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A novel method for MPPT in PV systems under partial shading conditions using fuzzy logic and PID controller

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ABSTRACT

Solar or Photovoltaic (PV) system is an alternative clean energy resource that has received much attention in the research and industries. The solar charge controller is the main part of a solar system. There are three types of CC are MPPT, PWM and ON/Off. MPPT is getting very much popularity nowadays for its high capability of power extracted from a solar panel. The MPPTs controllers are used to ensure a high PV system performance. This research paper explains the development of a new algorithm for MPPT in large PV systems under Partial Shading Conditions (PSC). The new technique is a combination of Fuzzy logic and PID. The methodology can be simulated in for different PV configurations under varying conditions. The integration of Fuzzy with PID controller is shown to yield faster convergence to the Global Maximum Power Point (GMPP) as compared to reference work. In our research work, DC voltage approximately 530V whereas in base work 40V. A novel maximum power point tracking scheme for PV power generation system under partially shaded condition gives a superior result as compared to reference work.

Keywords— *Maximum power point tracking, MPP controller, PWM, DC to DC converter*

1. INTRODUCTION

Photovoltaic solar electricity is the most elegant method to produce electricity without moving parts, emissions or noise and all this by converting abundant sunlight without practical limitations. The relevance of solar energy specifically PV can be justified mainly with the factors like scalability, environmental impact and the security of source. The scalability means the abundant availability of the solar radiation to be utilized for PV [1]. Solar cells are zero-emission electricity generators, which prove its environmental friendliness.

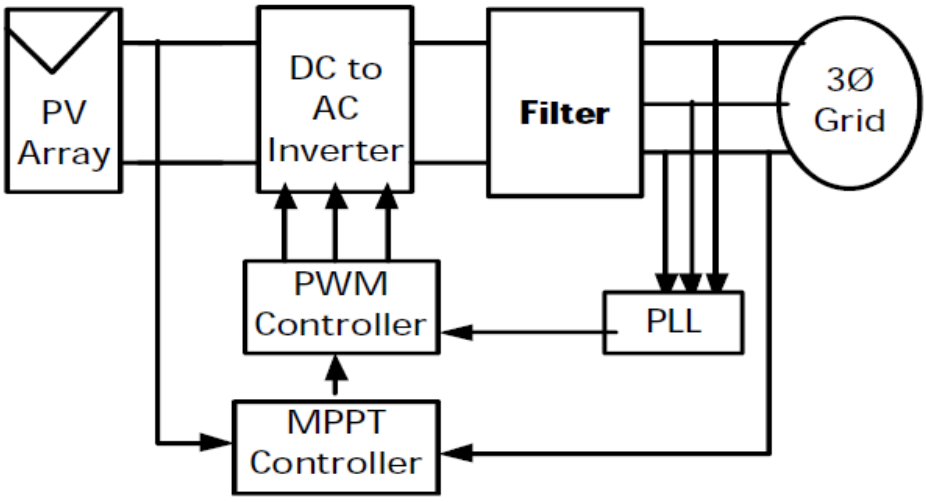

Fig. 1: Block diagram of the PV grid connected the inverter

The PV plant consists of PV cells and it is arranged in the series and parallel combined nation to supply the desired DC voltage and current. Normally PV cell is made up of a silicon semiconductor and each silicon cell generates 0.6V. The commercially available PV module consists of 36 or 72 cells connected in series to form a PV plant.

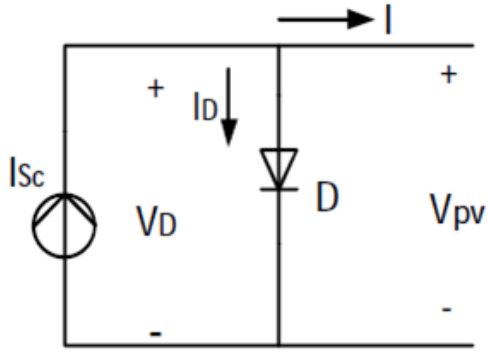

Fig. 2: Basic equivalent circuit of PV cell

Maximum Power Point Tracking frequently referred to as MPPT, is an electronic system that operates the PV-Hydro Diesel (PV) modules in a manner that allows the modules to produce all the power. MPPT is not a mechanical tracking system (MTS) that "physically moves" the modules directly at the sun which enhance the efficiency. MPPT is a fully automatic and electronic system that varies the electrical operating point to deliver maximum available power [2-3]. Additional powers harvested from the modules are used to increase battery charge current. MPPT can be used in conjunction with a mechanical tracking system (MTS), but two systems are different from each other completely. MPPT is an electronic method of capturing the most power from your PV solar modules (solar panels). MPPT controllers will convert the module operating voltage to battery voltage and increase the output current in the process. The word "tracking" has nothing to do with mechanically moving the PV modules to track the sun. The MPPT process will raise the current while lowering the voltage. This can be achieved through a procedure which is known as DC to DC conversion. The reason this works is that we can exchange current and voltage and yet have the same amount of power (Watts).MPPT circuits use this process during raising current, to decrease voltage close to battery voltage [5]. MPPT output current will be higher than the input if the MPPT controller is greater than battery voltage by approximately 5% or more than 5%.

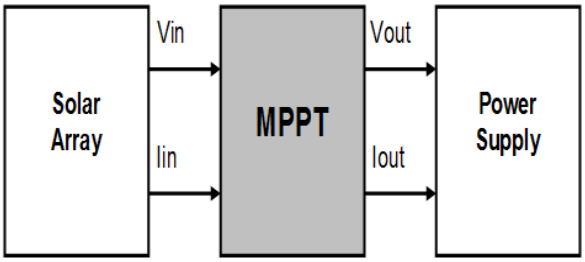

Fig. 3: Basic block diagram of MPPT

2. LITERATURE SURVEY

In recent years the attention towards utilization of renewable sources of energy has been increased drastically. Solar energy is one of the important renewable sources of energy since it is clean, pollution-free and inexhaustible. Though the initial installation cost is high the maintenance cost is considerably less. The output Power of Photovoltaic array always changes with weather conditions i.e., solar irradiation and atmospheric temperature. The energy that is being absorbed by photovoltaic cells is not being completely utilized because of irradiance effects. Hence Maximum power point tracking techniques (MPPT) are employed in photovoltaic systems to utilize the energy that is absorbed. These techniques vary in many aspects as a range of effectiveness, hardware, sensor required, and cost. This paper presents a comparative analysis of existing MPPT techniques and then an optimal controller is designed and implemented which has a better performance in achieving high efficiency [14]. Solar or photovoltaic (PV) system is an alternative clean energy resource that has received much attention in the research and industries. Solar charge controller (CC) is the heart of a solar system. Three common types of charge controller are ON/Off, pulse width modulation (PWM) and maximum power point tracking (MPPT). MPPT is getting very much popularity nowadays for its high capability of power extracted from the solar panel. This paper is presenting here an improved design of MPPT solar charge controller using Arduino [13]. This paper explains the development of a new algorithm for maximum power point tracking (MPPT) in large PV systems under partial shading conditions (PSC). The new algorithm combines the use of particle swarm optimization (PSO) for MPPT during the initial stages of tracking and then employs the traditional perturb and observe (PO) method at the final stages. The methodology has been first simulated in two different PV configurations under varying shading patterns and experimentally verified using a microcontroller-based experimental system. The integration of swarm intelligence with PO algorithm is shown to yield faster convergence to the global maximum power point (GMPP) than when the two methods are individually used [12]. This paper proposed an improved version of PSO. It actually modified the linear decreasing of weighing factor, cognitive and social parameter. The proposed control scheme can overcome the deficiency and accelerate the convergence of the IPSO-based MPPT algorithm. The approach is not only capable of tracking the maximum power point under uniform insulation state, but also able to find the maximum power point under fast-changing nonuniform insulation conditions [10].

3. PLANNING OF WORK/METHODOLOGY

3.1 Problem formulation

After analyzing various research papers a general conclusion is that every method possesses their own merits and demerits and all of them have a unique way of implementing. It is seen that P&O method is one of the simplest methods but it suffers from oscillation problem. To eliminate this drawback incremental conductance method comes into play through this method easily solves the problem of oscillation the cost and complexity of control make it hard to eliminate. Among all the soft computing

techniques PSO is found to be more simple and efficient but it also suffers from proper initialization of particle. Without proper initialization, this technique will take huge time for convergence of space analysis. In the base work, two control techniques are used to tracking maximum solar power in PV model the techniques are particle swarm optimization and perturb and observe (P&O**).** The motive of using this control technique to get maximum power from solar PV panel and these control technique help to get maximum power

3.2 Fuzzy Logic Controller

The fuzzy logic controller proposed is based on an initial knowledge of the system. It is used to modify and control the step of the reference voltage. A functional diagram of an FLC block can be structured by collaborating between four sections: Fuzzification, inference, Defuzzification, and rule base, as illustrated in Figure 4 where the modified values of the photovoltaic generator power ΔP_{PV} and those of the current ΔI_{PV} present the inputs and ΔV_{ref} presents the output that we will send to the P&O algorithm.

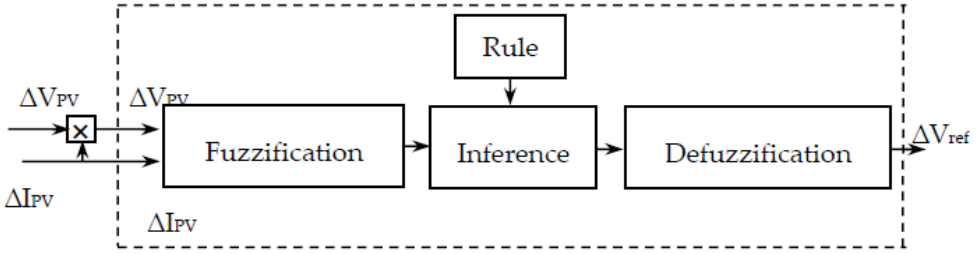

Fig. 4: Diagram of a Fuzzy logic Controller

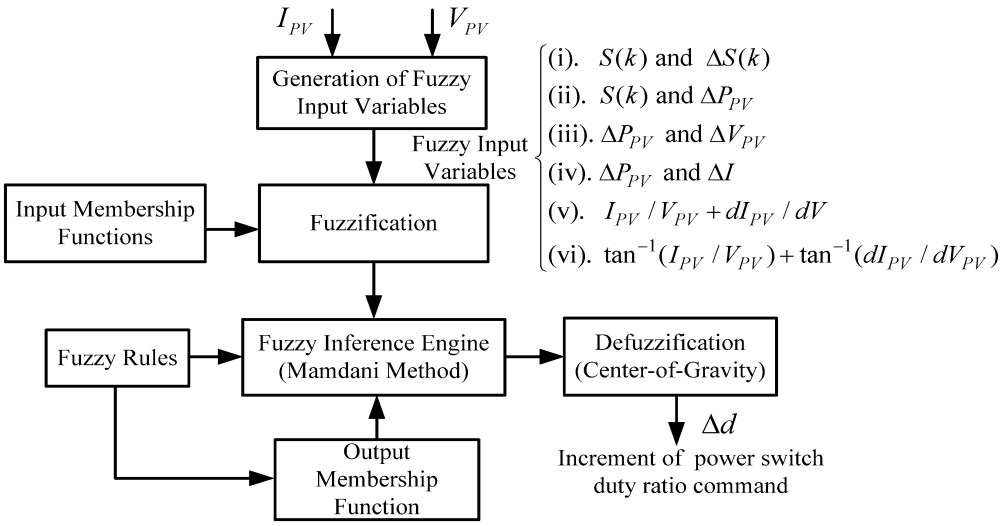

Fig. 5: Fuzzy logic flowcharts

In our dissertation work simulation model is designed in MATLAB 2016a version using Simulink library. Our model based on MPPT using the concept of Fuzzy Logic and PID controller to enhance the DC voltage. In simulation model PV array at temperature 25 degree Celsius and irradiance of 1000, switching circuits IGBT and boost converter also used to execute the desired result.

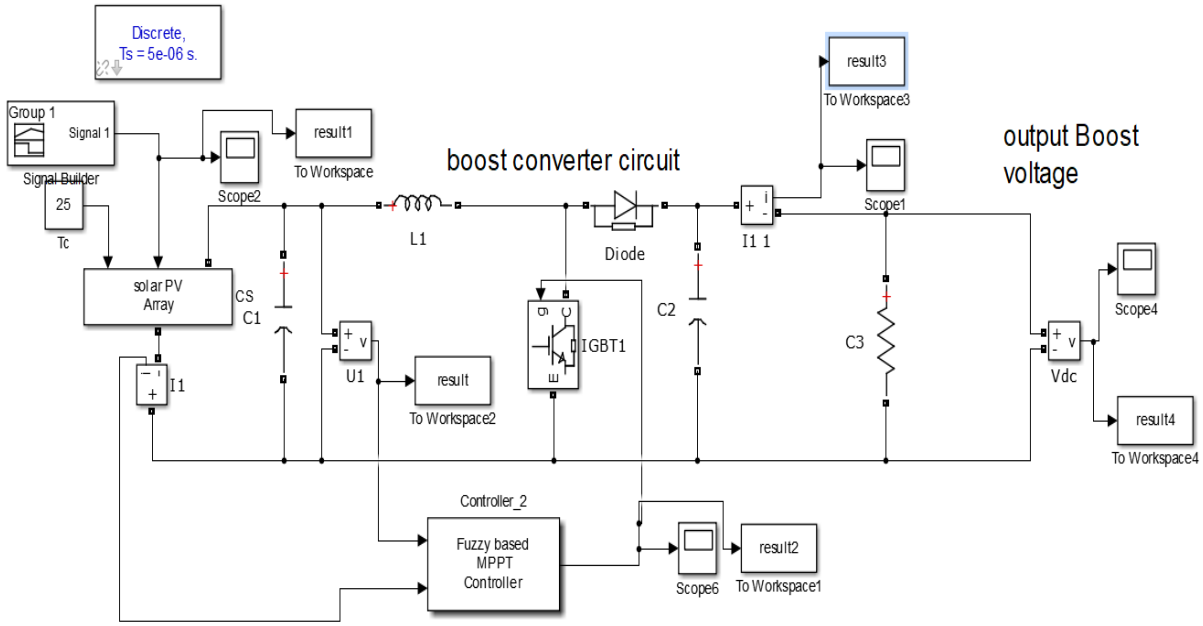

Fig. 6: Simulink model of research work

4. SOFTWARE USED AND SIMULATION RESULT

4.1 Software

Proposed scheme have developed in MATLAB 2015a tool. It is powerful software that provides an environment for numerical computation as well as a graphical display of outputs. In Matlab, the data input is in the ASCII format as well as binary format. It is a high-performance language for technical computing integrates computation, visualization, and programming in a simple way where problems and solutions are expressed in familiar mathematical notation.

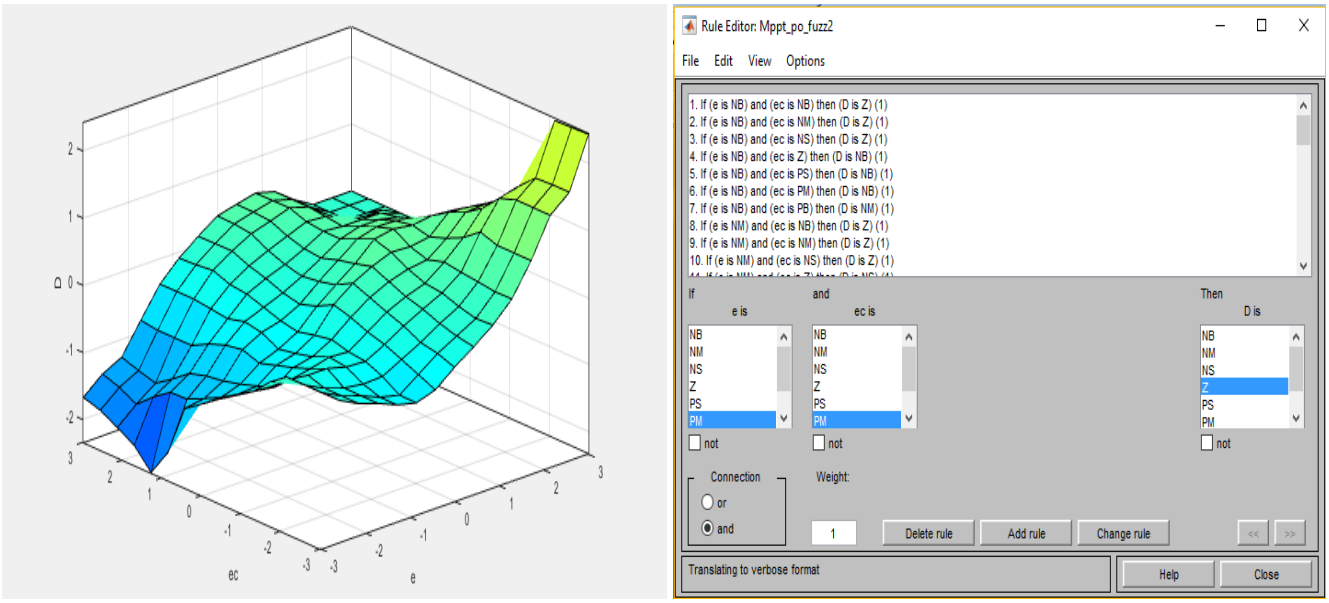

Fig. 7: Fuzzy IF-THEN rules representation in 3D view and MATLAB environment

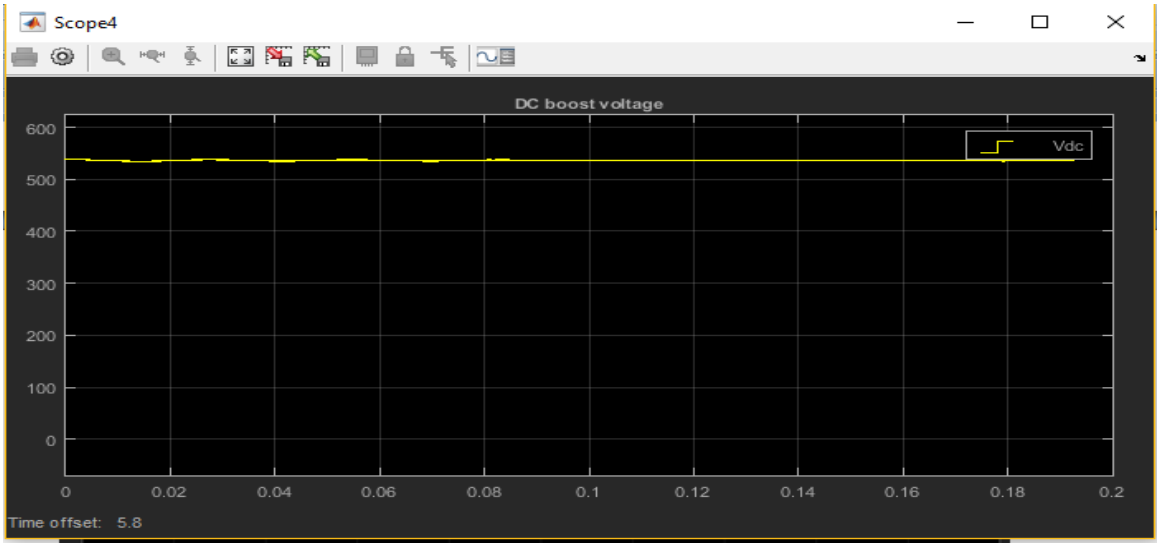

Fig. 8: Simulated DC Boost of PV array

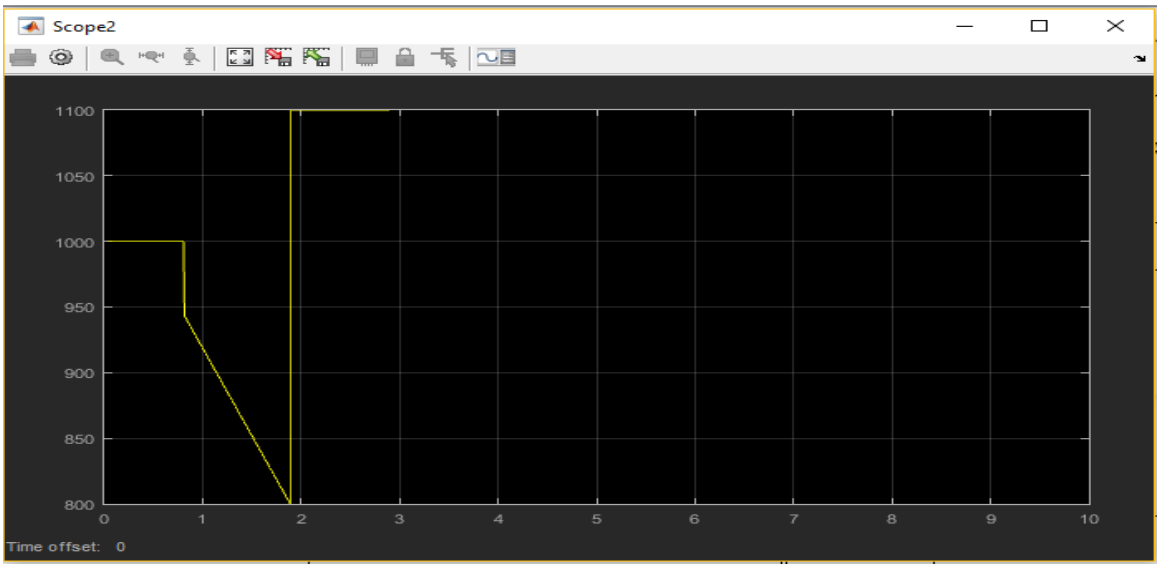

Fig. 9: Value of Irradiance with time [In India =1000]

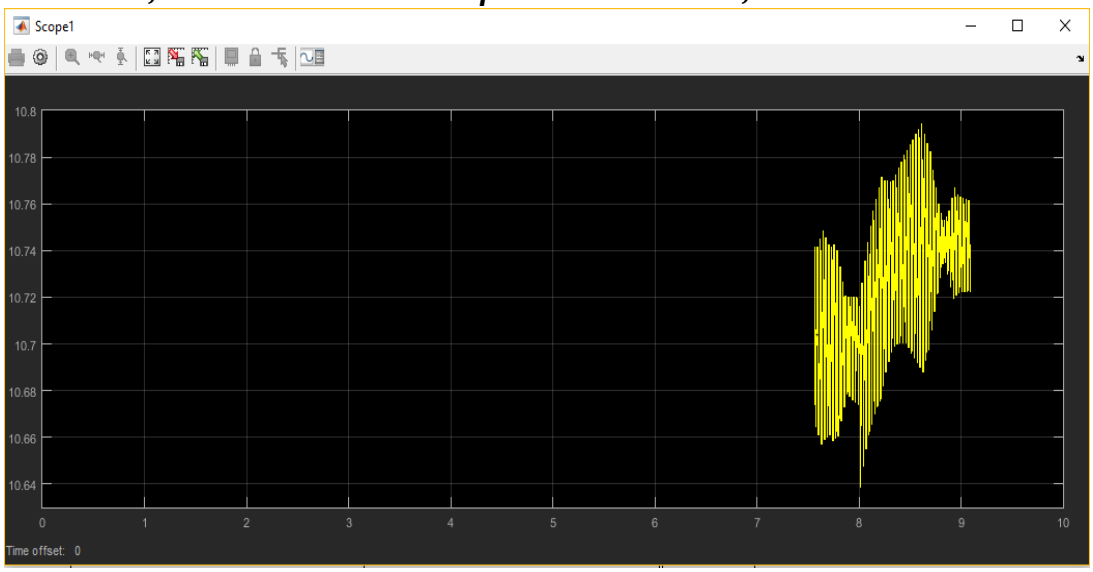

Fig. 10: Simulation graphs for current generated by PV array

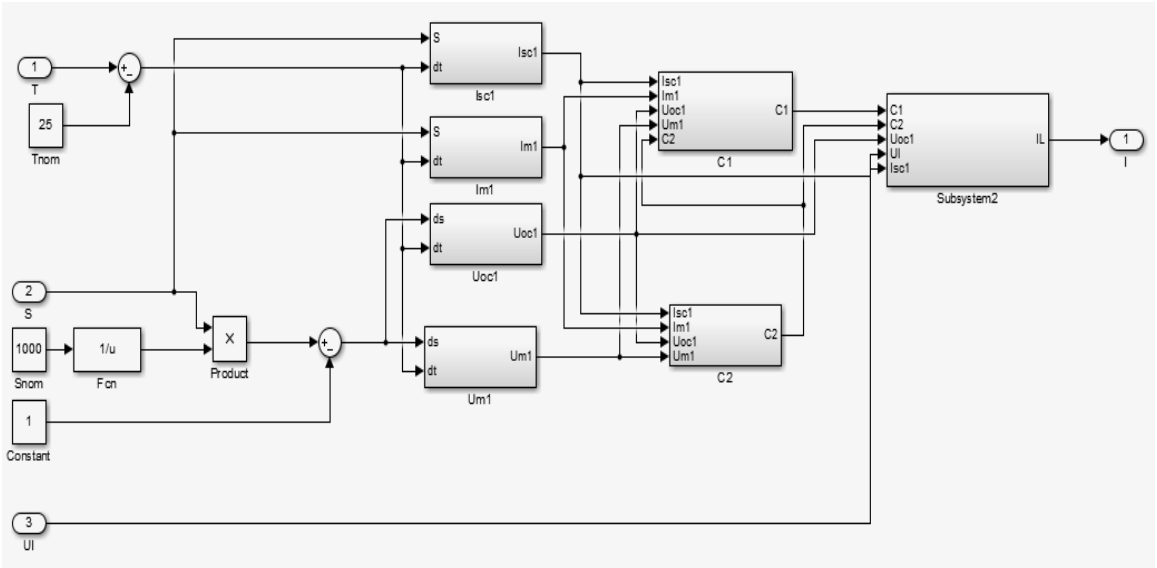

Fig. 11: Simulation system for generating normal dc voltage

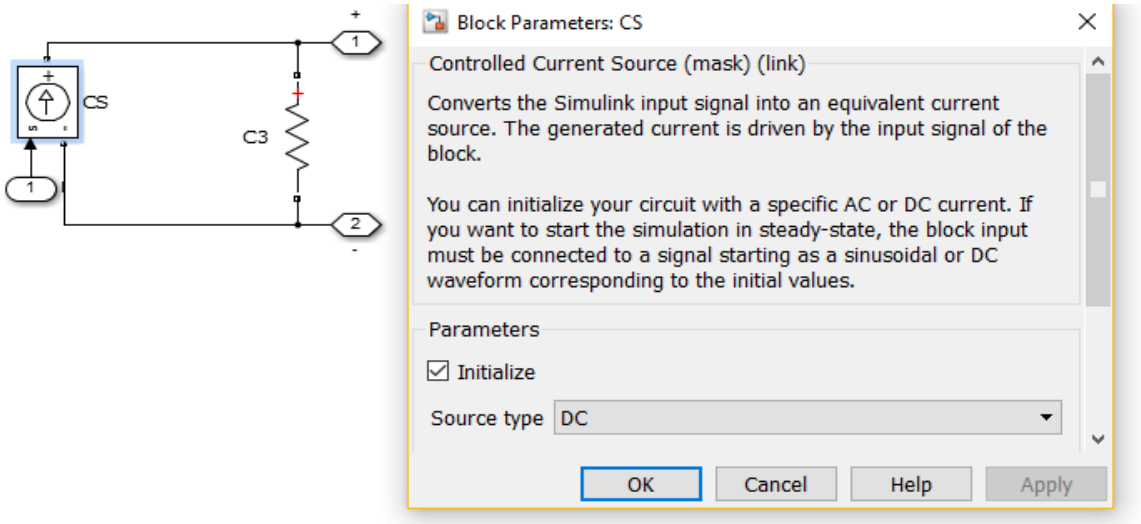

Fig. 12: Controlled current source circuit diagram for AC and DC current

5. CONCLUSION

In our dissertation work, hybrid technology is implemented for maximum power point tracking (MPPT) scheme for PV power generation system when the atmospheric condition is not suitable. In base work, there was a combination of two techniques that is PSO and P&O. When these techniques are implemented individually then result are not satisfactory but when combined result improved significantly. In our research work, the fuzzy logic concept is introduced with a PID controller and after executing an analysis between the base and proposed work, fuzzy and PID technique is much more efficient. The implemented technique has been executed and verified in MATLAB 2016a simulation environment under diverse condition. The future scope of this work

can be extended by using the following variation: Optimal sizing of a Hybrid System Based on Other Economic Parameters, Environmental Parameters and Prediction of Optimal Size through Advanced Techniques, Improved Model-Based MPPT, Centralized Monitoring and Control of a PV form through Wireless Networking, artificial intelligence, deep learning, and ANN and integrate these techniques with IoT.

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