A Power Management Scheme for PV based Microgrid using Particle swarm optimization

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Abstract:

Since the potential benefits are resulting from the use of renewable energy sources, Microgrid and Distributed Generation (DG) are becoming a significant research area. Microgrid can generally be composed of renewable microsources placed close to the load Centre. In order to have control over the real and reactive power of individual DG, Voltage-Frequency control, Power management strategy is required in microgrid. This project presents an investigation about the impact of integrating renewable energy based generation sources on the existing distribution system in terms of load sharing. This project presents genetic algorithm (GA) based maximum power point tracking (MPPT) for photovoltaic (PV) array integrated with battery storage unit (BSU) as power generation unit in standalone mode. PV generation depends on solar irradiance, site location and environmental factors like temperature. Thus output of PV output is fluctuating in nature and the addition of nonlinear load make the situation more critical. PSO based MPPT for PV generation works for local optimal solution. DC/DC and boost converter has been used to obtain rated desired rated voltage. And PI controller is used to maintain the DC-link voltage constant and close to its reference value under different conditions. Simulation results under different environmental and operating conditions are shown.

Introduction:

At present, most of energy demand in the world relies on fossil fuels such as petroleum, coal, and natural gas that are being exhausted very fast. One of the major severe problems of global warming is one of these fuels combustion products, carbon dioxide; these are resulting in great danger for life on our planet [1].

Among all the available Renewable energy sources, PV array systems are trusted to play a significant role in prospective energy production. PV systems transform photon energy into electrical energy. These energy systems generate low voltage output, thus, high step-up dc/dc converters are employed in many applications, including fuel cells, wind power, and photovoltaic systems, which converts low voltage into high voltage. Due to the increasing demand on electricity, and limited availability and high prices of non-renewable sources, the photovoltaic (PV) energy conversion system has becomes an alternative as it is freely available, pollution free, and has less operation al and low maintenance cost. Therefore, the utilization of PV energy systems has to be increased for standalone and as well as grid-connected modes of PV systems. Photovoltaic (PV) as a renewable energy resource naturally is not stable by location, time, season and weather and its installation cost is comparatively high. An important consideration in increasing the efficiency of PV systems is to operate the system near maximum power point (MPP)

so to obtain the approximately maximum power of PV array. For getting maximum possible energy produced by a solar system.

Also maximum power point tracking (MPPT) techniques are used for improving the performance of PV systems, a high efficiency power converter which is designed to extract maximum power from a PV panel is usually considered. Generally, there will be a unique point on the V -I curve, called the Maximum Power Point (MPP), at which the whole PV system serves with maximum efficiency and produces its maximum power output [l5-17]. The position of the MPP is unknown, but can be placed either by search algorithms or through calculation models. Maximum Power Point Tracking Techniques (MPPT) are used to maintain the PV array's operating point at the precise position where maximum power can be delivered [26-28]. Various MPPT algorithms have been considered in the literature; some of them are the Perturb and Observe (P&O) method [2-5], the Incremental Conductance (lC) method [2-6], the Artificial Neural Network method [7], the Fuzzy Logic method [8] etc .. The P&O and IC techniques, are the most widely used. In this paper, four MPPT algorithms are considered: P&O, Incremental Conductance (lC) method [2-6], Fuzzy Logic method [8], Particle Swarm Optimization method [l0].These methods are quite easily implemented and have been widely adopted for low cost applications. Other methods such as Sliding Mode [9], are not considered in this paper, because they are more complex and rarely used.
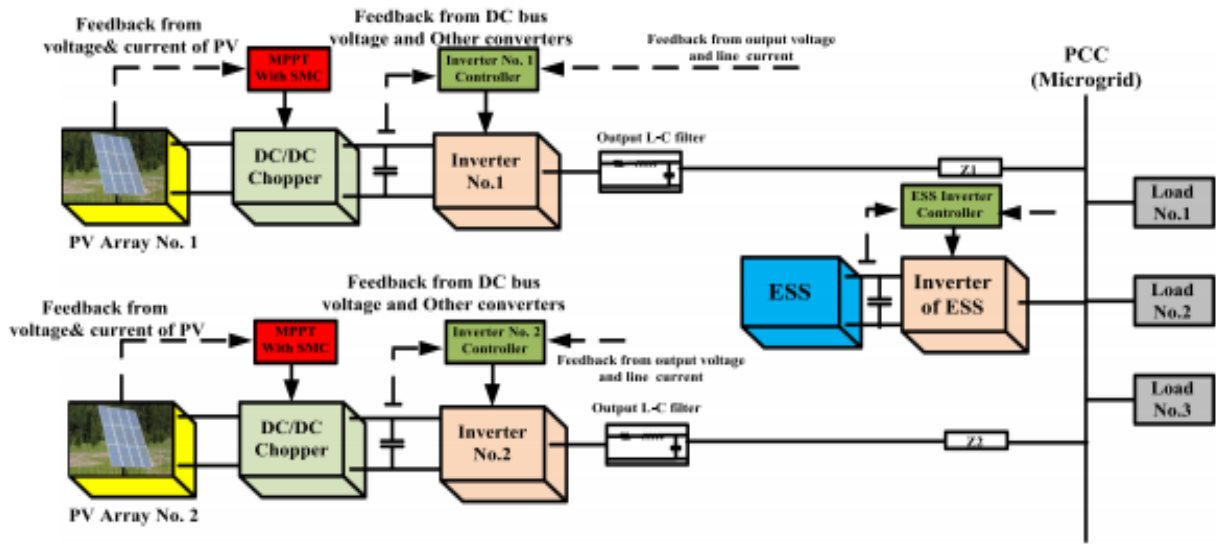

Figure 1: Configuration of proposed Parallel connected PV system

SOLAR SYSTEM:

In photovoltaic (PV) system, solar cell is the basic component. PV array is nothing but solar cells are connected in series or parallel for gaining required current, voltage and high power. Each Solar cell is similar to a diode with a p-n junction formed by semiconductor material [5]. It produces the currents when light absorbed at the junction, by the photovoltaic effect. Figure 3 shows at an insulation output power characteristic curves for the PV array. It can be seen that a maximum power point exists on each output power characteristic curve. The Figure 3 shows the (I-V) and (P-V) characteristics of the PV array at different solar intensities. The equivalent circuit of a

solar cell is the current source in parallel with a diode of a forward bias. Load is connected at the output terminals. The current equation of the solar cell is given by:

$$I = I_{ph} - I_D - I_{sh}$$

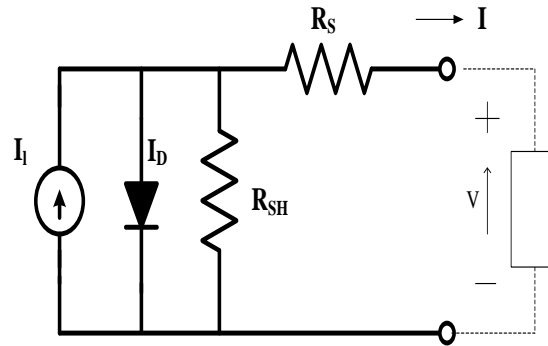$$I = I_{ph} - I_o [\exp (q \, V_D / nKT)] - (v_D / R_S)$$

Figure 2: Equivalent circuit of PV Module

MAXIMUM POWER POINT TRACKING METHOD:

The irradiance and temperature curves are the two most vital factors which influence the output power characteristics of the PV system. And these two are momentarily maintained by solar irradiation and temperature. As discussed, there will be blunt changes in the values of solar radiation during the day as shown in Fig. 1. A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the thevenin impedance of the circuit (source impedance) matches with the load impedance. In this way, Maximum power point tracking technique is necessarily used to improve the efficiency of the solar panel.

INCREMENTAL CONDUCTANCE METHOD:

This method consists in using the slope of the derivative of the current with respect to the voltage in order to reach the maximum power point [2].

What advantage does MPPT give in the real world that depends on the array, their climate, and their seasonal load pattern? It gives us an effective current boost only when the Vpp is more than about 1V higher than the battery voltage. In hot weather, this may not be the case unless the batteries are low in charge. In cold weather however, the Vpp can rise to 18V. If ther energy use is greatest in the winter (typical in most homes) and the have cold winter weather, then the can gain a substantial boost in energy when the need it the most.

Here is an example of MPPT action on a cold winter day:

Outside temperature: 20°F (-7°C) Wind is blowing a bit, so the PV cell temperature rises to only around 32°F (0°C). Vpp = 18V Batteries are a bit low, and loads are on, so battery voltage = 12.0
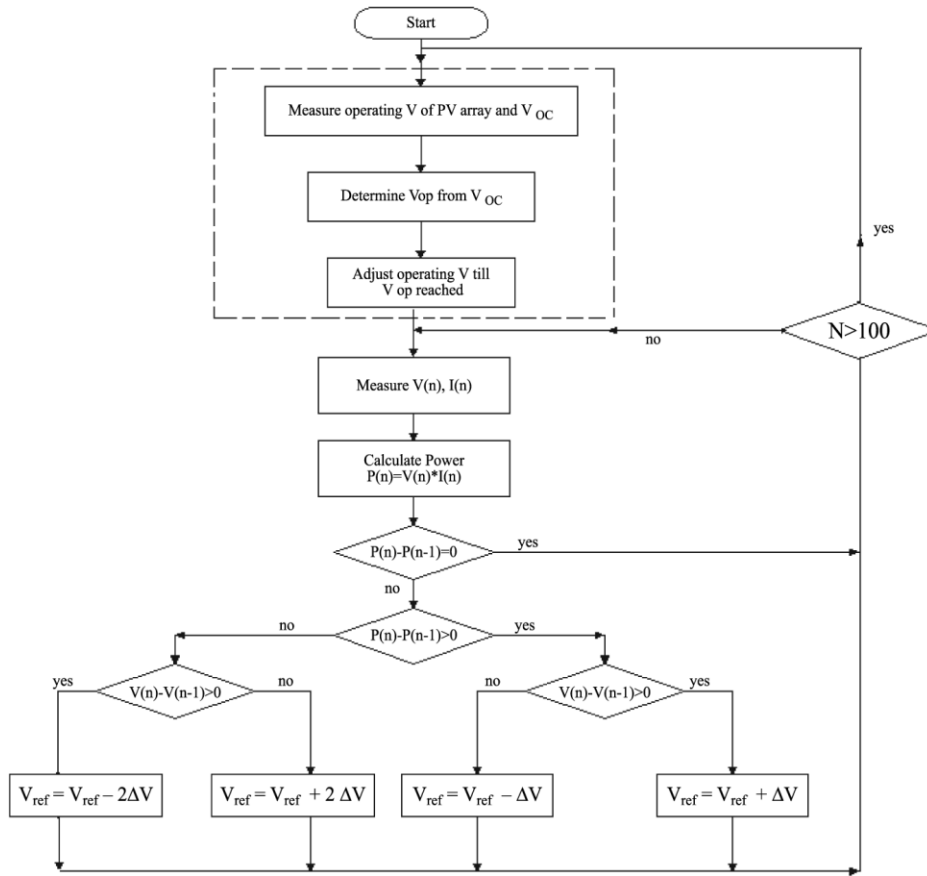
Ratio of Vpp to battery voltage is 18:12 = 1.5:1

Figure 3: Incremental Conductance Method Algorithm

Under these conditions, a theoretically perfect MPPT (with no voltage drop in the array circuit) would deliver a 50% increase in charge current. In reality, there are losses in the conversion just as there is friction in a car's transmission. Reports from the field indicate that increases of 20 to 30% are typically observed.

Analysis of PSO Technique:

The convergence criteria in the standard PSO algorithm aim to find the optimal solution or the success of the maximum number of iterations. However, in a PV system, the optimum point is not constant, as it depends on both weather conditions and load impedance. Therefore, the proposed PSO algorithm will reinitialize and search for the new MPP whenever the following conditions are satisfied:

$$\left| v(i+1) < \Delta v \right|$$
$$(pi(k+1) - pi(k) / pi(k) > \Delta p)$$

Where pi (k+1) is the new PV power,

pi (k) is the previous PV power at maximum point. From above equations, stand for the agent's convergence detection and abrupt alteration of insolation, correspondingly. There are two matters associated with ΔV choice: 1) lesser values lead to better MPPT firmness but a poor tracking reaction, and 2) superior values result in a faster tracking reaction at the cost of greater oscillations. Therefore, a balanced rate must be selected. Nevertheless, when

the ΔP is great, the subsequent constraint might not be fulfilled due to lesser variations in real power; therefore, the agents' rate of initialization is minor.
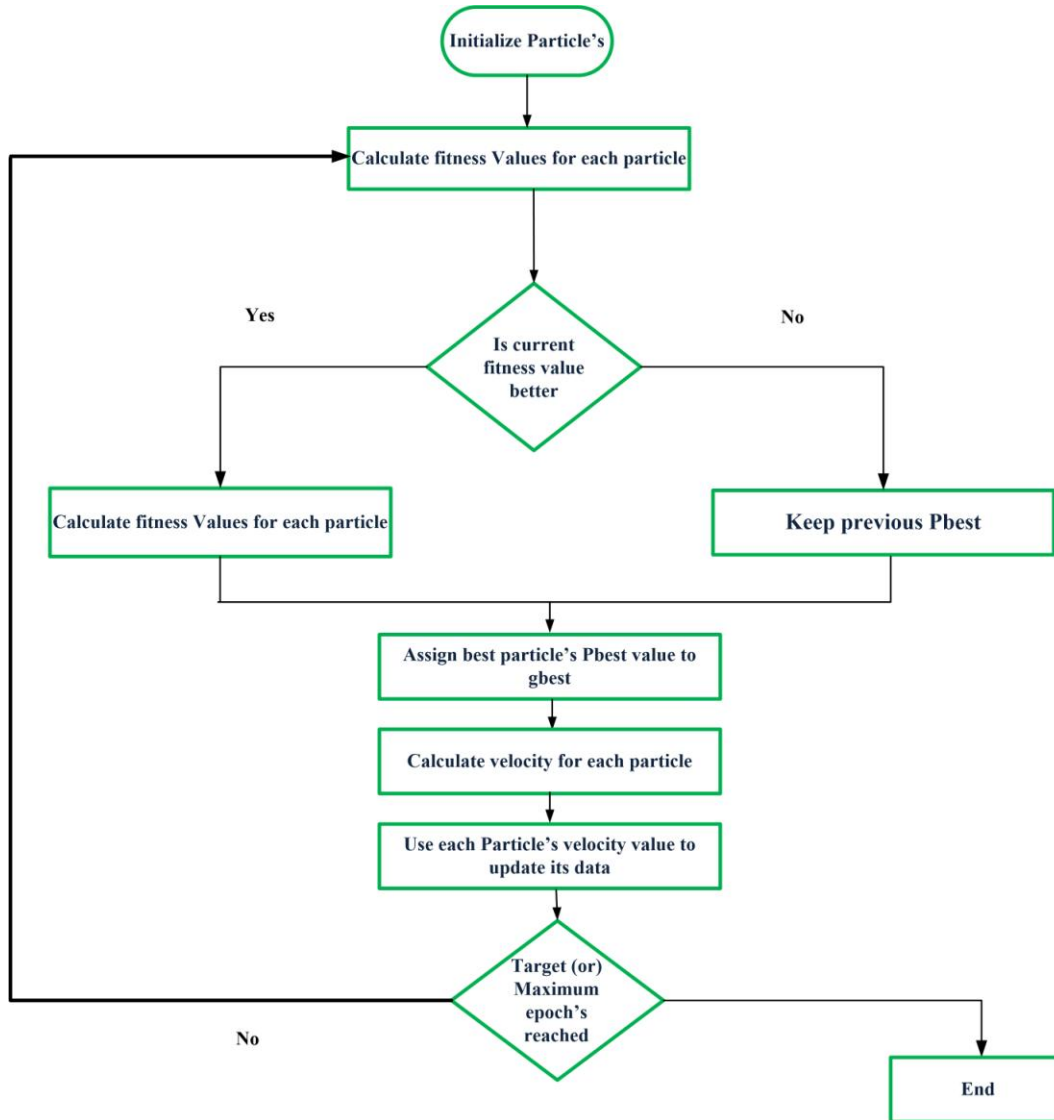

Fig.4. Algoritham for PSO Technique

Energy Management Strategies and Power Flow Management

Energy storage systems, which mostly consists of batteries and supercapacitors, have been widely used in grid-connected household nano-grid systems. Batteries, which is utilized to alleviate power fluctuation of grid-connected household nano-grid system in steady state, has the characteristic of large capacity and energy density, while supercapacitors which can manage the power fluctuation of nano-grid system in transient state, take advantage of large power density and fast response. Energy storage system that is instructed by EMS has the ability to smooth out the power fluctuations of distributed energy generation and residential load to prevent the power fluctuation on the tie-line.

Figure 6 shows how the PV voltage reference obtained. If the MPPT algorithm is off, then the PV-curtail algorithm will provide the PV voltage reference, and vice versa. Equation define the PV power (PPV) when the MPPT algorithm is used, while Equation define the (PPV) when the PV-curtail algorithm is used. The PV voltage at the maximum power point (VPV,mpp), PV current at the maximum power point (IPV,mpp), PV voltage during the curtail operation (VPV,curtail), and PV current during the curtail operation (IPV,curtail) are obtained from the power flow management process.
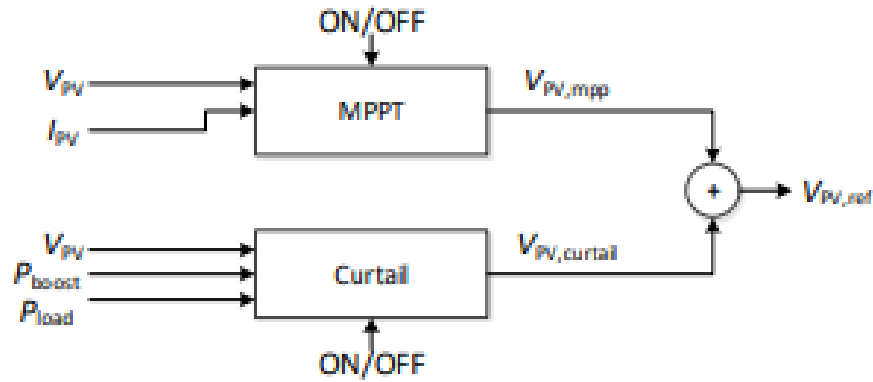

Figure 5: Control Structure for PMS System

RESULTS AND DISCUSSION:

The complete parallel connected PV system is implemented in matlab using the structure given in figure 1. The PV system consists of PV module in series mode and boost converter.
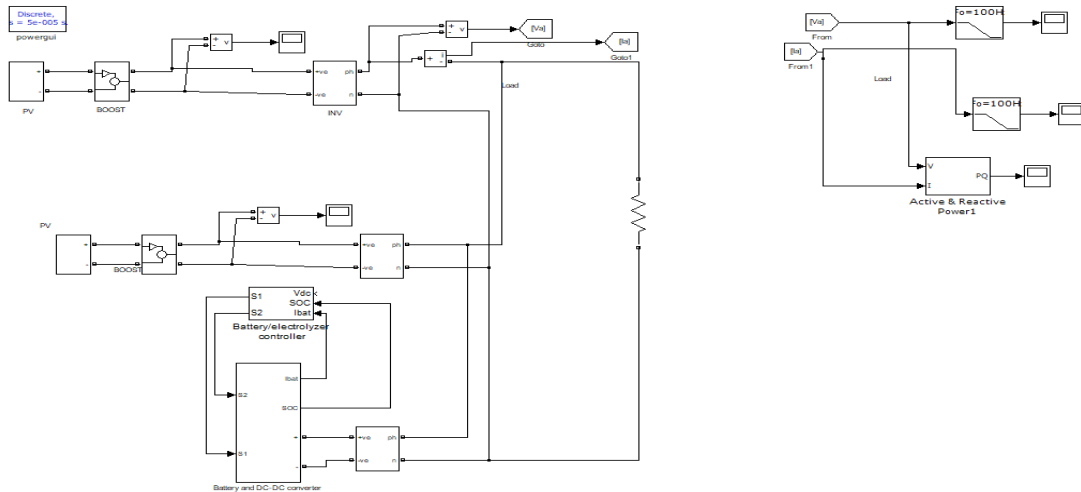

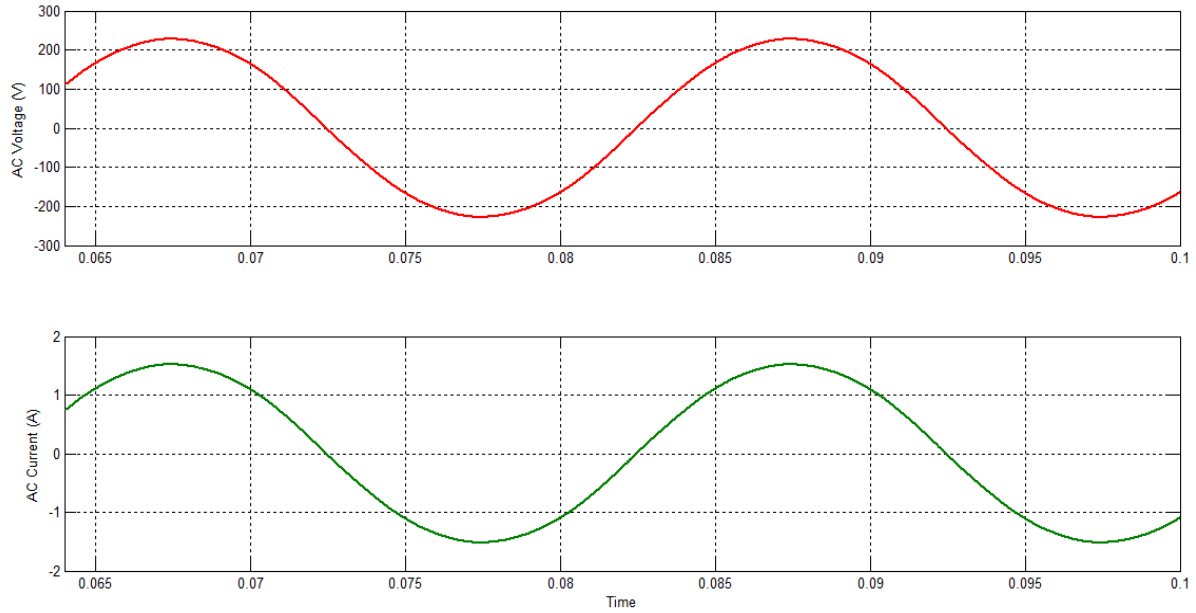Figure 6: Simulation Diagram for Proposed Parallel Connected PV Systems

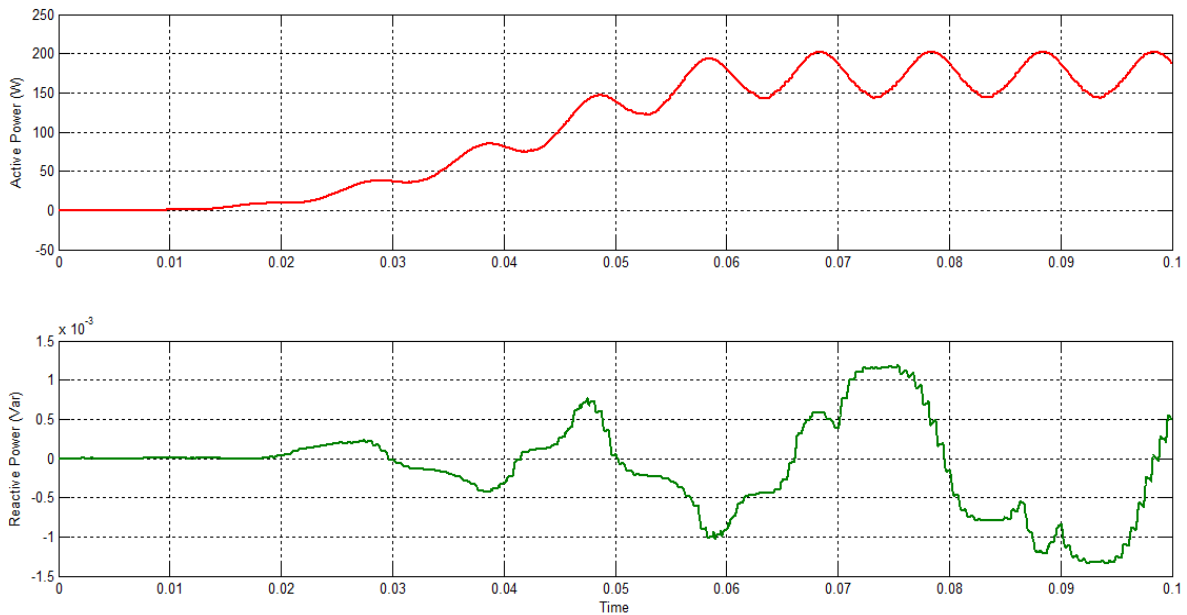Figure 7: Simulation Result for AC Voltage and Current

Figure 8: Simulation Result for Grid Active & Reactive Power

CONCLUSION

This review article provides a c1assification of available MPPT techniques based on the number of control variables involved. It also gives an idea about grid-tied or standalone mode of operations and types of preferable converters for each MPPT technique. This review has included many recent hybrid MPPT techniques along with their benefits. This review is expected to be a useful tool for not only the MPPT users but also the designers and

commercial manufacturers of PV systems. From this study we observe that both INC and PSO were developed based on the extreme value theory. Ideally, they can track the maximum power point accurately based on the maximum value condition. However, both rely on the numerical approximation of differentiation, of which the stability and accuracy is difficult to be guaranteed in practical applications considering noise and quantization error etc. The continuous oscillation around the optimal operating point is an intrinsic problem of the algorithms.

The effectiveness of isolated power systems are evaluated in MATLAB PC environment. The system considered is photovoltaic panels to meet the load which is highly advantageous for remote and inaccessible loads. It is observed that the proposed configuration is low cost and having less complexity. The gird is utilized to supply to the unmet power demand by the isolated power systems if they are connected to the gird. On the whole, the performance of isolated system is better and economically beneficial to the customers at large and is very effective for rural areas to meet remote loads.

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