the inputs, the neural network displays standard output, based on the input and the output the neural network is trained, after training the neural network the output is given to the fuzzy logic which generates the rules and membership functions. The flowchart of the ANFIS Algorithm is shown in figure 2.

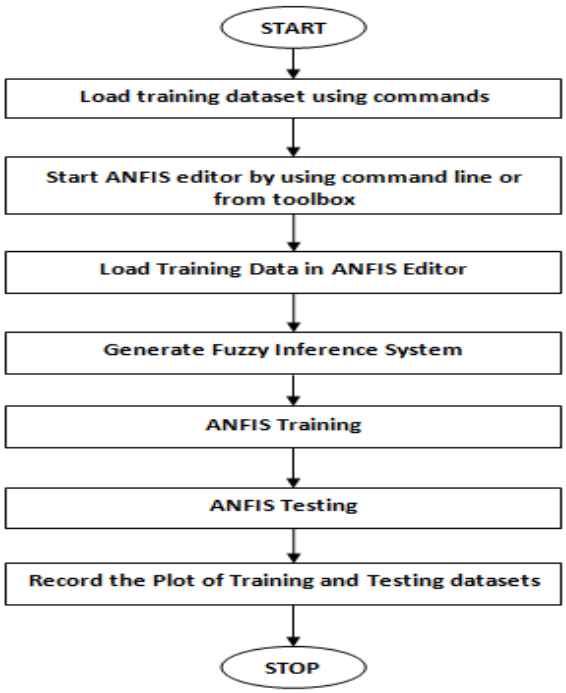

Figure 2. Flowchart of ANFIS Algorithm

4. Results and Discussion

The entire proposed system design is presented in Fig. 3 and is simulated in MATLAB using the Simulink module. The input for the boost converter is taken from the Photovoltaic panel. The MPPT uses the temperature and irradiance of the solar panel as inputs. These numbers are then processed using the ANFIS algorithm, which produces an output that serves as the MOSFET's gate input. The main aim of the proposed boost converter is to convert lower DC voltage to higher DC voltage The converter's output is connected to the battery. The output from the battery is fed to an inverter, where it converts the dc supply into ac supply. The output of the inverter is given to the single phase AC motor.

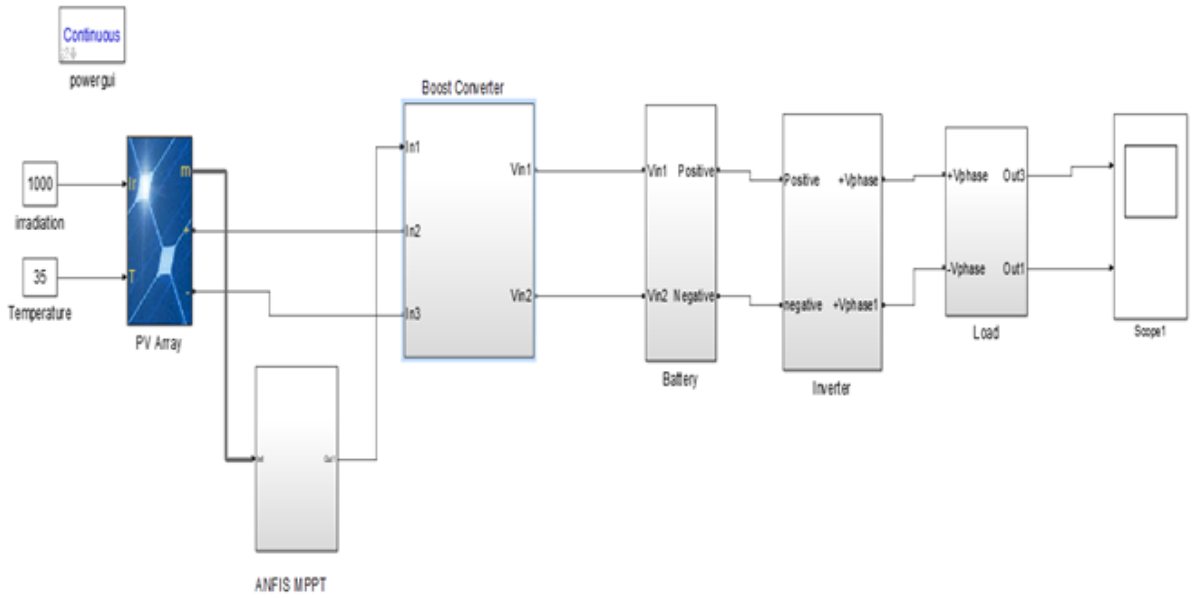

Figure 3. Simulation diagram of the proposed system

Figure 4. Training Data Sets

The solar irradiance and temperature of the panel are used as input data for the ANFIS controller in the first step. In addition, the current at Maximum Power Point is handled as a controller output. 365 data sets for irradiance and temperature are used to train the ANFIS network. The network is also trained across 1000 epochs. Figures 4 and 5 depict the training data and ANFIS structure, respectively. With 1000 epochs, the training error was 0.008. Figure 6 illustrates this. In addition, Fig. 7 shows a comparison of training data and the output of the ANFIS model.

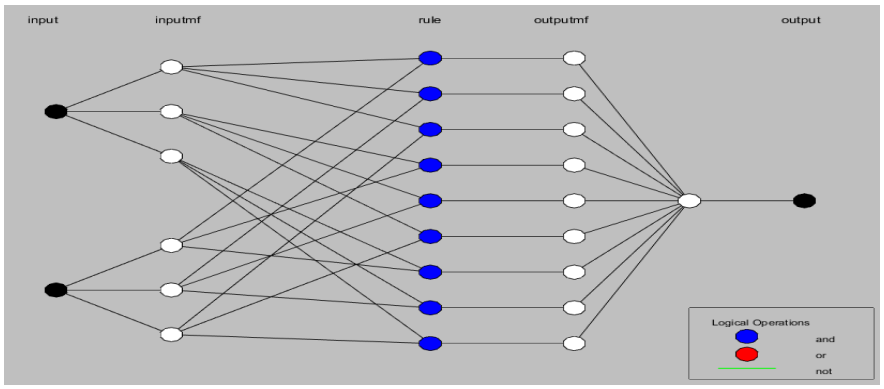

Figure 5. ANFIS Structure

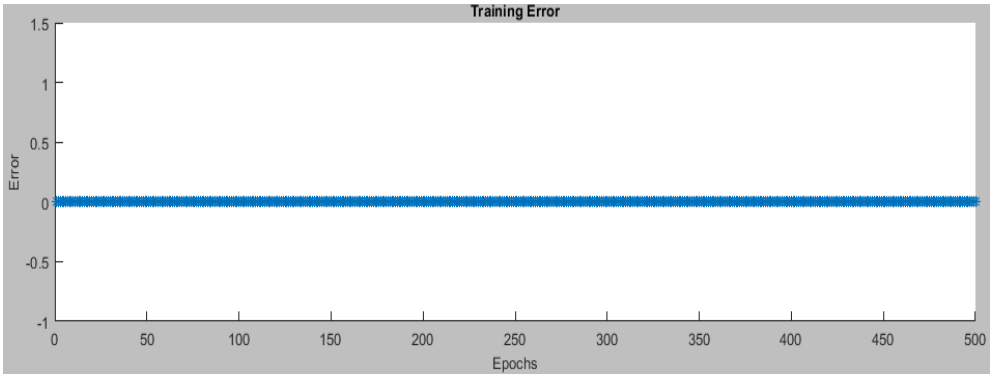

Figure 6. Training Error with 1000 epochs

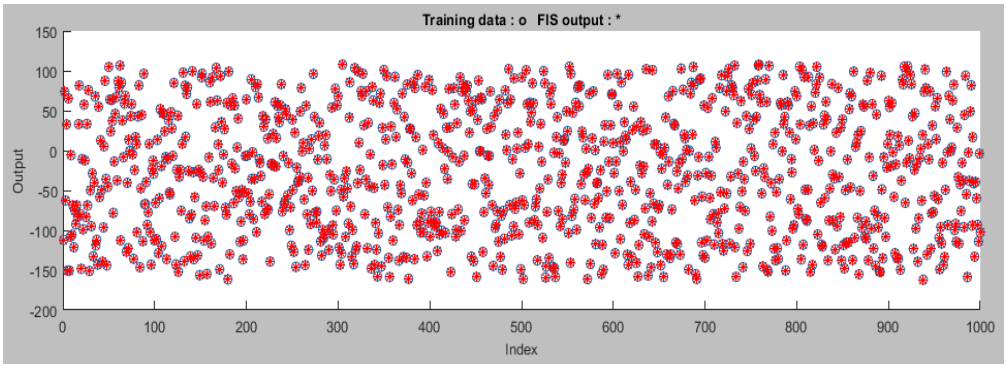

Figure 7. Training data compared with ANFIS

Figure 8 depicts The simulation result of the Solar Panel after connecting to the load of the proposed system.

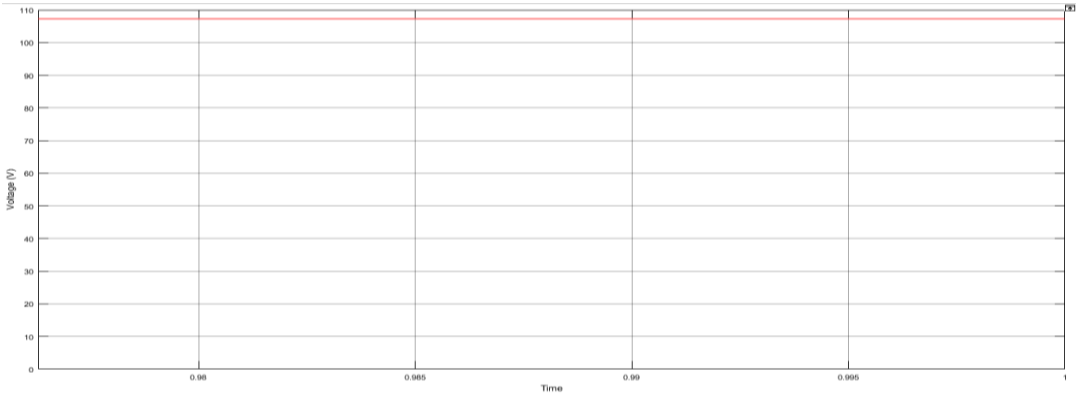

Figure 8. Solar Panel Output

The simulation result of the Boost Converter after connecting to the load of the proposed system is shown in figure 9. The boost converter converts DC-DC voltage by varying the duty cycle “D”. The simulation result of the output speed of the Single Phase AC motor of the proposed system is shown in figure 10.

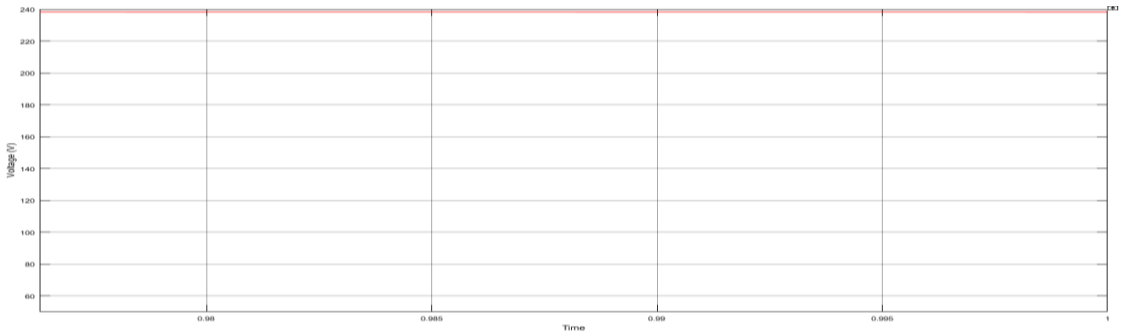

Figure 9. Boost Converter Output

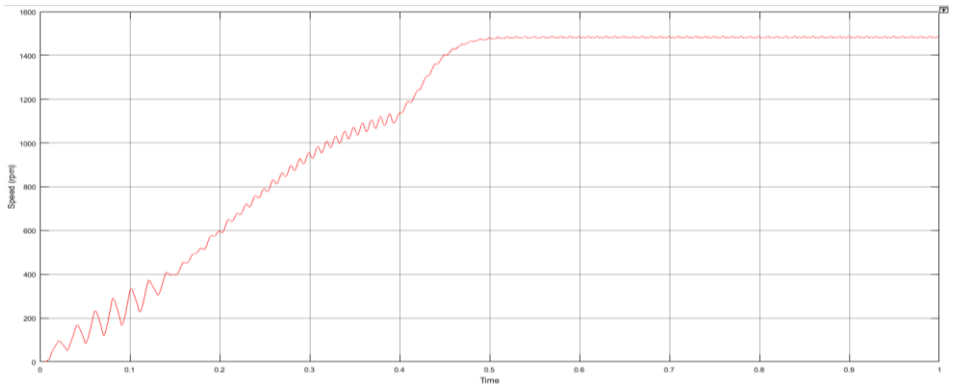

Figure 10. Motor Speed Output

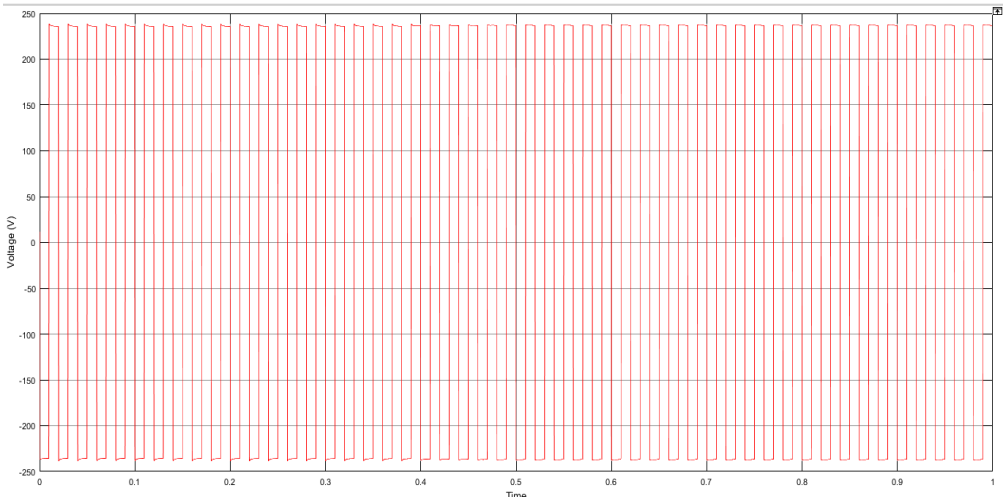

Figure 11. Final Simulation Output

The simulation result of the AC voltage value in the load side of the proposed system is depicted in figure 11. The output shown here is the instantaneous voltage value in the load side of the system. The voltage given to the load is taken from the battery where an inverter converts the DC voltage into AC voltage. Here, PWM types inverter is used for the conversion process of DC-AC voltage.

5. Conclusion

In recent years, the power demand has increased due to the increase in the number of industries. In this paper, a single phase water pumping system using adaptive Neuro-Fuzzy inference MPPT for PV system has been proposed. Mainly Neuro-Fuzzy Maximum Power Point Tracking algorithm is used to obtain the maximum power point. By using this algorithm and boost converter, solar array is operated at maximum power point irrespective of solar irradiance. The maximum power point of solar array can be swiftly tracked by using Neuro-Fuzzy at various weather conditions. The main aim of this proposed work is to provide compensation towards the energy demand by the use of a system which consists of MPPT controlled solar system where the energy is stored in battery for the energy saving purpose.

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