International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 167-169
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

ENHANCE DESIGN OF FPGA BASED CONTROLLERS FOR PHOTOVOLTAIC POWER SYSTEM

Himanshi Nigam
M.Tech Scholar
R N College of Engineering, Rohtak, India

***Abstract*— The word photovoltaic is a combination of two words, photo, which means light and voltaic that implies production of electricity. Generation of electricity from light is called PV technology. Converting solar irradiation into electricity is based o photovoltaic effect, which is a physical phenomenon of converting energy carried by optical electromagnetic radiation into electrical energy.**

I. INTRODUCTION

The global energy demand is increasing. The developing countries like India are supposed 5000MW of generation capacity every year to meet their energy demand. The fluctuations in pricing of fossil fuels, pressure to address the global warming and climate change from international community have forced the governments to focus on clean and sustainable energy sources like Solar power. The PV power generation has seen a rapid growth in the last few years leads to the wide usage of PV energy; a PV system has the advantages of low maintenance, and free from environmental pollution. These PV systems can serve as an alternating source for generating electric power to stand-alone as well as grid connected applications. This section reviews relevant literature of PV cell modelling,

MPPT, power conditioning circuits and inverters.

To develop a PV power system, the mathematical modelling of a PV cell is a key aspect. Recently, significant amount of research is being conducted to develop an accurate mathematical model of PV cell. This section reviews about the modelling approaches of different PV cells. The illuminated solar cell parameter evaluation by considering series and shunt resistances with a single diode model in five different parameter values were extracted from experimental I-V characteristics of solar modules. Mono-crystalline PV module using four and five parameter modelling and experimental verification of operating current is reported. Analytically described the I-V characteristic of PV module for the operative temperature and irradiance with single diode and five parameter with rapid convergence in provides accurate results.

II. PV ENERGY CONVERSION TECHNOLOGY

Fig 1 depicts the PV process. Energy from the sunlight comes in the form energy conversion which is the basic unit of light and other electromagnetic radiations. Photons include different quantity of energy corresponding to the different wavelengths of light [6]. From the energy equation $E = h\nu$, where h is Planck's constant and ν is the photon's frequency, it is observed that the energy of the photon decreases when its wavelength increases. When semiconductors are exposed to light, the photons within a certain energy band can be absorbed; rest of the photons may pass through the material or reflected without being absorbed as shown in Fig. 1.1. When a photon is absorbed, then that energy will be transferred to the electron of that material.

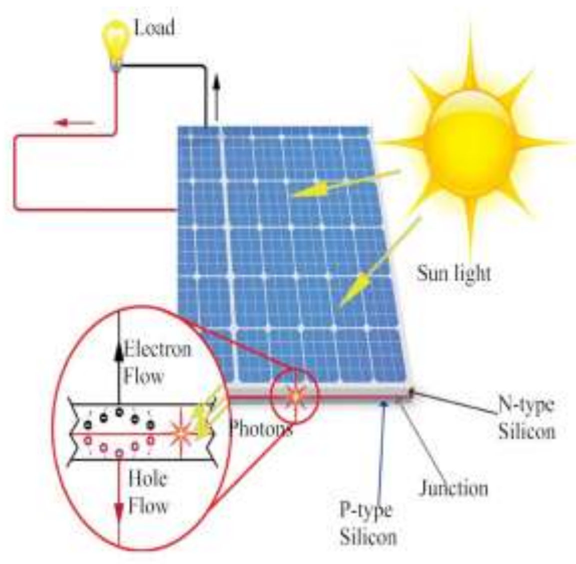

Figure 1Conversion mechanism of solar radiation into electricity

Different semiconductors have different optical absorption coefficients.

Some popular technologies e.g., PV cells can be manufactured using wafer-based silicon technology and thin-film technology. The wafer based cells are made of crystalline silicon, which includes polycrystalline silicon and mono-crystalline silicon. These are the most commonly PV cells used in large scale solar electric power generation systems with grid connections. Based on a p-n junction concept these cells are developed. PV cells are made of c-Si are made from wafers between 160 to 240 micrometers thick [7]. Polycrystalline silicon cells are made from cast square ingots. These cells are the most common type used in PV fabrication because of less expensive, but less efficient than mono-crystalline silicon. Mono-crystalline silicon solar cells look like an octagon, because of the wafer material is cut from cylindrical ingots, by the ”Czochralski” process [8].

The display of mono-crystalline silicon cells are a distinctive pattern of small white diamonds. Another type PV technology called thin-film technology yield thin-film PV cells which use very thin layers of semiconducting materials, so these can be fabricated in a large quantity at low cost, but the efficiency is also low. Thin-film technology reduces the quantity of active material in a cell. Cadmium telluride (CdTe), copper indium gallium selenide (CIGS) and amorphous silicon (a-Si) are three thin-film technologies [9] often used for outdoor applications. Currently, thin film technology is mostly used to power the small consumer electronic applications such as watches, calculators and toys.

III. CHALLENGES IN PV SYSTEM

In a PV system, the PV array converts solar energy in to electrical energy. The suitable power converter with a control strategy is required to achieve I-V and P-V charcteristics. The performance of the PV system is influenced by the nonlinear aspects of the PV array, converter topology and control strategy. To study and characterize the transient responses of a PV system one needs precise mathematical models, that includes nonlinear aspects of PV panel to facilitate for effective simulation studies. The development of PV panel needs robust mathematical models to capture I-V and P-V characteristics of PV system.

The energy conversion in PV systems is greatly influenced owing to shading, variation in the intensity of sunlight and generation cost per unit. Due to intermittent fluctuation and randomness, output power from PV system fluctuates substantially. The PV cell output Characteristics are nonlinear and the output power varies largely, due to difficulties in tracking the maximum power point which is affected by temperature and irradiance. PV system can produce energy when there is good sunlight is available. The applications connected to solar energy systems demand more power while running few applications. The main complication to achieve the power demand is the lack of economical and efficient power converters. One more drawback is variation in solar power density because changes in temperature over day to night and summer to winter at a particular locality. Therefore, there is a need of power converter topologies to equip solar energy systems for efficient functioning of controllers, filters, inverters and storage devices economically. Another drawback of PV systems is these systems are not cost effective when compared with conventional power generation schemes. Though the customers are aware of the benefits of the PV applications, still they have a preference the buying of conventional electricity due to high cost of PV power per unit. The average power generation efficiency of an industrial PV system is around 20%. The efficiency of PV power can be improved by devising the efficient maximum power point tracker (MPPT) to extract the maximum power from the available power. Control systems are generally implemented using microcontrollers and FPGAs.

IV. MAXIMUM POWER POINT TRACKING (MPPT)

Even-though the PV technology is one of the best renewable energy systems converting the solar energy in to electrical energy and rapidly growing technology in many countries, but, it has some limitations such as high initial cost, low conversion energy efficiency, large area is required to capture sun light, energy can be tracked only at sunny and day time. The output is fluctuating to a large extent because of temperature and irradiance and output characteristics of PV cell are non-linear in nature.

Because of weather fluctuations or varying temperature and irradiance the maximum power point of the PV cells changes a lot. Commercial PV systems have very less average power generation efficiency. With the help of better MPPT technique, with good tracking speed one can use the generated PV power practically in a short time. Therefore, research in MPPT is of great importance for maximizing the utilization of PV cells [18–22].

An adequate amount of research has been done to improve the efficiency and power quality of PV system. The energy conversion efficiency of PV system is low because of the time varying characteristics (I-V, P-V) and non-linear in nature with respect to the temperature and irradiance. For this reason, the PV systems are required to operate at their MPPs because the PV panel functioning is more efficient to deliver the maximum power at MPP. To track the maximum power point in a PV system, a

International Journal of Engineering Applied Sciences and Technology, 2017
Vol. 2, Issue 5, ISSN No. 2455-2143, Pages 167-169
Published Online March-April 2017 in IJEAST (http://www.ijeast.com)

maximum power point tracker (MPPT) is required. The MPPT controller controls the PV system and improves the power generation efficiency. Thus the MPPT is considered as an integral component in a PV system

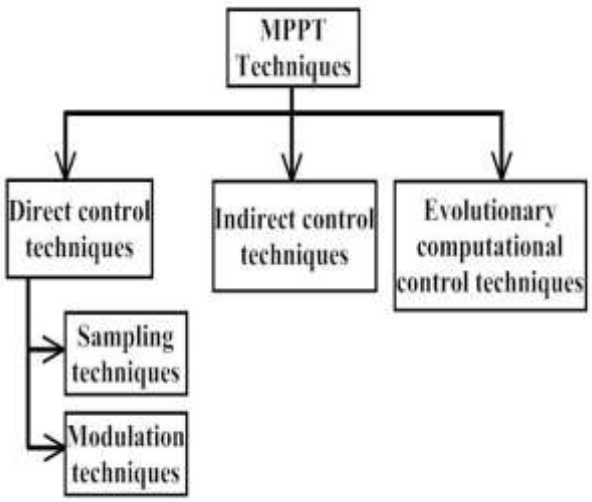

Figure 2: Classification of MPPTs according to control techniques

List of MPPT techniques

1. Curve Fitting (CF) MPPT technique
2. One Cycle Control MPPT
3. Feedback voltage (FV) or current MPPT technique
4. Perturb & Observe (P& O) and Hill climbing MPPT technique
5. Incremental Conductance (Inc Cond) MPPT technique
6. Steepest Decent MPPT technique
7. Intelligent MPPT techniques
a) Fuzzy logic based MPPT technique
b) Artificial Neural Network (ANN) based MPPT technique
8. Sliding mode control (SMC) based MPPT technique
9. Load current/voltage maximization (LVM) MPPT technique.

V. CONCLUSION

The scopes of this work can be outlined as follows
• DC-DC boost converter is analyzed and developed to boost the PV output voltage to a required level.

• The effects of PV at partial shading is observed and validated with a PV simulator. Different PWM-VSI current control techniques like HCC and MPC are developed to generate the PWM pulses for inverter.

• Single phase PV power system using HCC technique is validated experimentally with NI-cRIO-9075, which includes FPGA.

• Design and development of an active power filter to improve the power quality with a PV system employing adaptive HCC technique.

VI. REFERENCE

[1] M. G. Villalva, J. R. Gazoli, et al. Comprehensive approach to modeling and simulation of photovoltaic arrays. IEEE Transactions on Power Electronics, 24(5):1198–1208, 2009.

[2] O. Isabella. Light management in thin-film silicon solar cells. Delft University of Technology, 2013.

[3] W. H. Wai, R. J. Wang and C. Y. Lin. High-performance stand-alone photovoltaic generation system. IEEE Transactions on Industrial Electronics, 55(1):240–250, 2008.

[4] S. Ravaee, H. Farahat and F.z Sarhaddi. Artificial neural network based model of photovoltaic thermal (pv/t) collector. The Journal of Mathematics and Computer Science, 4(3):411–417, 2012.

[5] Pv light house. http://www.pvlighthouse.com.au/.

[6] B. S. G. Dzimano. Modelling of photovoltaic systems. The Ohio state University, 2008.

[7] Renewable. http://www.altenergy.org/renewables/renewables.html.

[8] P.P Dash. Design methodology and stability analysis for a photovoltaic plant interfaced with a distribution network. The university of Western Ontario, 2008.

[9] T. Mates. Structure and properties of thin silicon films for solar cells Studied by combined atomic force microscopy. Charles University, Czech Republic, 2006.