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Design and Implementation of DC-DC Converter for DC Nano Grid Integrated with Photovoltaic Power Generation System

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Abstract— **Solar photovoltaic power generation system is one of the burning research fields these days, even governments are also making plans toward increasing the amount of power generation from renewable energy sources because in future viability and crisis of conventional energy sources will increase. Further government liberalization and technical developments encourage the use of renewable sources for power generation in terms of distributed generation system. In order to rigging the present energy crisis one renewable method is to develop an efficient manner in which power extracts from the incoming son light radiation calling Solar Energy. Solar Photovoltaic (PV) power generation system comprises several elements like solar panel, DC-DC converter, MPPT circuit, Battery charge controller and load.**

Recently the growth of DC operative home appliances like mobile and lap top 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. This thesis presents simulation results of a buck boost converter, MPPT algorithm (P & O method) with fuzzy and PID controller for solar PV module. 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.

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

I. INTRODUCTION

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. Traditional power grids in large-area countries have posed some demerits such as being costly to expand, having limited efficiency in power delivery [1], being vulnerable and insecure in operation. These reasons call for a modern power grid for today and the future. As fossil fuels such as coal, oil is depleting, alternative energy sources have been encouraged to ensure energy security of each nation as well as the whole world. There are 2 main types of alternative energy sources: nuclear power, and renewable energy. After nuclear crisis in Japan, March 2011, the world leaders have had to take into consideration the safety issues of nuclear power. Consequently, energy policies have been changed and construction of new nuclear power plants has been postponed or canceled. On the other side, use of renewable energy sources such as solar photo-voltaic (PV), wind energy, geothermal energy, and so on, are being encouraged. Germany is the nation that has already had 20% penetration of renewable energy in power generation (2010), and said No to nuclear power.

Today most of the equipment's are working on DC voltage supply. Normally, the supply coming from power station to the homes, offices, industries etc. in form of AC supply. So it is needed to convert AC supply into DC supply to make useful for the equipment's which works on DC supply. Nowadays, energy generates in form of clean, efficient, and environmentally friendly sources have become one of the major challenges for engineers and scientists [2]. Out of all the available renewable energy resources, solar source attract more attention because they provide awesome opportunity to generate electricity and free source [2] [3]. However, despite all the aforementioned advantages of solar power system, they do not present desirable efficient [4].

The development of renewable energy has been an increasingly critical topic in the 21st century because of the growth in global warming and other environmental issues. Today most of the equipment's are working on DC voltage supply. Normally, the supply coming from power station to the homes, offices, industries etc. in form of AC supply. So it is needed to convert AC supply into DC supply to make useful for the equipment's which works on DC supply. Nowadays, energy generates in form of clean, efficient, and environmentally friendly sources have become one of the major challenges for engineers and scientists [1]. Out of all the available renewable energy resources, solar source attract more attention because they provide awesome opportunity to generate electricity and free source [1] [2].

However, despite all the aforementioned advantages of solar power system, they do not present desirable efficient [3]. 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 [4]. Many MPPT techniques have been proposed in the literature; examples are the P&O method [5], incremental conductance (IncCon) method [6-7] and fuzzy logic method [6] 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

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radiation falling on a PV module varies throughout the day, 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.

In addition, much research is focused on increasing the poor efficiency of the power processing stage, as well as improving the power yield of the overall system [8]. Recently, the concept of cascaded DC/DC converter has become popular [9-10]. A low voltage DC Nano grid can be used to supply sensitive electronic loads, since it combines the advantages of using a DC supply for electronic loads and using local generation to supply sensitive loads. Changes in insolation onpanels due to fast climatic changes such as cloudy weather and increase in ambient temperature can reduce the photovoltaic (PV) array output.

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. DC Nano Grid

Nano grids take from micro grids their primary goals: making available power with diverse characteristics; better matching power supply to the needs of the devices being supplied; enabling distributed generation and storage; and energy efficiency opportunities. Nano grids merit attention for energy efficiency research and policy to understand how they can be used and promoted where they do save energy. Nano grids may also get increasing use for their other benefits (regardless of their energy impact) so it is worth making them as efficient as feasible.

Nano grid is self-controlled elements and worked in either grid-associated or island mode, which interconnect neighborhood DERs and burdens with nearby dissemination frameworks [11]. The primary favorable position of a DC Nano grid is that it gives superior consistence DC sorts of DERs and burdens [12]. For instance, solar PV and battery stockpiling would just use a DC/DC transformation in DC Nano grid which gives a more straightforward and cost effective structure with a substantially less demanding control procedure.The Nano grid concept illustrates these issues by associating a variety of distributed energy sources and loads in a power network capable of an islanding operation with the main grid [13]. The deployments of Nano grids are expected to impact the economic, environmental electricity supply quality and reliability aspects [14]. Nano grid refer to a small scale of the power network, with voltage levels used on the distribution network (≤20 kV) and power ratings ranging up to 1 MW.

III. 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.

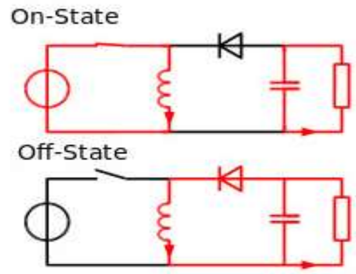


Figure 1: Buck-Boost Converter

IV. System Description

The figure 2 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.

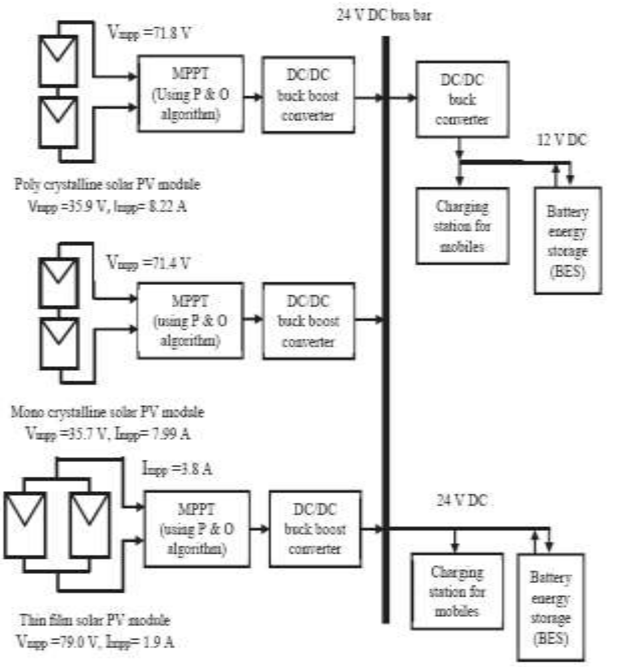


Figure 2:DC Nano grid integrated with solar PV generation

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.

V. 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 3). 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.

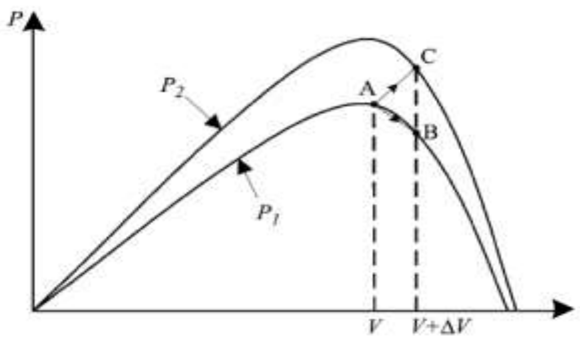


Figure 3: Divergence of P&O from MPPT

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&Oa), 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.

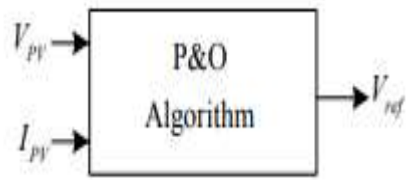
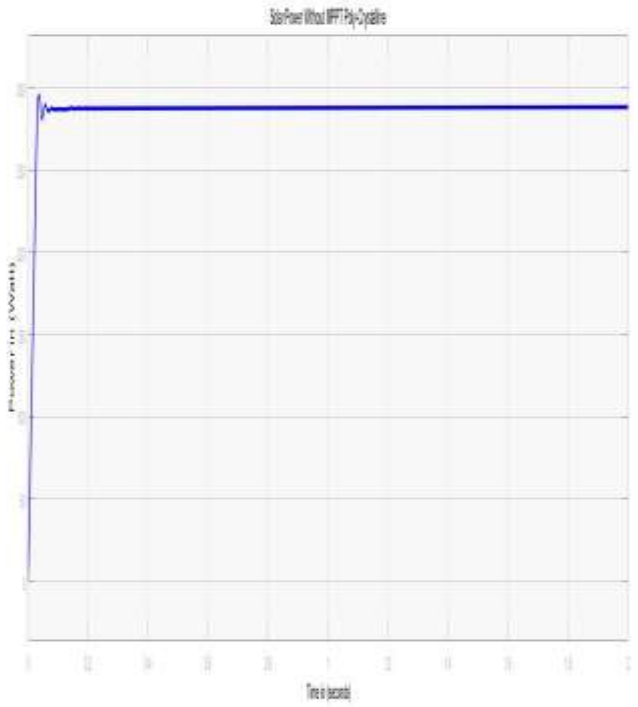
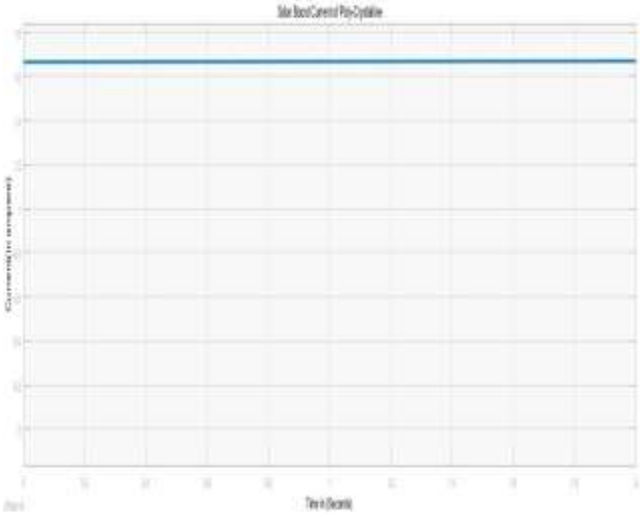


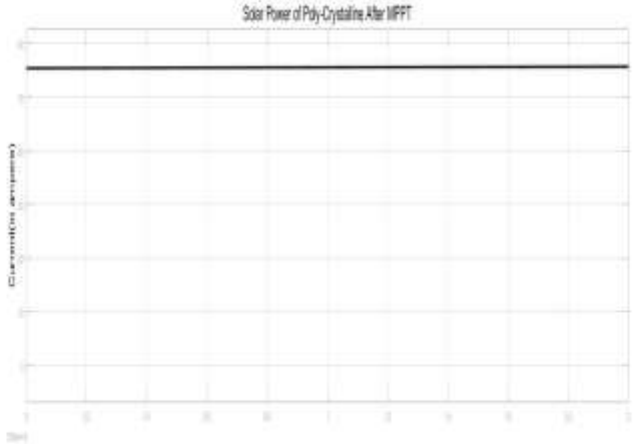
Figure 4: P&O block diagram

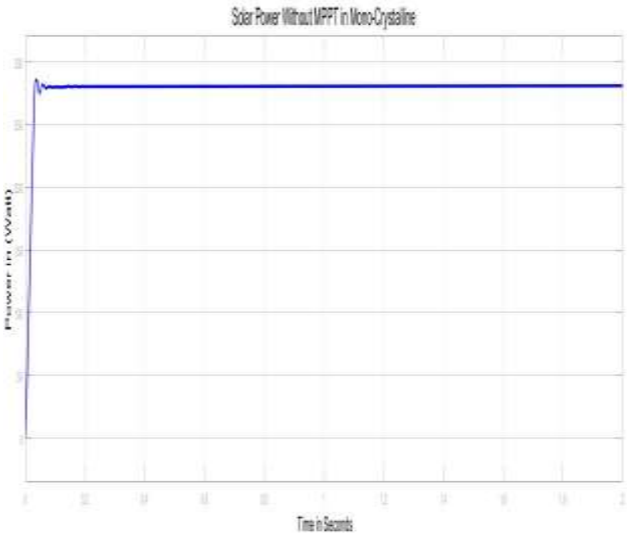
VI. Result and Analysis

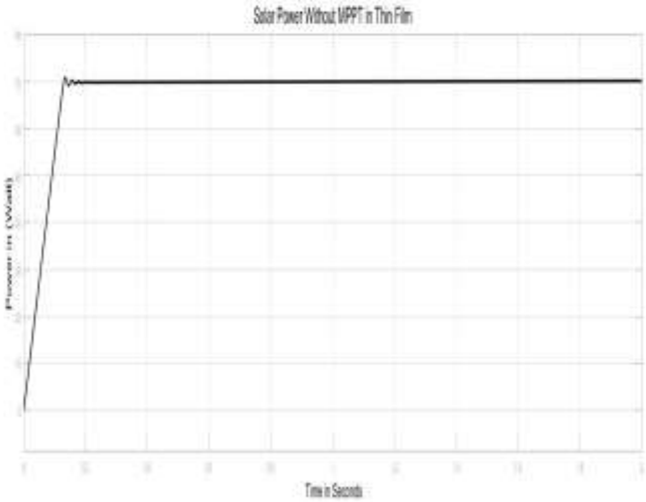
The Simulink model of a closed loop buck boost converter for DC Nano grid integrated with mono crystalline solar PV module is shown in results. The mono crystalline solar PV module is modelled using electrical characteristics for provide the output current and voltage of the PV module. Modeling a solar 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.

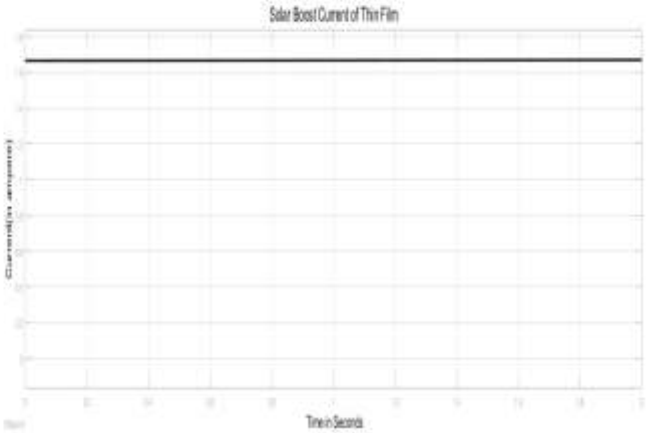


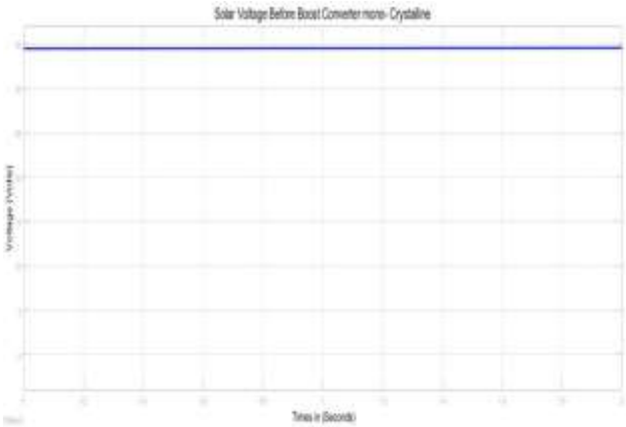

Solar Boost Current of Poly-Crystalline
Current(in ampere)
Time in Seconds

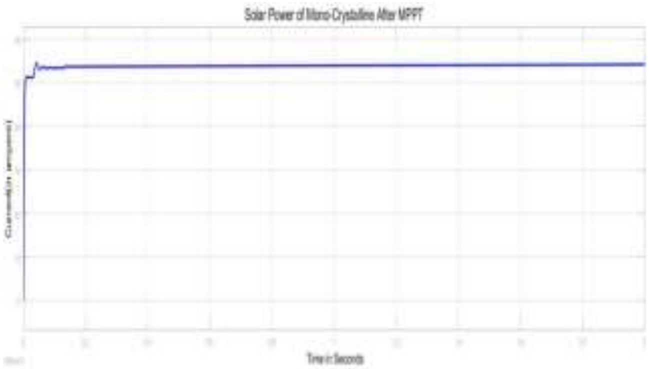

Solar Power of Poly-Crystalline After MPPT
Current(in ampere)

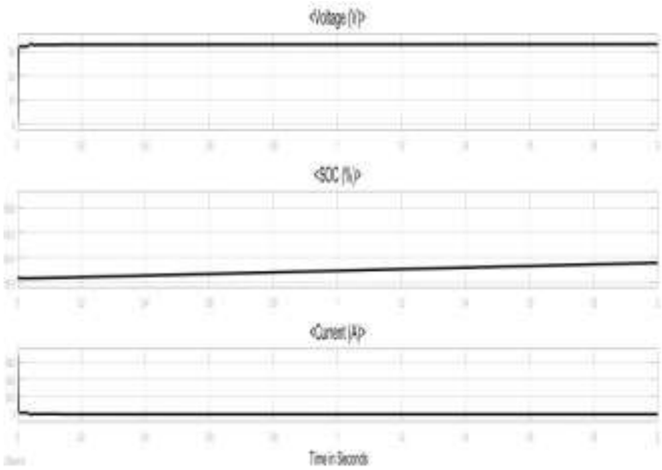

Solar Power Without MPPT in Mono-Crystalline
Power in (Watt)
Time in Seconds


Solar Power Without MPPT in Thin Film
Power in (Watt)
Time in Seconds


Solar Boost Current of Thin Film
Current(in ampere)
Time in Seconds


Solar Voltage Before Boost Converter mono- Crystalline
Voltage (Volts)
Times in (Seconds)


Solar Power of Mono-Crystalline After MPPT
Current(in ampere)
Time in Seconds


<Voltage (V)>
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<Current (A)>
Time in Seconds

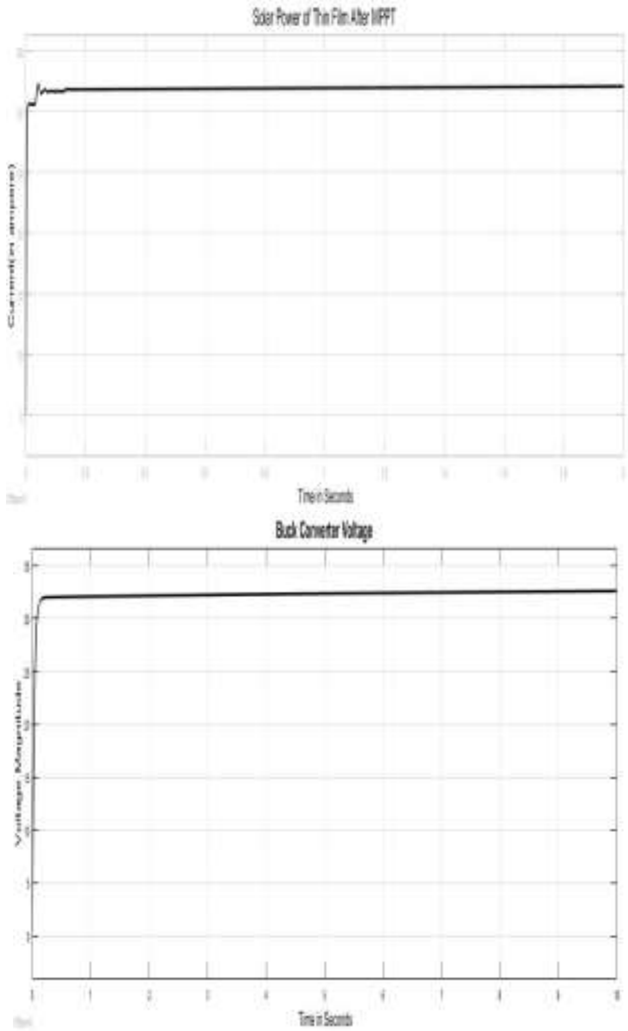

Figure 5: All Simulated Results of DC-DC Converters with Fuzzy and PID controller

VII. Conclusion

This work simulates the DC-DC converter for application of DC Nano grid, at two voltage levels: 12 V & 24 V 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. The voltage at which PV module can produce maximum power is called 'maximum power point' or peak power voltage. Also it improves the system efficiency by reducing no. of conversions.

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