Journal of Green Engineering (JGE)

Volume-10, Issue-12, December 2020

Simulation of a Novel Topology For DC Nano Grids Using MATLAB

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Abstract

Nowadays it is necessary to develop modern technologies for self-sustaining intelligent power buildings containing these devices through the use of several mobile devices – the main sources for energy use with the popularity of DC voltage appliances such as LEDs, computers and laptops. These smart office buildings are the next generation of smart cities. This article suggests a novel topology system in the DC Nano grid, keeping these points in mind. The Nano-Grid PV system is used in small-scale structures to maximise grid efficiency and to reduce power plant emissions. DC nano-grid has promising research platforms for integration with small buildings/offices and the use of new DC appliances in recent studies to increase the number of smart homes and create a clean environment, due to its high efficiency, simple architecture, low cost and ease of control. The foremost objective of our proposed model is to improve the efficiency of the traditional solar system. In this work, we construct the DC Nano grid which works on sharing basis between solar PV systems and utility grid with DC loads. Solar energy is given the predominance and the system will take the required power proportion from the utility grid if the solar power is not enough. This is done by linearly adding the power from the SPV system and the Utility. Thus we can reduce the usage of utility supply and maximise the utilization of the solar power, thus reducing the cost and improving efficiency.

Journal of Green Engineering, Vol.10_12,13452-13466.

Alpha Publishers

Keywords: DC Nano grid, DC voltage, Maximum power point tracker, solar panel, Zeta converter.

1 Introduction

In recent years the interest in renewable energy resources in energy production was becoming increasingly important due to declining coal and other fossil fuels, expensive and rising environmental problems. The two key driving factors for the construction of DC Nano-Networks in the rural areas are energy conservation and continuous electricity needs in remote villages. The advantageous technologies for satisfying demand in these areas are Solar Photovoltaic (PV), fuel cell and Wind. DC Nano-grid systems have to combine solar or wind energy sources with battery-based storage [1 and 2] due to the varying existence and reliance of these sources on atmospheric conditions.

There have been several attempts to build a sustainable house in remote areas, also known as Net Non-Energy Homes (NZEH) [3]. The building blocks for aesthetics and power management technologies fused modern architectural features, using PV modules as building blocks to allow use of durable resources. The electric power system of a remote zone or a new commercial building is a subset of intelligent grid systems and is called a Nano-Grid by many authors [4]. Several controllers and techniques for a DC nano-grid device have been built here.

The high cost of capital is one of the biggest issues with the construction of a DC nano grid. To achieve a reasonably reliable system at minimal costs, an optimum sizing procedure is required for an independent solar photovoltaic system [5]. Many size optimisation methods for the selection of optimum number of photovoltaic modules and battery storage capacity are currently available [6]. The PV array size for DC nano grids depends on weather information as well as on the temperature and solar irradiation, and it has not been tried so far. If the energy management system is included [7], the size of the panels will be substantially reduced. In addition, energy efficiency would reduce peak loads [8], thus improving the efficient use of renewable resources. In addition, if the working time of the DC loads is modified, the size of the PV array and storage will decrease significantly. In recent reports, the development of new appliances suggested that smart offices should be increased in order to create an efficient and green friendly climate. As a result, the appliance industry has deliberately begun manufacturing new technology and software to create smart systems [9],[10],[11].

The key contribution of this paper is the design of a new topology in the DC Nano-grid system to increase the reliability on the DC source, which decreases costs and saves more electricity. For this reason, the DC nano-grid is used to produce and increase the power efficiency of the loads.

Typical DC loads are used to create DC nano-grids to minimise the amount of power consumption by using the buck converter at the utility end. A Zeta converter is used to improve the stability of the DC load output voltage in end of the solar PV system.

2 Proposed Method Design And Simulation

A DC nano-grid system is a small, renewable-based power grid system. An rise in the release of atmospheric gas emissions that cause global warming is leading to renewable, safe and environmentally friendly sources of energy. Photovoltaic photovoltaic plant is the most frequent renewable source used because of its safe, quiet, cost-efficient and simple installation. With changes to the sunlight radiation and power quality, however, the performance of PV systems is changing. Thus, the world is dependent on these renewable energy sources. The model simulation circuit diagram is shown in Figure 1 below. In Matlab/Simulink software the proposed device is built and implemented, in which solar cells convert sunlight to PV DC Voltage.

In this proposed model, we introducing the new topology to provide maximum voltage with better efficiency and also working on a sharing principle of solar and grid utility. Converter topology model as Zeta converter and buck converter, which stabilize the output voltages to the DC load. In MPPT section, we used the IC technology scheme to provide maximum power from available sunshine.

The results of this approach are also economic, enhancing reliability and energy conservation for the better performance of load DC voltage.

The system current bands can be modified to control the bus voltage and adapt the current. This current is fired in the same angular frequency into the grid. The current hysteresis control loop reference is created by a PI controller on the DC voltage control loop with the Discrete PI control and the voltage is metered and viewed by scope. The system uses the DC loads to work in DC so conversion levels can be decreased in the DC/AC converter rather than handle regular AC loads due to the specified power conversion and adequate power losses on the system. This leads to an improvement in device performance by reducing the corrective loads.

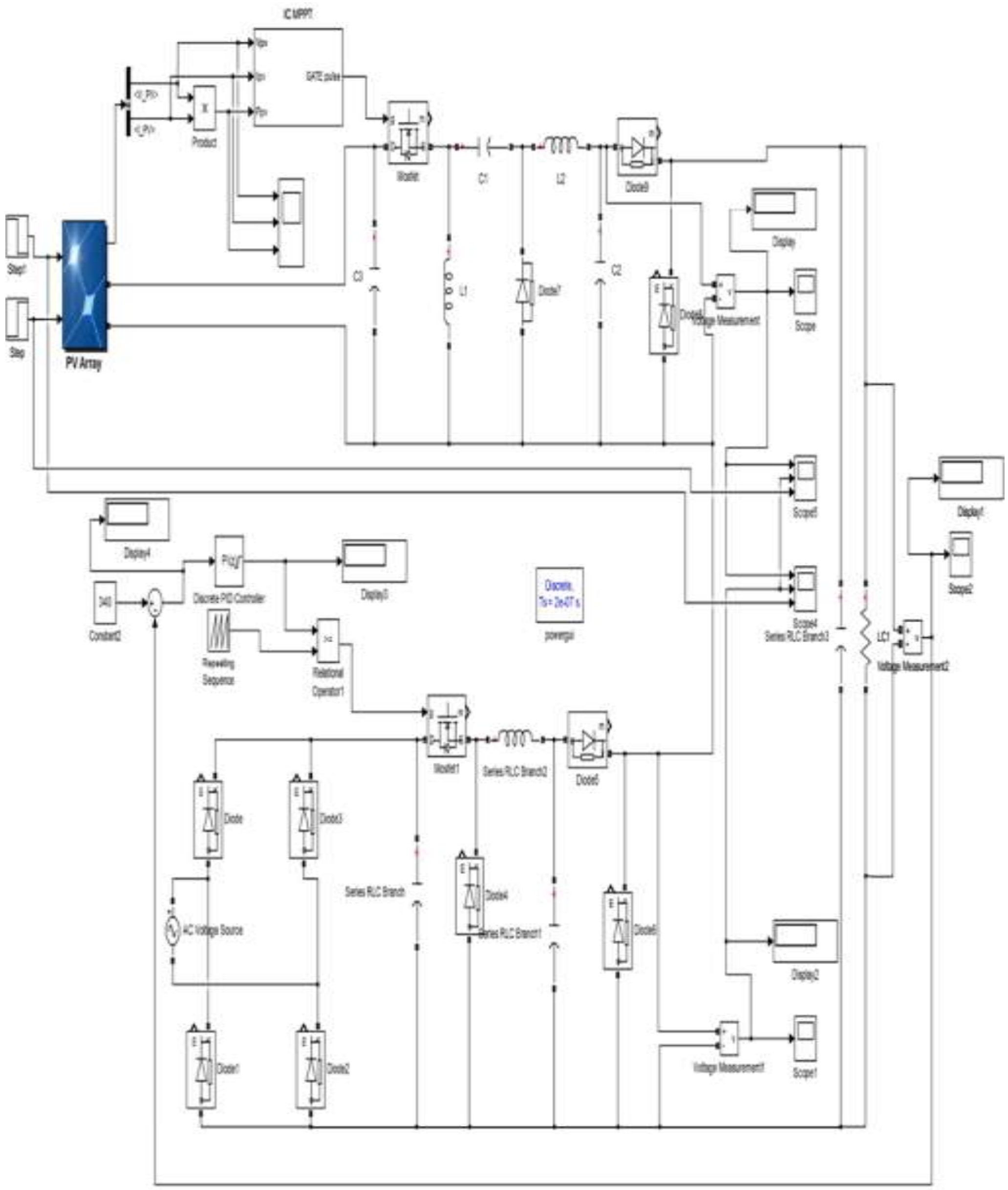

Figure 1 Circuit diagram of the proposed DC nano-grid system

2.1 PI controller

Different controller types are used to enhance control systems performance. We used in this study controllers such as photovoltaic proportional and integral controllers. The proportional integral controller generates the output of the proportional and integral controllers. The block diagram of the negative feedback of the unit is shown in Figure 2 in the following chart along with the proportional integral controller. A PI controller is supplied with the instantaneous voltage. The integrated term in the PI controller increases monitoring by reducing the transition from the solar to the utility grid instantaneously. Solar pv controller aims to monitor unpredictable DC voltage fluctuations, such as changes in the environment, solar PV irradiation.

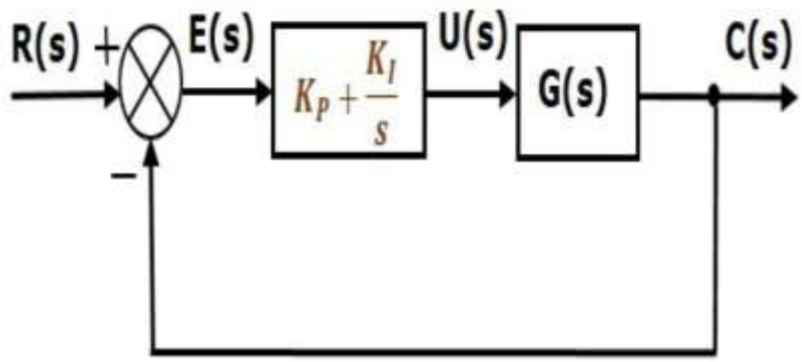

Figure 2 proportional integral controller.

2.2 Maximum Power Point Tracking (MPPT) Controller

DC blocks must act as buffers between PV generators and the DC connector in PV systems to increase input voltage at the required DC connection voltage and track the maximum power point for PV. PV systems must (MPP). The MPPT method of incremental conductance was adopted [12] because of its quick and precise power tracking capability. A proportional–integral controller diminishes the error $dI/dV + I/V,$ then, its yield passes over a voltage controlled oscillator. An IC MPPT is the form in which the above stated disadvantages are overridden. The terminal voltage of the table will always be set to the MPP voltage in this process. It is focused on the PV module's incremental and instantaneous activity.

2.3 Buck Converter

A higher input dc voltage is converted to a lower dc output voltage. Figure 3 shows the basic topology of the dc-dc buck converter. It includes a managed SW switch, an unregulated switch diode (D), an L-inductor, C capability and load resistance (R). The conversion definition assumes that all components are ideal and the conversion unit even works in continuous driving mode. Buck converter is interface with end of the utility grid to deliver the proper voltage supply [13].

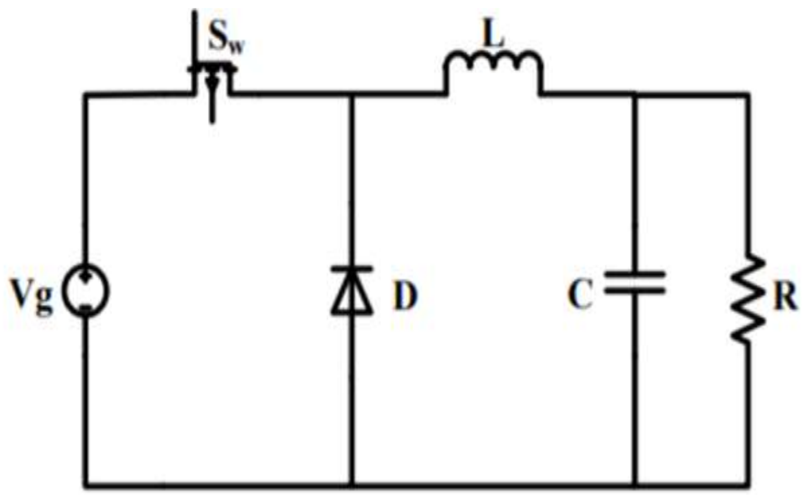

Figure 3 Buck converter circuit diagram

3 Simulation Result

The diagram of the proposed system designed in MATLAB and Simulink shown in below figure 4. Which include the PV module electrical circuit. The given components are choose according to the setup. The PV module is moulded using electrical characteristics to provide the output voltage of the PV module. The PI control loop is eliminated and the duty cycle is adjusted directly in the MPPT. To compensate the lack of PI controller loop in the proposed topology. The MPPT scheme is directly connected with the Zeta converter, which is connected to the end of the solar PV system.

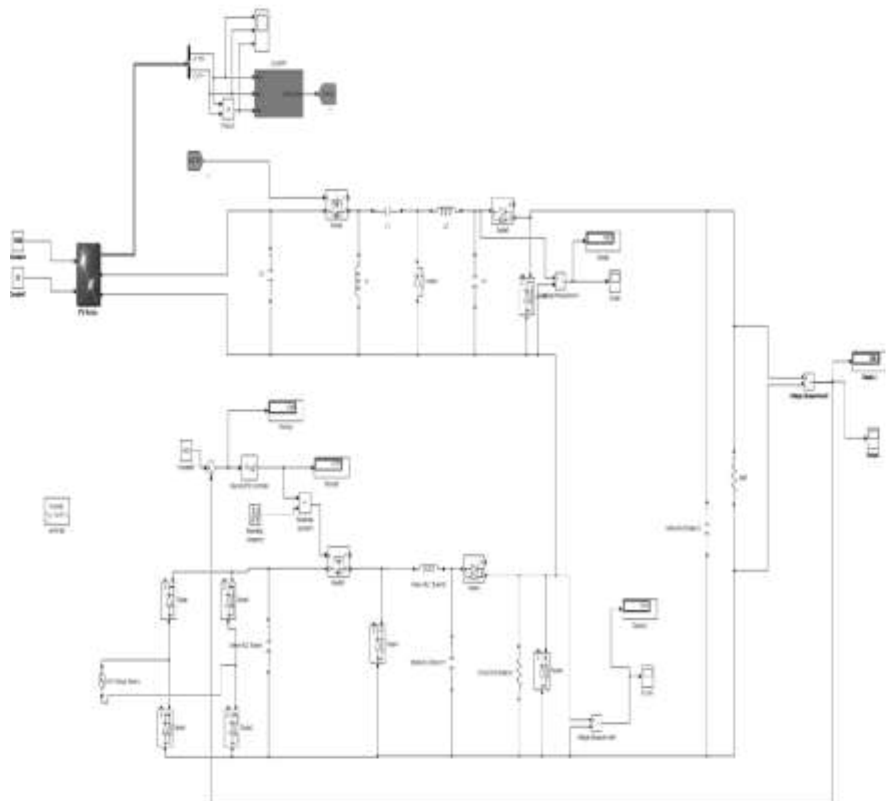

Figure 4. Simulation circuit diagram of MPPT solar PV system

Because the PV system of solar panels is directly environmentally dependent, the PV production is also dependent on load current, irradiance and temperature. Variation and irradiation of the current load is investigated in real time. A small irradiance variance leads to a disruption of the output parameters generated from the PV module due to environmental conditions.

In Fig. 5 shows the effect of changing the irradiance on the purposed system at no load. In this figure X axis represent the time (seconds) and Y axis represent the voltage (volts). The PV module output voltage irradiance is constant on 1000w/ m2. These findings show that non-uniform PV modules' irradiation creates more complex PV array features, e.g. several power peaks appear in the P–V curves. Here are ways of enhancing the model's precision, which focuses on the electrical features of PV modules in non-uniform irradiance conditions. Part of the work was completed, for example a model for simulating circuit topology and its control strategy on uniform irradiance conditions.

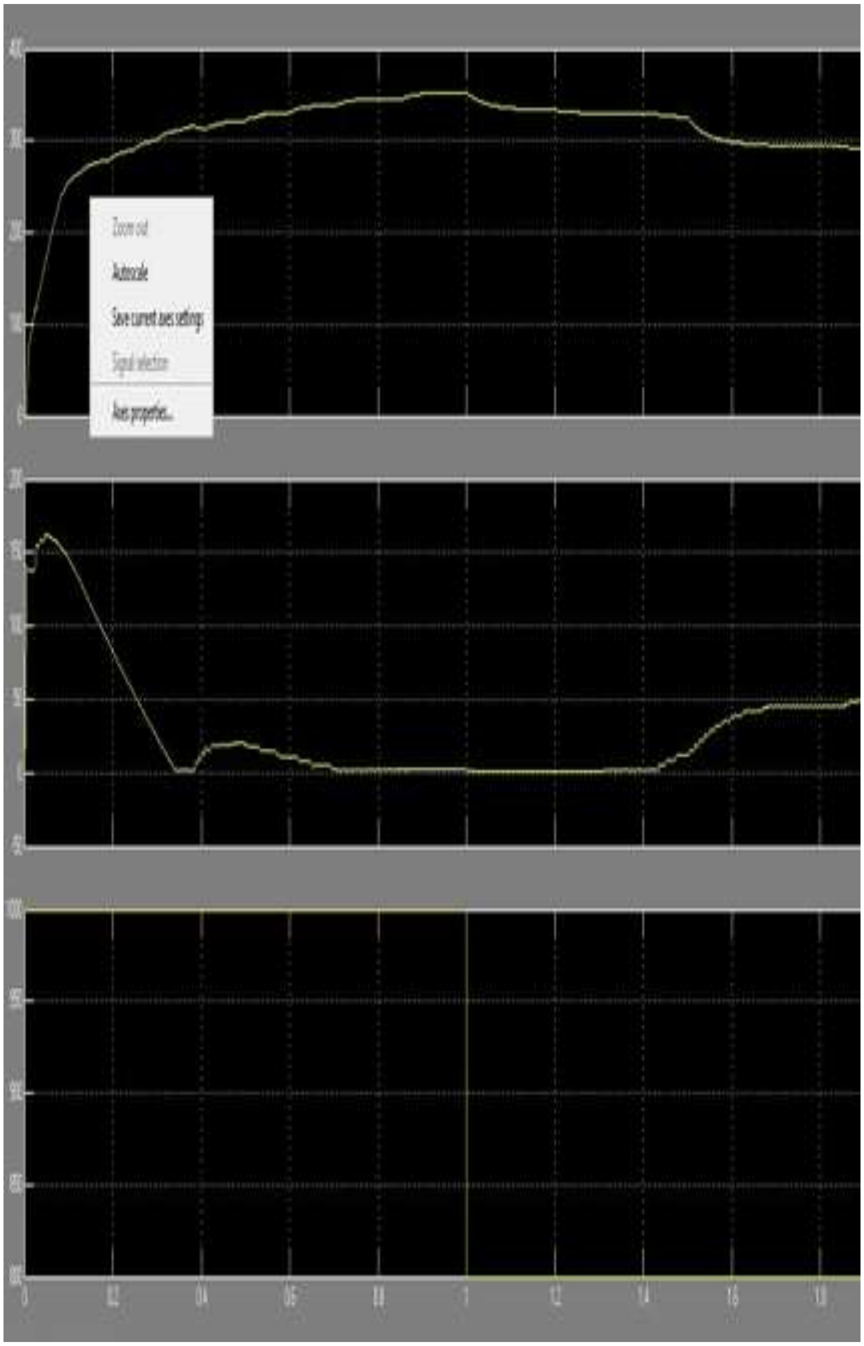

Figure 5 The PV module output voltage in irradiation condition

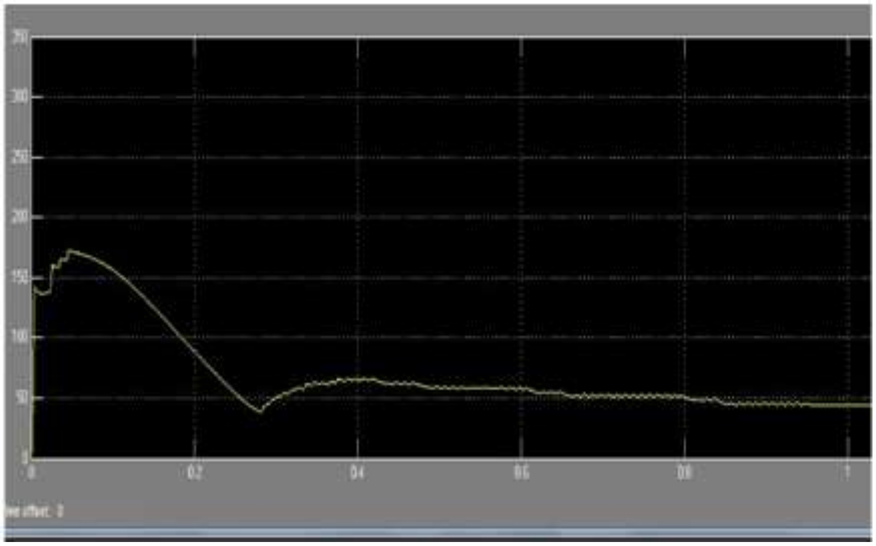

Figure 6 solar power output (Zeta converter is connected at the end)

The figure 6 represent that the solar output voltage, while zeta converter is connected at the end of the output, the stability of output voltage is graphically represented in the figure 5, here x axis labelled that the time and y axis labelled that the time (ms). Zeta converter is an intermediate power processor in the PV system that adjusts the amount of voltage to obtain full power from the PV array. Changing the voltage and turning the fixed charge into a variable load is nothing more than that grid utility.

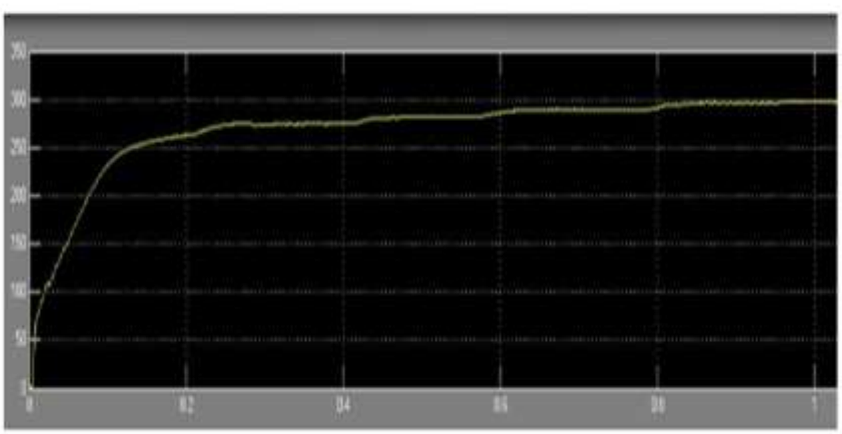

Figure 7 solar power output (buck converter is connected at the end)

The buck converter is connected at grid end, reason of when voltage is down or up condition at that time buck converter has compensate the output voltage to stable condition. When voltage goes low condition, converter act as a boost converter. And another hand voltage goes high, converter act as buck kind to drop the voltage according to the DC load. The buck converter output is graphically represented in the figure 7.

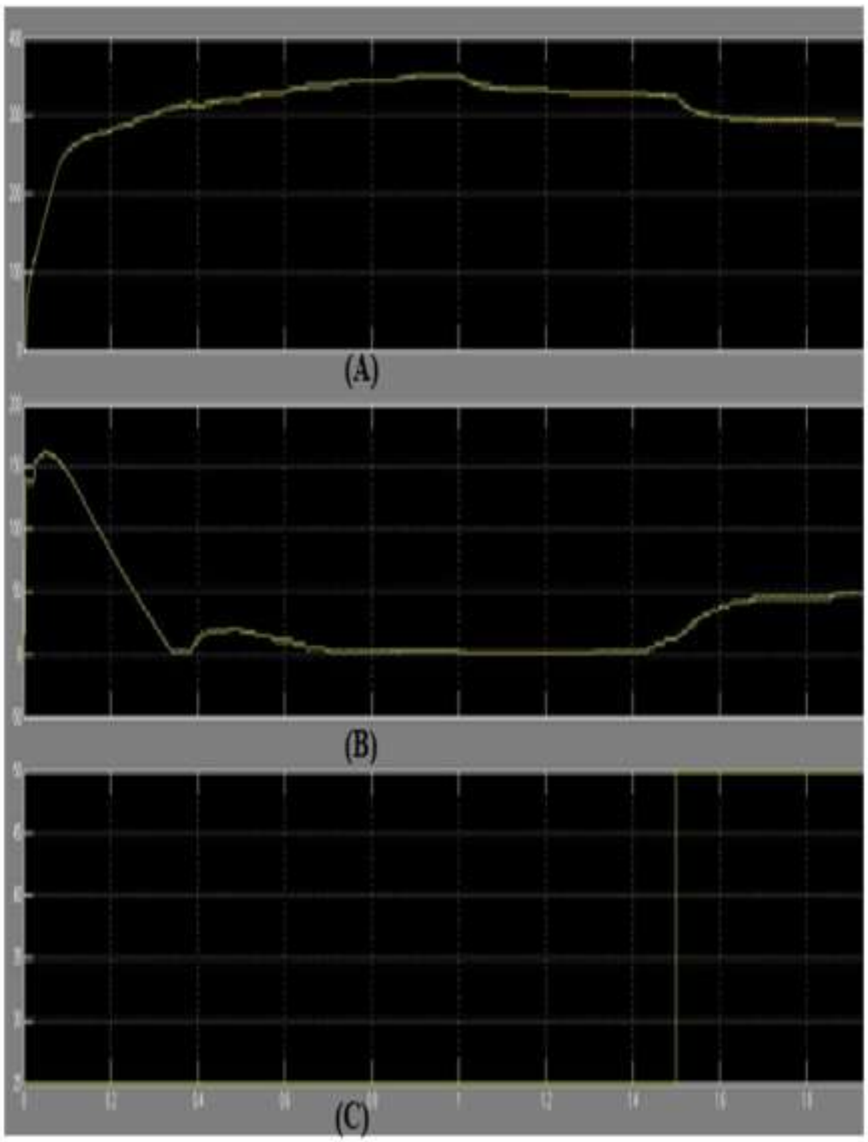

Figure 8 (a) MPPT output (b) utility grid power (c) temperature variation

In figure 8 represent the output power of solar and utility grid. In figure 8(A) represent the solar power MPPT output, which power is delivered from solar panel through MPPT. Another figure 8 (B) represent that the utility power, which is delivered from the grid. Another figure 8 (C) represent that the temperature variation under different environmental factor. when temperature increases from 25 to 50 degree, when MPPT power goes down. However the grid power is automatically goes to high, this principle can provide uninterrupted power source to the load.

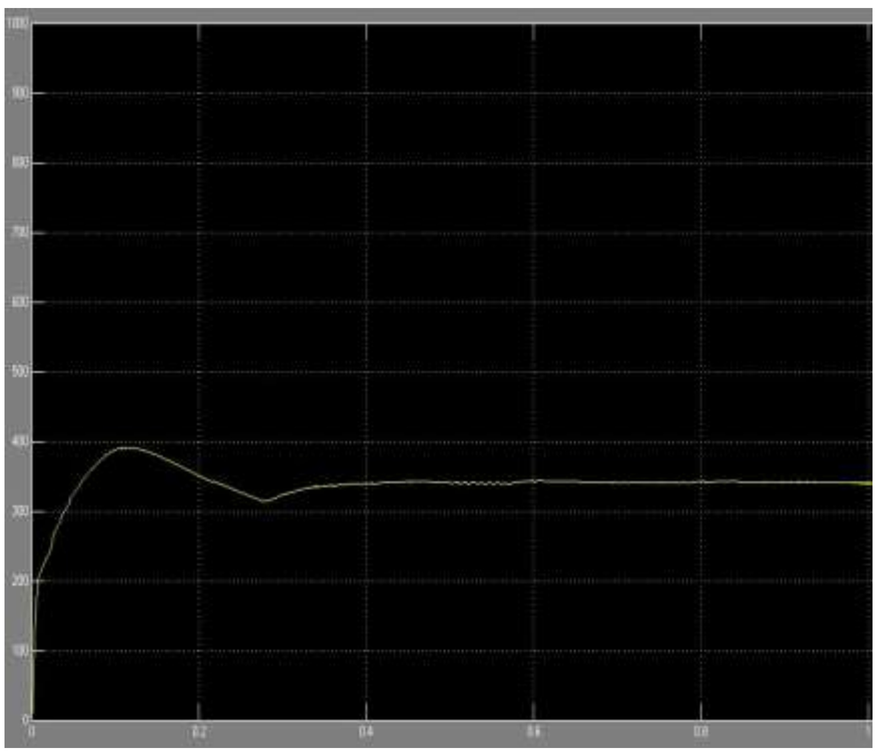

Figure 9 Total Output across the load in normal working conditions

In figure 9 graphically represent that the system working in normal condition of total output across the load. The module operates at the highest power point in the optimum sunshine state in which the variance of the output conductance is equal to the negative of the output conductance.

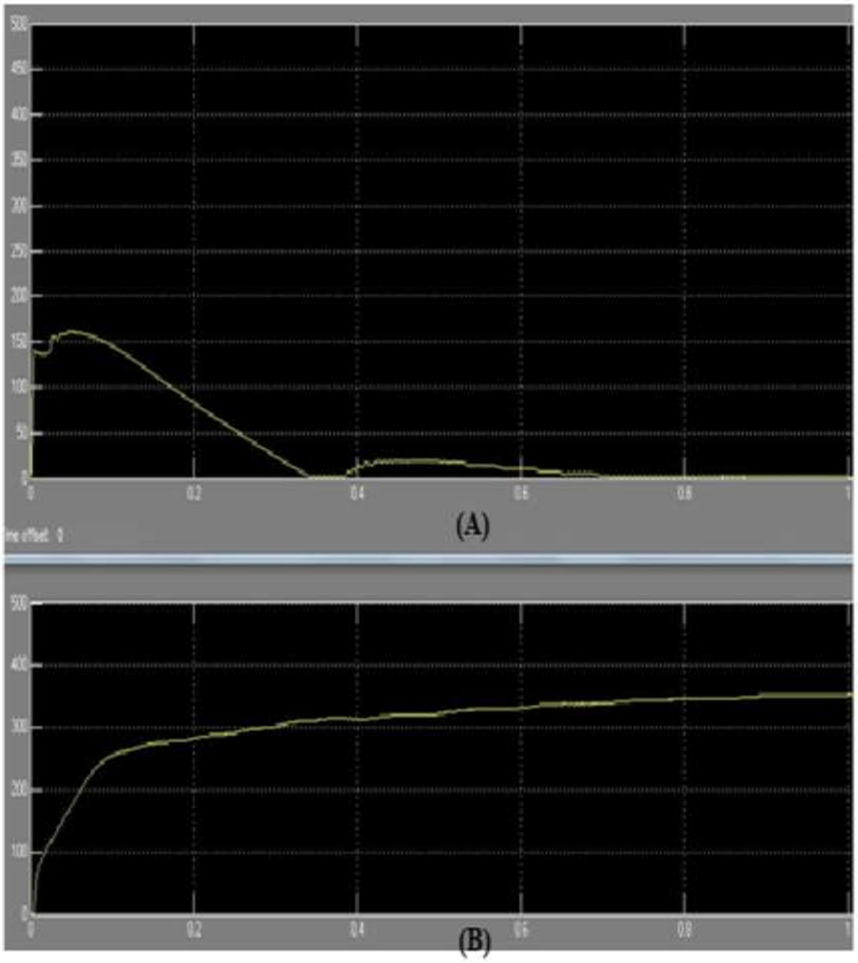

Figure 10 (a) utility output voltage (b) MPPT output voltage

In figure 10 shows that the both utility and MPPT output voltage. In figure 10 (a) represent that the output voltage of utility, which power is delivered from the grid side. On another, figure (b) signifies the output voltage of MPPT, which output is delivered from the solar panel through the MPPT. This technology increases the solar panel's performance. The power output of a circuit is optimum when the Thevenin impedance of the circuit corresponds to the load Impedance according to the maximum power transfer theorem. This makes monitoring the full power point difficult to match impedances. MPPT is tracked in many ways but this paper is dedicated to gradual behaviour. Incremental conductance uses source and current information to find the appropriate point of operation.

It can be seen that the as the MPPT output increases, the utility supply decreases and vice versa, highlighting the power sharing methodolgy of the circuit giving the first preference to the solar power and augmenting the power from utility if required. 340 V is the desired DC as the equivalent to 240V AC.

4 Conclusion

This paper simulates a novel topology using a zeta converter to supply a commercial nano-grid voltage for the application of DC Nano grid output voltages to DC loads for smart office appliances. This DC output voltage level is used for small and high loads of appliances. Constant DC output voltage is achieved by two levels using the Discrete PI controller and the MPPT for maximum track power from the solar PV module. IC MPPT is more efficient and accurate at constant temperature and irradiance. The simulation results show the application of a zeta converter to maintain constant voltage on a DC bus regardless of the variation in solar PV generation. It also improves system voltage efficiency by reducing costs and voltage losses. Simulation circuit blocks can be used seriously to achieve the desired power levels, thus meeting the high power load requirements. Both the Nano grid and its main building block have shown good performance and work is underway to test the entire system experimentally.

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Biographies

Joseph.P.P received his Post Graduation in Electronics from the prestigious St.Josephs' College, Tiruchirapally. He is currently working as Assistant Professor, Head of the Department of Electronics in Prajyoti Niketan College (Govt Aided), Pudukad, and Kerala. He has published 3 papers in International journals. His research area is Solar Photovoltaics and DC utility.

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