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Simulation of Advanced DC-DC Converter for DC Nano-Grid Unified with Solar PV Power Generation System

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Abstract— **The constantly growing need for more electric power as a result of a global technological development on one side, but vulnerable environment on the other, definitely influences the way how the electricity will be produced, transmitted, distributed and utilized in the future. This will inevitably put the existing electric power system under a serious revision in order to increase efficiency, reliability and response to the end user, but in the same time offer more controllability, higher safety and user-friendly access. Power electronics, along with an advanced energy management provides an excellent solution to this problem, and it may not be unusual if tomorrow our complete power system operates.**

Recently the growth of DC operative home appliances like mobile and laptop chargers, ovens and hair dryer's etc. are increasing and therefore a DC/DC converter is an efficient way to meet the electricity need from the local DER and helps in improving the system efficiency. In our dissertation, we took three different section of the solar panel and after that simulation carried out with help of buck-boost converter and besides this MPPT algorithm (P & O method) for solar PV module and closed loop PI control system also used. The proposed methodology is to extract maximum DC power from solar PV system and it is directly fed to DC load or DC Nano grid. The simulation results demonstrate the buck-boost converter application for maintain constant voltage at DC bus irrespective of variation of solar PV generation. Also it improves the system efficiency by reducing no. of conversions.

Index Terms— **Distributed energy resources (DER),Photovoltaic (PV),Maximum power point tracking (MPPT) and Perturb & observe (P&O).**

I. INTRODUCTION

AC electric energy systems were proved to be mostefficient way of transmitting and distributing power untilrecent past. The advent of various distributed energysources, especially renewable energy generation whoseoutput is DC power, demand DC grids for efficientoperation. Moreover, user end power requirement in theterminal end for most of the present day devices such asbattery chargers, led lights, electronic gadgets, etc. boilsdown to DC voltage, where conversion elements are addedin AC grids to make the voltage level suitable for endequipment connected. This needs further demands use of DCfor power distribution.Use of small-scale isolated DC grids inremote areas, with solar PV as the source, was proved to beeconomically beneficial than extending AC grids to thatlocation [1]. Different economic issues and advantages of DC solar nanogrids were summarized in [2]. Detailedstructuring of an isolated grid of capacity 200W – 600W aredescribed in [3]. Different challenges involved in theformation of such nanogrids is discussed in [4] and [5],which also presents various aspects of the nanogrids such asdistribution levels, local, central power management units,and their functions. Performance improvement technique ofa microgrid is discussed in [6]. The detailed modelling of acontrol strategy for interconnected nanogrids is presented in[7]. A detailed note on present nanogrids projects in India,their working models, technical features, problemsencountered were discussed in [8].

The DC bus is the crucial component of the DCnanogrids. Maintaining constant the voltage on the DC busis of paramount importance in the nanogrids because it is themain factor deciding the performance of the system. The busvoltage varies because of the variations in input power fromsources like Solar Photovoltaic (PV) modules. It varies inrelation to the amount of power injected into the bus. Similarto this, the voltage on the bus varies with the change in theload power requirement. Strict monitoring and control of busvoltage are required to supply the loads at rated voltage. Thereference paper [9] discusses different topologies ofbidirectional DC-DC converters such as a bidirectionalbuck-boost converter, bidirectional full-bridge converter,multi-phase interleaved converter and floating interleavedconverter. Different control strategies for the control of theseconverters like current mode control, power control and nonlinearcontrol also have been discussed in the paper [9]. Useof few advanced control techniques such as sliding modecontrol, self-tuning control, recursive identification methodand minimum variance control.

However, despite all the aforementioned advantages of solar power system, they do not present desirable efficient [10]. The efficiency of solar cells depends on many factors such as temperature, insolation, spectral characteristics of sunlight, dirt, shadow, and so on. In addressing the poor efficiency of PV system some methods are proposed for improving an efficiency of solar PV system among by implementing a new concept called "maximum power point tracking" (MPPT). The DC/DC converter is responsible for transferring maximum power from the solar PV module to the load. A MPPT is used for extracting the maximum power from the solar PV module and transferring that power to the load [11]. Many MPPT techniques have been proposed in the literature; examples are the P&O method [12], incremental conductance (IncCon) method [13] and fuzzy logic method [13] etc. When a solar PV module is used in a system, its operating point is decided by the load to which it is connected. Since solar radiation falling on a PV module varies throughout the day,

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the operating points of module also change. The maximum power produced by a solar cell change according to the solar radiation and temperature. A PV module is a nonlinear generator. The most widely used algorithm is the Perturb & Observe (P&O) algorithm. The P&O algorithm with fuzzy and PID perturbs the duty cycle which controls the power converter, in this way it takes steps over the P-V characteristic to find the MPP.
This present paper has addressed the review of MPPT algorithm (P &O method) , fuzzy logic method and Simulink of DC/DC converter for DC Nano-Grid Integrated with Solar PV using MPPT with Fuzzy and PID.

II. Need of Solar Power Generation

In the field of power sector in these days one of the major concerns is day by day increasing more power demand but the quantity and availability of conventional energy sources are not enough resources to meet up the current day's power demand. While thinking about future availability of conventional sources of power generation, it is become very important that the renewable energy sources must be utilized along with source of conventional energy generation systems to full fill the requirement of the energy demand.
In order to rigging the current day's energy crisis one renewable method is the method in which power extracts from the incoming son radiation calling Solar Energy, which is globally free for everyone. Solar energy is lavishly available on the earth surface as well as on space so that we can harvest its energy and convert that energy into our suitability form of energy and properly utilize it with efficiently. Power generation from solar energy can be grid connected or it can be an isolated or standalone power generating system that depends on the utility, location of load area, availability of power grid nearby it. Thus where the availability of grids connection is very difficult or costly the solar can be used to supply the power to those areas. The most important two advantages of solar power are that its fuel cost is absolutely zero and solar power generations during its operation do not emanate any greenhouse gases. Another advantage of using solar power for small power generation is its portability; we can carry that whenever wherever small power generation is required.
Scientists are constantly trying to improve in the field of development of the solar cells manufacturing technology for increasing efficiency. That will definitely help to make the solar generation as in habit for use in daily life as prime renewable source of electrical power on a wider range basis than present day conditions. In solar power generation system the latest power control mechanisms is using now these days calling the Maximum Power Point Tracking frequently referred as MPPT, it has guide to the increase in the efficiency of operation of power generation from the solar cells. Thus MPPT is most important in the field of consumption of renewable sources of energy.

III. Nano Grid Structure

The structure of a nanogrid is shown in Figure 1. The primary building blocks of anano grid are power electronic interface converters. Step-up converters allow low voltage sources to supply power to the nanogrid, and step-down converters allow the loads to draw power from the nano grid. Bidirectional converters allow storage nodes to charge from and discharge into the nano grid.
Aside from the interface converters, a nanogrid comprises renewable sources, storage, non-renewable backup generation, loads, and a transmission network. Variable renewable sources supply the average load demand, and since the peak output of these sources is incapable of being controlled, energy storage devices are included in the system to act as an energy buffer, balancing differences between the source and load powers. Backup generation may be included to improve the system's reliability in the event of a long-term shortage of renewable energy. Being a distributed system, a nanogrid has the advantages of increased redundancy and ease of expansion compared to a centralized power system. Generator failure in a centralized power system has a major impact on the system; however, in a distributed system, the system is not completely crippled by supply failure as additional supply nodes are still operating. Thedistributed structure of the nanogrid also lends itself well to modular construction and easy expansion. The need for initial investment is thus reduced since the system can be made small initially, and then expanded as the load demand grows.

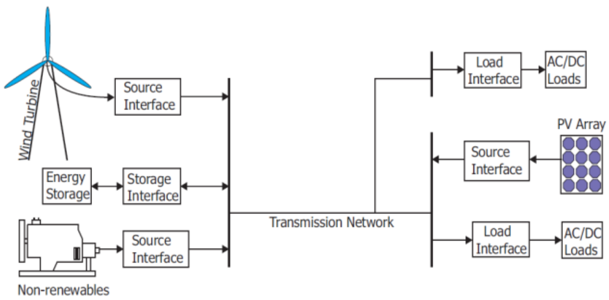


Figure 1: Structure of a standalone hybrid renewable nanogrid [14]

While there is no physical restriction on the size of a nanogrid in theory, efficiency andeconomics will largely dictate the size of a nanogrid in practice. For example, increasing the size of a nano grid by including distant loads may improve the viability of the nano grid due to the economies of scale that are gained in using larger generators. Other variable factors such as government subsidies, technological advances, and mass production will also affect the economic feasibility and hence size of a nanogrid. For the purposes of this thesis however, the size of a nanogrid that is considered is a cluster of 2-10 local loads that are located within 5 km of the sources. Assuming these loads are residential type loads, the power rating of such a system would be approximately 2-20 kW. High voltage transmission is not required for a system of this scale. Transmission voltages of several hundred volts are sufficient to provide efficient transmission of electrical energy in a localized system with these specifications.

IV. Buck Boost Converter

The buck boost converter is a DC to DC converter. The output voltage of the DC to DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle. it has a magnitude of output voltage. It may be more or less than equal to the input voltage magnitude. The place of the transformer a buck boost converter is equal to fly back circuit and single inductor is used. In this there are two types of converters in the buck boost converter first is buck converter and the other one is boost converter. These converters can construct the range of output voltage than the input voltage. The following diagram shows the basic buck boost converter.

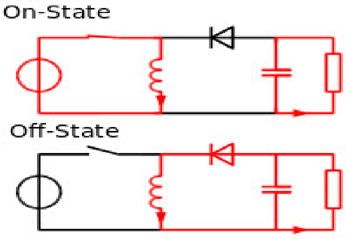


Figure 2: Buck-Boost Converter

V. System Description

The figure 3 shows the DC Nano grid integrated with solar PV generation is making a group of different type of solar PV modules (like Poly crystalline, Mono crystalline, Thin film), MPPT algorithm, DC/DC converter and connected DC loads like, mobile chargers, laptop chargers and battery energy storage system. Each solar PV modules are connected to series with each other for obtaining large output voltage. Power delivered by a module depends on the load connected to the module. MPPT is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions.

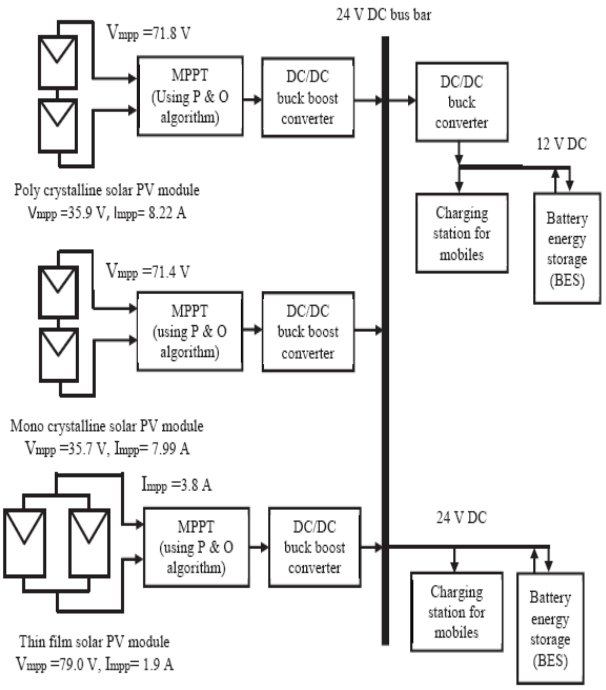


Figure 3:DC Nano grid integrated with solar PV generation

Recently, the deployment of DC appliances is exponentially increasing in all sectors like, industrial, commercial and domestic customers. The voltage at PV module can provide maximum power is called 'maximum power' or peak power voltage. The solar PV modules produce DC power and therefore it can be directly fed to DC load from side to side DC/DC converter to minimize the conversion losses and improve power quality and efficiency. It is used for noise isolation, power bus regulation and current boosting. Power electronic devices are used, whenever change of DC electrical power from one voltage level to another voltage level is needed on output side.

VI. MPPT (P & O Method) Algorithm

The efficiency of a solar cell is very low. In order to increase the efficiency, methods are to be undertaken to match the source and load properly. One such method is the Maximum Power Point Tracking (MPPT). This is a technique used to obtain the maximum possible power from a varying source. In photovoltaic systems the I-V curve is non-linear, thereby making it difficult to be used to power a certain load. This is done by utilizing a boost converter whose duty cycle is varied by using amppt algorithm. MPPT is algorithm that included in charge controllers used for extracting maximum availablepower from PV module under certain conditions. The voltageat which PV module can produce maximum power is called'maximum power point' or peak power voltage. MPPT ismost effective under, cold weather, cloudy or hazy days.There are large numbers of algorithms that are able to trackMPPs. Some of them are simple, such as those based onvoltage and current feedback, like (P&O) method.
The P&O algorithms operate by periodically perturbing (i.e. incrementing or decrementing) the array terminal voltage or current and comparing the PV output power with that of the previous perturbation cycle. If the PV array operating voltage changes and power increases (dP/dVPV>0), the control system moves the PV array operating point in that direction; otherwise the operating point is moved in the opposite direction. In the next perturbation cycle the algorithm continues in the same way. A common problem in P&O algorithms is that the array terminal voltage is perturbed every MPPT cycle; therefore when the MPP is reached, the output power oscillates around the maximum, resulting in power loss in the PV system. This is especially true in constant or slowly-varying atmospheric conditions. Furthermore, P&O methods can fail under rapidly changing atmospheric conditions (Figure 4). Starting from an operating point A, if atmospheric conditions stay approximately constant, a perturbation ΔV the voltage V will bring the operating point to B and the perturbation will be reversed due to a decrease in power. However, if the irradiance increases and shifts the power curve from P1 to P2 within one sampling period, the operating point will move from A to C. This represents an increase in power and the perturbation is kept the same. Consequently, the operating point diverges from the MPP and will keep diverging if the irradiance steadily increases.

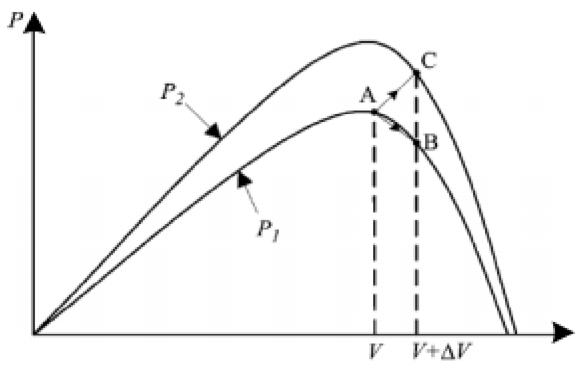


Figure 4: Divergence of P&O from MPPT

There are many different P&O methods available in the literature. In this paper we consider the classic, the optimized and the three-point weight comparison algorithms. In the classic P&O technique (P&O a), the perturbations of the PV operating point have a fixed magnitude. In our analysis, the magnitude of perturbation is 0.37% of the PV array VOV (around 2V) in the optimized P&O technique (P&Ob), an average of several samples of the array power is used to dynamically adjust the perturbation magnitude of the PV operating point. In the three-point weight comparison method (P&Oc), the perturbation direction is decided by comparing the PV output power on three points of the P-V curve. These three points are the current operation point (A), a point B perturbed from point A, and a point C doubly perturbed in the opposite direction from point B. All three algorithms require two measurements: a measurement of the voltage VPV and a measurement of the current IPV.

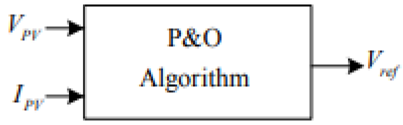
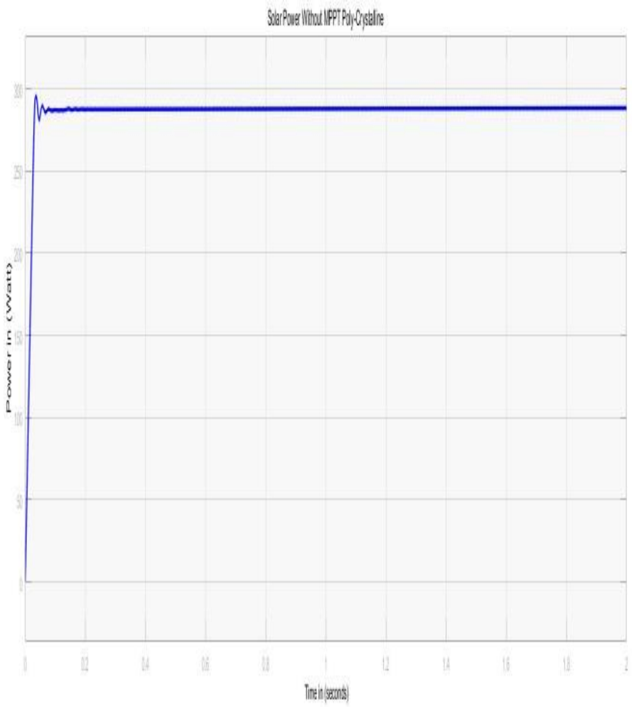
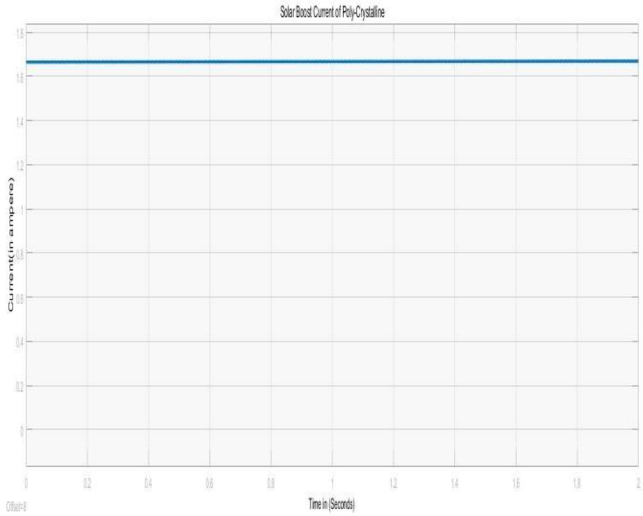


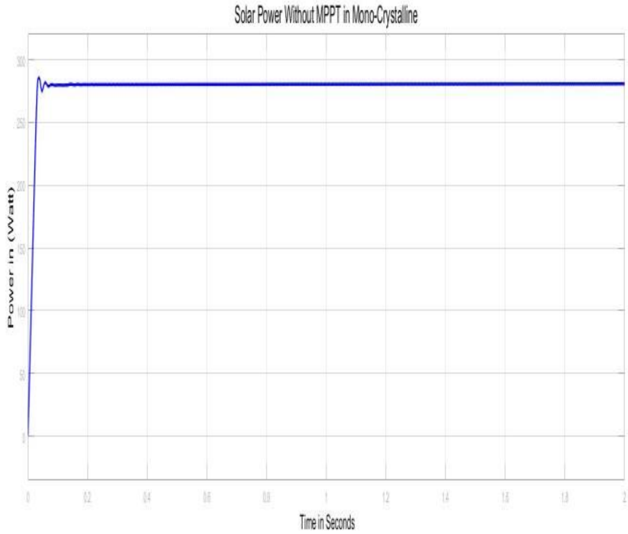
Figure 5: P&O block diagram

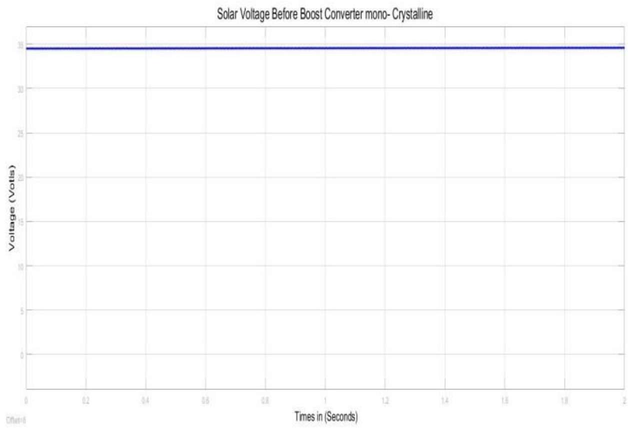
VII. Result and Analysis

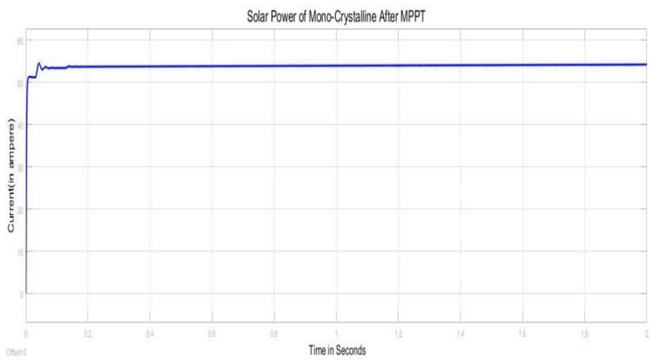
The Simulink model of a closed loop buck boost converter for DC Nano grid integrated with mono crystalline solar PV module is shown in results. The mono crystalline solar PV module is modelled using electrical characteristics for provide the output current and voltage of the PV module. Modeling a solar PV mono crystalline module using standard equation of solar PV cell [10] in MATLAB/ Simulink. Design a P & O algorithm in MATLAB function block using C language. PWM signals are generate using combination of output of MPPT duty cycle and output of Fuzzy and PID controller.

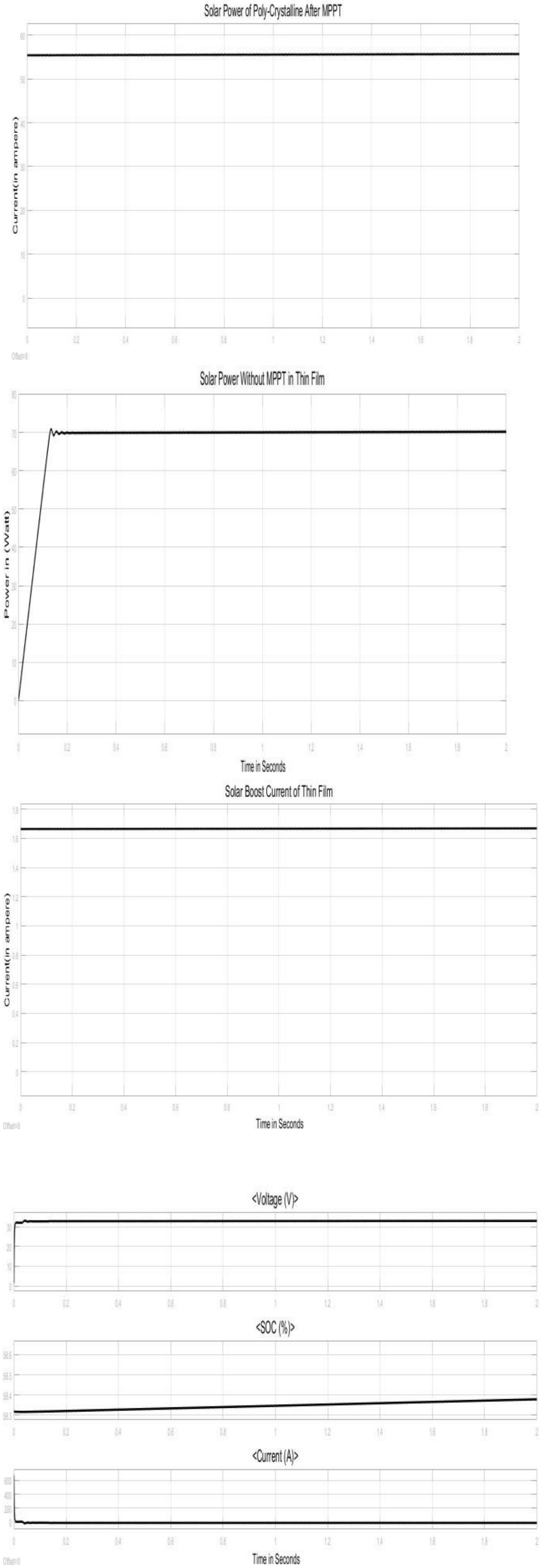












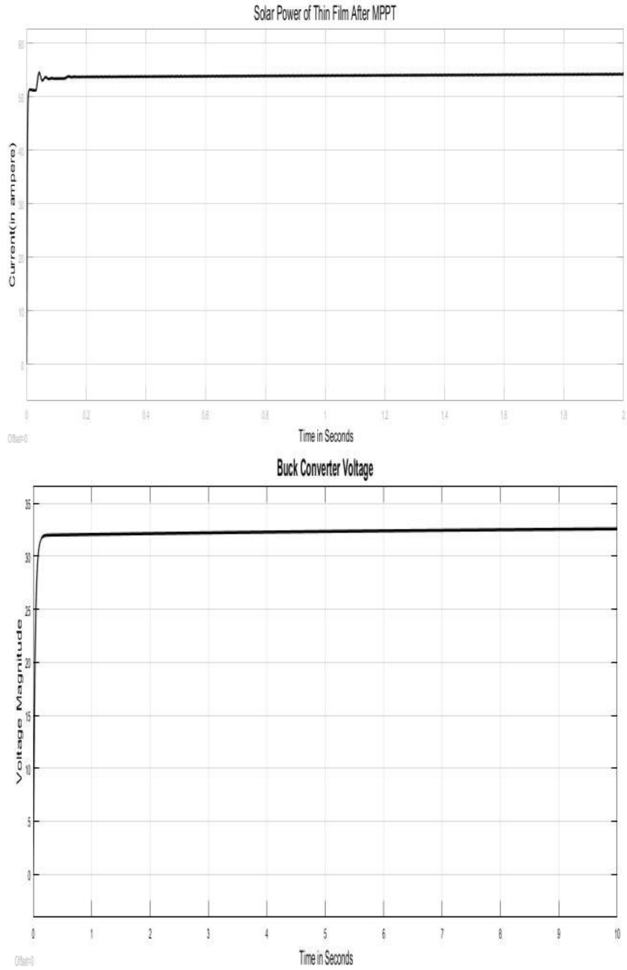


Figure 6: All Simulated Results of DC-DC Converters with Fuzzy and PID controller

VIII. Conclusion

In dc Nano-grid applications, safety is mainconsiderationfor residential loads. The united groundingis preferablefor Flexible maintenance and high efficiency. This work simulates the DC-DC converter for application of DC Nano grid, DC output voltages from buck boost converter. This small level DC output voltage is used for small home appliances load. The constant DC output voltage is obtained through two level using PID controller and MPPT algorithm for track maximum power from solar PV module. Mathematical modelling of PV solar, MPPT Algorithm (P & O method), and DC buck Boost converter for solar PV module are done with fuzzy and PID controller.

The simulation results demonstrate the solar PV modules (like Poly crystalline, Mono crystalline, Thin film) using MPPT Techniques. Further work in this area may use different MPPT method and modified algorithms for increasing efficiency in fast changing environmental conditions. Try to design such model for solar PV system which should compact size and cheaper and also its maintaining and operating cost should be less so that people attract to use in behavior and don't go for conventional sources even for isolated systems. Inverter should be design by using SMPS circuits if further implementation will happen from this project. Over all physical implementation of the system will remains for the future research.

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