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IMPROVE DESIGN OF FPGA BASED CONTROLLERS FOR PHOTOVOLTAIC POWER SYSTEM

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***Abstract*—The global average energy consumption is over 400 Terawatt-hour, achieved by burning of fossil fuels, hydro, nuclear power and etc. The major source of electric power comes from burning of fossil fuels. Major countries such as USA, China and India depend upon fossil fuels for electricity generation. Excessive usage of fossil fuels is likely damage the idea of sustainable development in the future [1]. Global warming is a major concern and it is for all developed and developing nations to cut down their carbon emissions. 24% of carbon emissions from China, 6% from USA and 1% from India come from burning of fossil fuels [2]. Apart from this it is known that, fossil fuels are not renewable and for exploration and processing of fossil fuels are not cost effective [3]. In recent years, there is a challenge for the researchers and engineers to develop efficient techniques for harvesting renewable energy cost effective while reducing global warming.**

I. INTRODUCTION

The PV solar cells are made with semiconductor material for absorbing a large part of the solar spectrum.The PV energy source is free and abundant in nature, hence, it is sustainable. Usage of PV energy is pollution free, because it does not produce carbon dioxide. No noise and no mechanical moving parts in PV panles. PV converts solar irradiation into electricity directly from watts to megawatts range also. The PV modules have a very long lifetime.

These are some advantages of PV. Toxic chemicals (cadmium and arsenic) are used in the PV cell production process.These chemicals impacts in environment are negligible and can be easily controlled for disposal or recycling. PV energy is more expensive than conventional energy, because of manufacturing and cost of PV cells in the low conversion efficiencies of the equipment. The PV energy generation depends upon intensity of the sunlight on that particular day. Solar facilities will not produce power during entire periods, thus leads to shortage of energy. These are the disadvantages of PV. The characteristics of these technologies are presented and corresponding figures are shown in Fig. 1. The formation of PV array from a PV cell is shown in below.

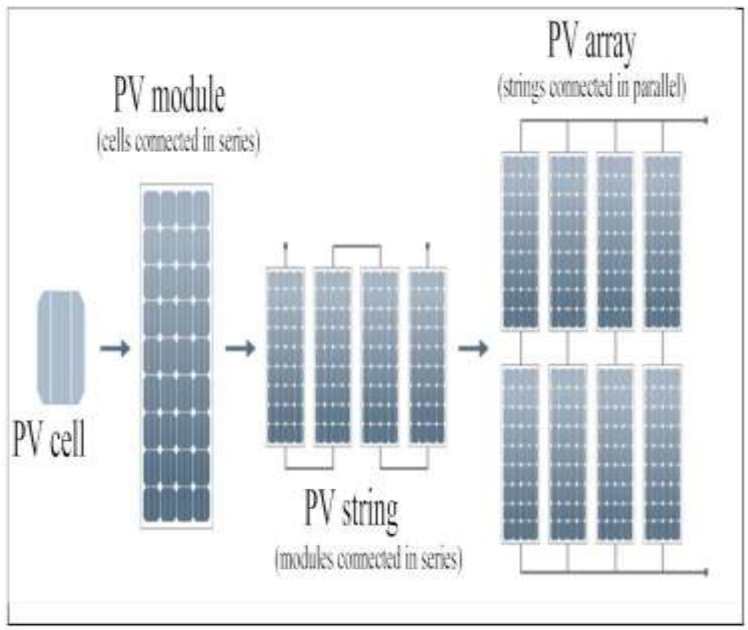


Figure 1. Formation of PV array from a PV cell

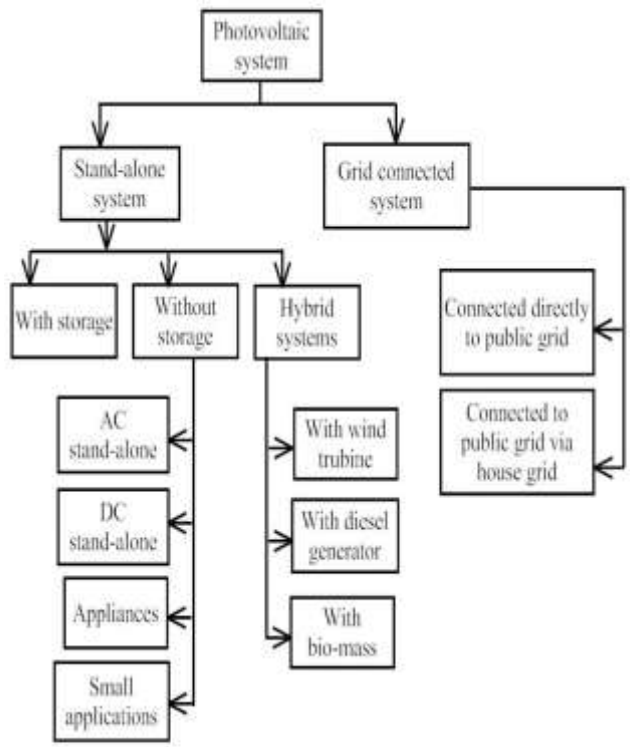
Poly crystalline: Made up of a poly crystalline silicon material, it is composed of small silicon crystals. Efficient at good light conditions.

Mono crystalline: Made up of a single silicon material. Most efficient in good weather conditions Energy conversion efficiency is 12-15%.

Thin film: Made up of materials like CdTe, CIGS, a-Si. Efficient at poor light conditions also environmental friendly. Energy conversion efficient

II. PV ENERGY SYSTEM

PV systems are composed of interconnected components designed to achieve precise goals ranging from a small device to main distribution grid. PV systems are classified [6] according to the diagram shown in Fig. 2.



Stand-alone PV systems: In this type, the PV array is directly connected to a battery; which stores PV generated electricity and acts as the main power supply. An inverter can be connected to a battery to convert the PV generated DC power into AC power. It enables the usage of house hold appliances without mains power. Grid connected PV system: These types of PV systems are more popular and it can be used in residential as well as industrial areas. Here the PV system is connected to the local electrical utility network (grid) allowing the excess amount of generated PV power to be sold to the utility. During cloudy days, night power can be drawn from grid to maintain constant power supply. An inverter is connected to the PV system to convert the generated DC power in to AC power to run the all electrical equipments.

III. PV SYSTEM ARCHITECTURE

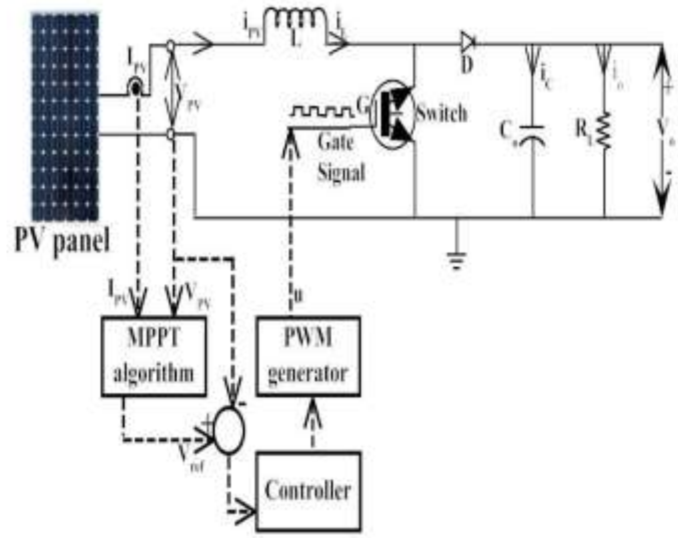


Figure 1.8: Standalone PV with MPPT

PV systems with MPPT techniques are already used in many applications like water pumping, satellite power supply, grid-tied, household appliances like mobile charging and etc in Germany, Japan, China and USA. The global energy demand is increasing. The developing countries like India are supposed to add 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,

IV. DESIGN OF DC-DC BOOST CONVERTER

A DC-DC boost converter is a power converter with an output voltage greater than its input voltage. It belongs to the class of SMPS containing a minimum of two semiconductor switches (a diode and a transistor) and at least one energy storage element, either capacitor, or inductor, or both [88]. Filters are used to reduce the output voltage ripple. The advantage of boost converter includes higher efficiency with fewer components. To reduce ripples at output the values of capacitor and inductor are chosen precisely. However, the large inductance tends to increase the start-up time slightly while small inductance allows the coil current to ramp up to higher levels before switch turns OFF [61]. The duty cycle is varied at high switching frequency to convert the unregulated voltage into a regulated supply.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.

The state-space averaging technique is widely used to derive the expressions and analysis for the small signal characteristics of pulse width modulated controlled DC-DC converters. The dynamics of this converter can be determined by applying Kirchhoffs voltage law on the loop containing the inductor and Kirchhoffs current law at the node with the capacitor branch connected to it. The circuit diagram of the DC-DC boost converter is shown in Fig. 3 and the functioning will depend on the switch ON and OFF.

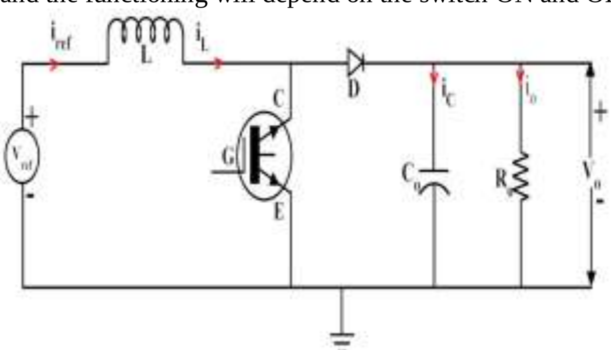


Figure 3: DC-DC boost converter circuit diagram

The voltage induced in the inductor adds to the supply voltage and this total voltage appears as output voltage, at that situation the capacitor C also charges to the boosted voltage. The inductor and supply provides the energy to the load when the transistor is turned OFF. The current through the inductor decreases because its stored energy goes on reducing. After some time the transistor is again turned ON and the cycle repeats.

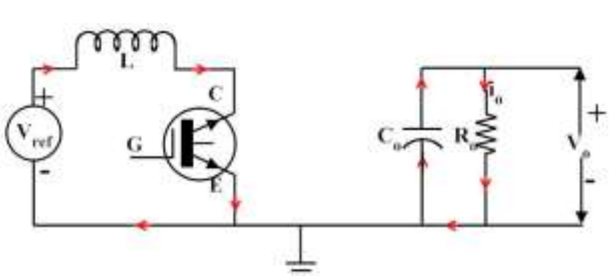


Figure 4: Boost converter current flow at switch ON condition

V. CONCLUSION

A modified P&O MPPT controller is proposed for handling standard test conditions. The proposed controller is compared with the conventional incremental conductance, Perturb & Observe (P&O) controllers. The simulation results are verified with RTDS and experimental results using prototype set-up are presented to validate the efficiency of the proposed approaches. The FPGA implementation simplified the control circuit and added flexibility to the system. Experimental setup contains E4360A solar array simulator, LabView-2012, NI-cRIO 9014, Hall Effect sensor and DC-DC boost converter. The simulation and experimental results demonstrated that the proposed controllers provide effective tracking of MPP so that maximum power can be extracted from the PV panel at standard test conditons.

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