An-Najah National University

Artificial Intelligence

Research

PV MPPT Based on Neural Network

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Chapter 1

Abstract

This research is about energy management in stand-alone hybrid power systems. The hybrid system consists of PV panels, wind turbine (WT), battery storage, and proton exchange membrane fuel cell (PEMFC). This system is designed to manage the power flow between hybrid power system and energy storage elements using artificial neural network and fuzzy logic controller. The neural network controller is used to achieve the maximum power point (MPP) for different types of photo voltaic (PV) panels. The dynamic behavior of the proposed model is examined under different operating conditions and with real-time measured parameters used as inputs to the system. A maximum power point tracking (MPPT) technique is needed to operate the PV module at its maximum power point because of the changes in this point due to the unpredictable change in solar irradiation and therefore it is important to calculate this point (MPPT).

Chapter 2

Introduction

The world is going towards finding an alternative to the currently used energy sources such as fossil fuel, and the best thing people could dream of is the renewable energy sources, especially solar and wind power. These sources are environmentally friendly and sustainable and the technologies developed for them is very promising. However, there are some challenges that face the use of these sources, the biggest one of them is geographic and seasonal climatic conditions which controls the output of the solar-wind system. In order to depend on the solar-wind system as a primary energy source we must provide a backup for the cases that the system does not work properly, so we use the PEMFC with a reversible energy storage system. However, the PEMFC is costly and the membrane lifetime is short, and the incompatibility between the energy source and the producing systems can lead to critical problems in stability and power quality. So, the hybrid system should manage the flow of energy to increase the membrane lifetime and avoid stability problems.

Chapter 3

Energy Management and Control System

There are many techniques to compute the maximum power point tracking (MPPT) , and tracking the MPP of a photovoltaic array is an essential part of a PV system , for example we can use the perturb and observe (P&O) algorithm to find this point.

3.1 perturb and observe algorithm

It is a simple algorithm that does not require previous knowledge of the PV generator characteristics and is easy to implement with analogue and digital circuits . There are a lot of disadvantages to using this algorithm :

- If there is any shadow on any of panels (because they have been in series or parallel) then the power- voltage curve of the PV is going to have several peak and (P&O) method can't find the real peak .
- (P&O) method is slow to find the MPP if the voltage is far away from MPP.

- Rapid changes in solar irradiance level can cause serious problem in the algorithm behavior.
- Costly.
- This method presents oscillations around the MPP, because the oscillations in steady state are proportional to the step size and this slows down the response of the system.

Because of these disadvantages in this algorithm we use in this study the artificial neural network to find MPPT in order to increase the tracking response and consequently increase the tracking efficiency.

Chapter 4

The structure of the proposed PV control system

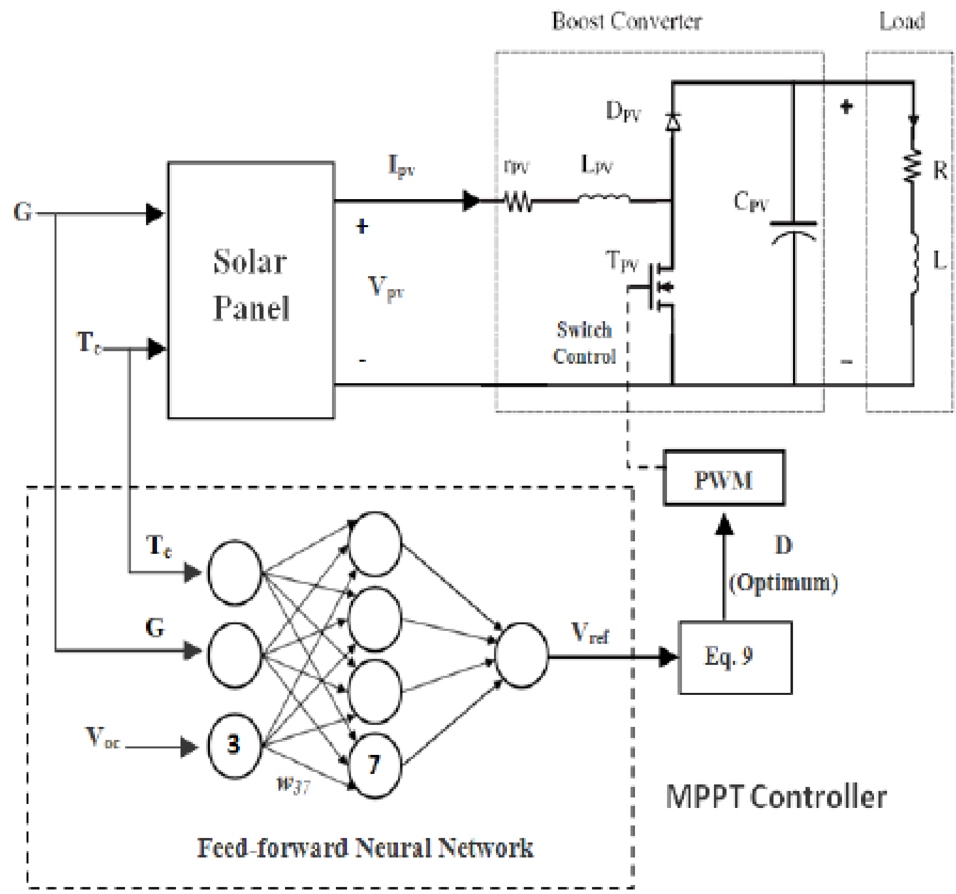

Figure 4.1: PV control system

This system consist of 4 parts , the next pages show these parts and show how to use this system to find (MPPT).

4.1 Photovoltaic Module

Is a term which covers the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photo-chemistry, and electrochemistry. The figure 3.1 below illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current that is, electricity. This electricity can then be used to power a load, such as a light or a tool.A number of solar cells electrically connected to each other and mounted in a support structure or frame is called a photovoltaic module. Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. The current produced is directly dependent on how much light strikes the module.

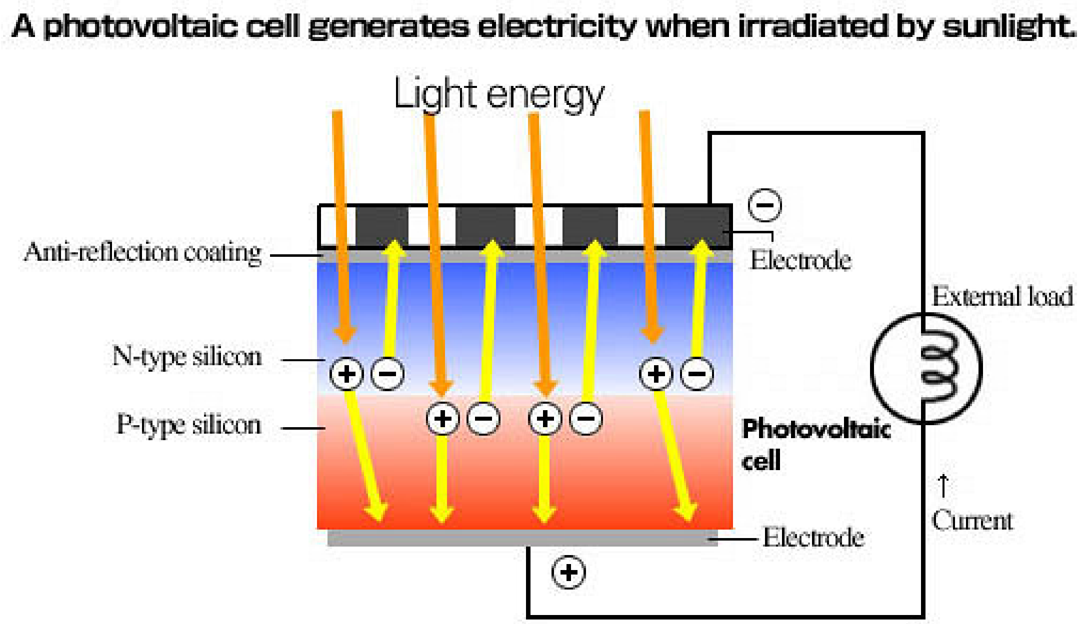

Figure 4.2: photovoltaic cell

4.2 Neural Network

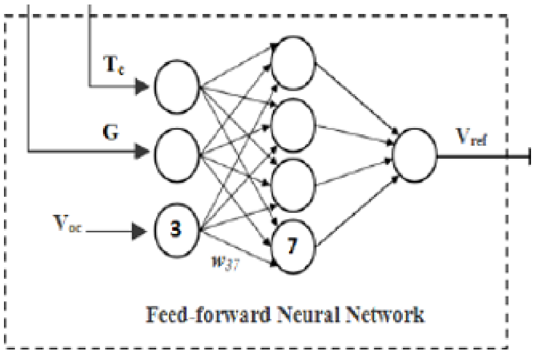

Figure 4.3: Feed Forward Neural Network

The neural network consists of three layers:

- The input layer : it composed of three nodes which are:
  - The solar radiation (G) .
  - The cell temperature (Tc).
  - The cell's open circuit voltage (Voc) at a 25C and 1 kW/m2 .
- The hidden layer: it composed of four nodes. The activation function that used in hidden layer is the hyperbolic tangent sigmoid transfer function.
- The output layer :it composed of one node that is the optimum operating voltage The function of activation is of the linear type.

4.3 Boost converter

It is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter) ,it is used to connect a photovoltaic to an external system .

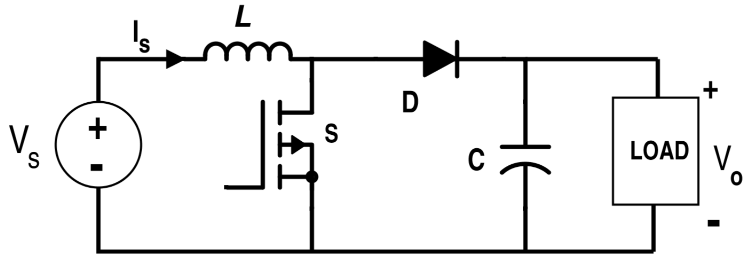

Figure 4.4: Boost Converter

4.4 MPPT controller

Maximum Power Point Tracking Solar Charge Controllers (MPPT) are more efficient and more feature rich than the traditional PWM solar charge controllers. MPPT solar charge controllers allow your solar panels to operate at their optimum power output voltage, improving their performance by as much as 30%. Traditional solar charge controllers reduce the efficiency of one part of your system in order to make it work with another.
The following equation describes the relation between the input and the output voltage of a boost converter as a function of the duty cycle D.

$$\frac{V_{out}}{V_{in}} = \frac{1}{1-D}$$

Chapter 5

How Does Neural Network Work to find Vref ?

To estimate the PV array operating voltage (Vref) we use the neural network control in the figure 4.1 , the proposed NNC uses the Levenberg Marquardt (LM) training algorithm to recognize the relationships between the input and output parameters .

- Give an initial small random values for the interlayer connection weight and the processing element's thresholds .
- The network presented with a set of training patterns .
- Each set is composed of one output and three inputs .
  - inputs are :
    - solar irradiance (G). It gathered from a 28.8 kW solar power system .
    - temperature (Tc). It gathered from a 28.8 kW solar power system .
    - cells open circuit voltage(Voc). It is used as a reference variable to select from among several PV panels

  - The Output : It is generated from an applied Matlab code which analyzes the output P-V characteristics of the validated PV model.

- Give a training set huge number of cases were this cases obtained from different PV panels which covers the different solar radiation and temperature conditions that could possibly take place.

- Voc select a panel from among several PV panels.

- Provide repetitive training patterns for this neural network and make adjustments after each repetition if the output of the network differs from the desired output.

- This process continues until the mean square error (MSE) converged and is measure at less than 0.01.

Chapter 6

Levenberg Marquardt (LM) training algorithm

The Levenberg-Marquardt algorithm was designed to approach second-order training speed without having to compute the Hessian matrix. When the performance function has the form of a sum of squares (as is typical in training feedforward networks), then the Hessian matrix can be approximated as

$$H = JtJ$$

and the gradient can be computed as :

$$g = Jte$$

where J is the Jacobian matrix that contains first derivatives of the network errors with respect to the weights and biases, and e is a vector of network errors. The Jacobian matrix can be computed through a standard backpropagation technique .

The Levenberg-Marquardt algorithm uses this approximation to the Hessian matrix in the following Newton-like update:

$$xk+1=xk[JtJ+I]1Jte$$

When is large, this becomes gradient descent with a small step size. is decreased after each successful step (reduction in performance function) and is increased only when a tentative step would increase the performance function. In this way, the performance function is always reduced at each iteration of the algorithm.

This algorithm appears to be the fastest method for training moderate-sized feed forward neural networks (up to several hundred weights). It also has an efficient implementation in MATLAB® software, because the solution of the matrix equation is a built-in function, so its attributes become even more pronounced in a MATLAB environment.

Chapter 7

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