A Solar-Powered Battery Charging System Using Levenberg-Marquard Algorithum

Shweta A. Raut, M.T. Kolte, Snehal P. Hon

Abstract : Neural control is a branch of the general field of intelligent control, which is based on the concept of artificial intelligence. Neural controller can operate at different conditions of load current at different orbital periods without any tuning such in case of PID controller. So an artificial neural network (ANN) based model has been developed for the optimum operation of power system. In this a boost converter is used. The controlled boost converter is used as an interface between photovoltaic (PV) panels and the loads connected to them. It converts any input voltage within its operating range into a constant output voltage that is suitable for load feeding. An ANN is trained using a back propagation with Levenberg–Marquardt algorithm. Neural network controller architecture gives satisfactory result with small number of neuron, hence battery in terms of memory and time are required for neural network controller implementation. To implement the neural network into hardware design, it is required to translate generated mode into device structure. VHDL language is used to describe those networks into hardware. Hardware Descriptive Language code has been proposed to implement ANNs as well as to present simulation results. Field programmable gate array (FPGA) is a digital device which helped in reprogrammable properties and robust flexibility. With low precision artificial neural network design, FPGAs have higher speed and smaller size for real time application than the VLSI and DSP chips

1. Introduction

Power generation and storage control mechanism is one of the significant and a crucial factor in the generation as well as controlling system. There are various classical methods are available in the electronics. In such areas controlling the system in remote way with efficiency is becoming a hurdle and to overcome it in last few years numerous alternative control techniques, have been developed in the field of control units. There are various methods of controlling of solar power generation and battery storage system on which efficiency is being worked out as a major issue. If the electricity losses in between PV cell - Consumption unit and Battery storage – Consumption unit are at a comparatively large scale then it became a crucial factor[2][4]. In present, as the problem of fossil energy depletion becomes more severe, photovoltaic has received much interest to be used as a secondary energy source. The term photovoltaic refers to the phenomenon involving the conversion of sunlight into electrical energy via a solar cell. Performance of a photovoltaic-based system strongly depends upon the capability to determine an optimal operating point of the solar array at which the maximum power can be drawn for any given load. Under certain temperature and light intensity, there is only single maximum-power point in a normal cell. Therefore, maximum power point tracking (MPPT) of the solar cell is essential as far as the system efficiency is concerned. The Pulse width modulated (PWM) adaptive intelligent Power converter (inverter) has been designed and developed where the input DC power stored in the battery bank obtained through PV and/or Grid sources, has been digitized to produce a sequence of PWM pulses (approximate to a sine wave) at the output of power converter and deliver power to the load.

- Shweta A. Raut , Prof. Dr.M.T. Kolte, Snehal P. Hon
- Electronics and telecommunication department of MITCOE, Pune

The traditional analog method for generating PWM pulses adopt the technology where a high frequency carrier signal is compared with sinusoidal wave as reference signal set at desired output frequency and thus needed two signals to produce PWM signal. In the present scheme, the PWM pulses are directly generate through software programmed using Verilog codes and downloaded in FPGA Spartan 3E starter kit to produce base drive signals for inverter power device switches. The FPGA technology offers a fast system with many more advantages as compared to other conventional technology including DSP based controller. The software programmed can easily be changed to optimize and control the inverter parameters like frequency, voltage amplitude, number of half cycle PWM pulses etc. without changing the hardware circuit. It is integrated to a boost converter to form a solar-powered battery charging system. There is no external sensory unit required to be added into the system. Despite of its cost-effectiveness, we shall demonstrate that the system performance is outstanding.

2. Renewable energy

Energy which comes from natural resources such as sunlight, wind, rain, geothermal heat etc. is called renewable energy. And this energy is continuously filled again. There are various types of renewable energy such as bioenergy, geothermal energy, hydropower, hybrid, ocean energy, solar energy, wind energy etc. Renewable energy is very important because the non-renewable energy such as petrol, diesel, and fossil fuels are limited. Most of renewable energy is comes from the sun[1]. Renewable energy resources are inexhaustible, clean as compared with conventional resources. There are various types of renewable energy such as wind, sun and biomass etc. renewable energy is an energy which is comes continually refill such as sunlight, wind, rain, waves and geothermal heat. About 16% of global final energy consumption comes from renewable resources, with 10% of all energy from tradition biomass, mainly used for heating, and 3.4% from hydroelectricity. New renewable (small hydro, modern biomass, wind, solar, geothermal ands biofuels) accounted for another 3% and are growing very rapidly. The share of renewable in electricity generation is

around 19% with 165 of electricity coming from hydroelectricity.

3. Neural Network

One of the key elements of a neural network is its ability to learn. A neural network is not just a complex system, but a complex adaptive system, meaning it can change its internal structure based on the information flowing through it. Typically, this is achieved through the adjusting of weight. In the diagram above, each line represents a connection between two neurons and indicates the pathway for the flow of information. Each connection has a weight a number that controls the signal between the two neurons. If the network generates a “good” output, there is no need to adjust the weights. However, if the network generates a “poor” output—an error, so to speak—then the system adapts, altering the weights in order to improve subsequent results[3].

4. Photovoltaic Power Generation System

Photovoltaic systems mainly operate in a stand-alone mode. Such systems consist of a PV generator, energy storage (for example a battery), AC and DC consumers and elements for power conditioning and no interaction with a utility grid. A PV generator can contain several arrays. Each array is composed of several modules, while each module is composed of several solar cells. The battery bank stores energy when the power supplied by the PV modules exceeds load demand and releases it backs when the PV supply is insufficient. The load for a stand-alone PV system can be of many types, both DC (television, lighting) and AC (electric motors, heaters, etc.). The power conditioning system provides an interface between all the elements of the PV system, giving protection and control. In this we also used a boost converter. The training of neural network is done by the Levenberg-Marquart back propagation algorithm [5].

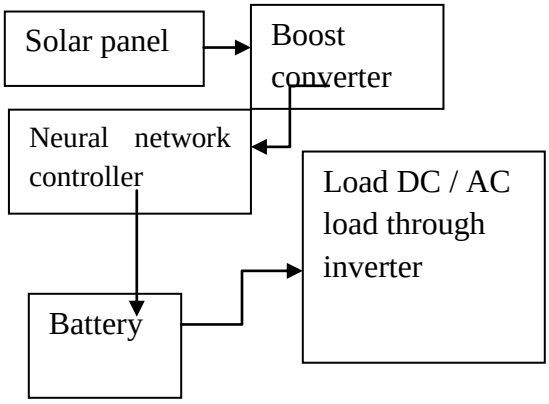

Figure.1 Block diagram of solar power system

5. Experimental Results

Using a boost convert whose characteristics are describe above, as shown in figure 2 we see that the voltage is less before boosting and voltage increase after boosting and in figure 3 we see that using a PWM and boost convert if the voltage is less then duty cycle is more. In this we get the duty cycle 50%. Figure.4 indicates the MATLAB-SIMULINK of neural network architecture of solar system. The global system of consists of PV, battery, and control subsystem. As depicted in Figure.5 the inputs to the PV subsystem are isolation and temperature variables of, while the outputs are the battery charge voltage.

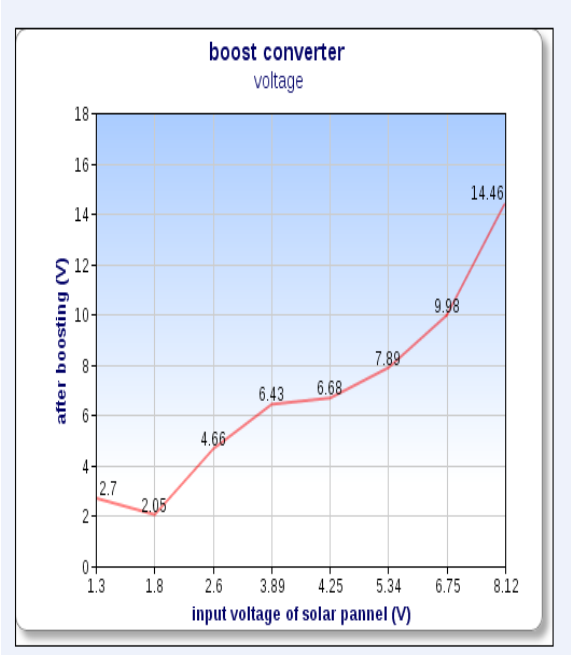

Figure.2 Graph of boost converter

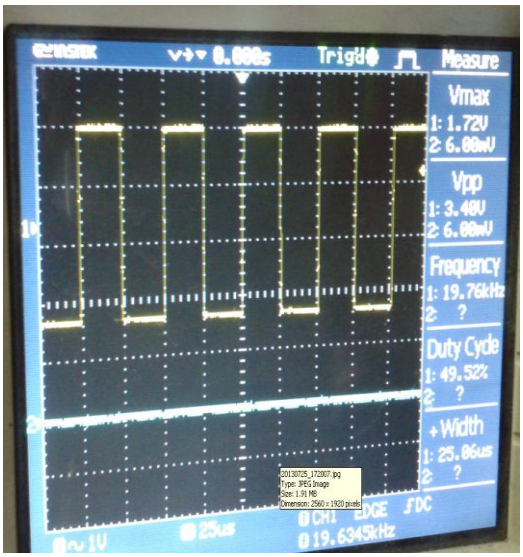

Figure.3 PWM

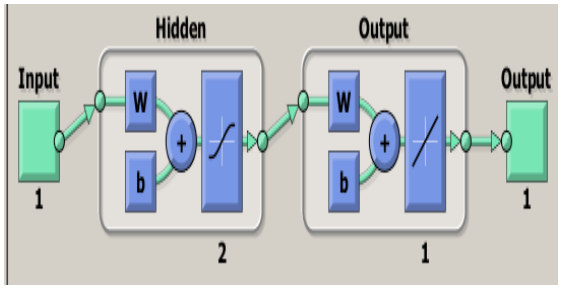

Figure.4 Neural network

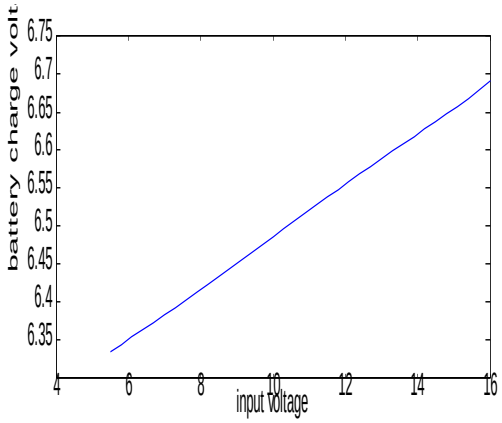

Figure.5 Battery charging status

6. Conclusion

Analyzing the working of ANN and FPGA along with the system architecture of battery storage system it is observed that the use of ANN is the most feasible and the accurate mode of optimizing power generated through an earth station. The flexibility and speed of FPGA enables us to development of newer controllers in this era of optimization of solar power. A control system, which includes the NNC is developed for achieving the coordination between the components of standalone power system as well as control the energy flow.

10. References

[1] Adel Mellit, Soteris A. Kalogirou, Mahmoud Drif "Application of neural networks and genetic algorithms for sizing of photovoltaic systems" *Renewable Energy* 2010;2881-2893

[2] T. Markvarta, A. Fragakia, J.N. Ros "PV system sizing using observed time series of solar radiation" *Solar Energy 80* (2006); 46–50.

[3] Adel Mellita,1, Soteris A. Kalogirou, "Artificial intelligence techniques for photovoltaic applications: A review" *Progress in Energy and Combustion Science* 34 (2008); pp.574–632

[4] Hanaa T. El-Madany, Faten H. Fahmy, Ninet M. A. El-Rahman, Hassen T. Dorrah, "Design of FPGA Based Neural Network Controller for Earth Station Power System" *TELKOMNIKA*, Vol.10, No.2, June 2012, pp. 281-290.

[5] Rafik Zayani, Ridha Bouallegue, Daniel Roviras "Levenberg-Marquardt Learning Neural Network For Adaptive Predistortion for Time-Varying Hpa With Memory In OFDM System" *16th European Signal Processing Conference,* August 25-29, 2008.