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A Power Management Strategy for Photovoltaic-Based Microgrids Employing PSO

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ABSTRACT

Microgrids and distributed generation (DG) are becoming key areas of research due to the potential benefits that are occurring from the usage of renewable energy sources. In most cases, a microgrid will consist of renewable microsources that are located in close proximity to the load Center. In a microgrid, having a Voltage-Frequency control and Power management plan in place is essential in order to have control over the actual and reactive power of each individual DG. This study examines the load-sharing effects of integrating renewable energy sources into the present distribution system. This study presents genetic algorithm (GA) based MPPT for photovoltaic (PV) array connected with BESS in standalone mode. Maximum power point tracking (MPPT) Sun photovoltaic (PV) production depends on solar irradiance and temperature.Therefore, the output of PV is prone to fluctuations due to the nature of the technology, and the inclusion of nonlinear demand makes the situation even more precarious. PSO-based MPPT, which is used for PV generation, is effective for finding the local optimal solution. In order to get the needed rated voltage, a DC/DC converter as well as a boost converter were utilised. A PI controller is utilised in order to keep the DC-link voltage stable and within a close proximity to its reference value regardless of the environmental circumstances. The results of the simulation under a variety of operational and environmental circumstances are shown below.

1. INTRODUCTION

Most of the world's energy needs is met by fossil fuels like oil, coal, and natural gas, which are depleting quickly. Burning these fuels releases carbon dioxide, which threatens life on Earth [1]. This is a major global warming problem.

It is expected that photovoltaic (PV) array systems will play a significant role in the production of energy in the future. Photovoltaic (PV) systems generate power from sunlight. In order to convert a low voltage to a high voltage, high step-up dc/dc converters are used in fuel cells, wind generation, and solar systems. They convert DC current into AC current. Photovoltaic (PV) energy conversion has emerged as a viable alternative due to the increasing demand for electricity and the limited availability and high prices of non-renewable sources because it does not produce pollution, is easily accessible, requires fewer resources to operate, and has a low overall cost of ownership and maintenance. Growth is needed in both standalone and grid-connected photovoltaic (PV) energy systems. Photovoltaic (PV) energy is costly to install and is very variable in terms of location, time of year, and weather.. Operate the system at its MPP to get the most electricity from the PV array.

This improves PV system efficiency. To maximise solar energy output.

When improving PV system performance, a high-efficiency power converter that extracts the most power from a PV panel is commonly considered. MPPT methods are also used. In most circumstances, the V-I curve has a Maximum Electricity Point (MPP). This is where the PV system is most efficient and produces the greatest electricity [5-17]. You may find the MPP utilising search engines or calculation models. Highest Power Point Tracking Techniques (MPPT) retain the PV array's operating point where it can generate the most power [26-28]. MPPT algorithm research has considered numerous techniques. P&O, lC, ANN, Fuzzy Logic, etc. P&O and IC are common. This study compares four MPPT algorithms: P&O, lC, fuzzy logic, and PSO. These low-cost methods are straightforward to adopt. Other techniques, like Sliding Mode [9], are more complex and infrequent.

This study offers a simulation model to construct and scale a hybrid system for different loads and conditions. Simulations using Matlab and SimPower Systems illustrate the system's efficiency. Figure 1 depicts the hybrid grid-connected system.

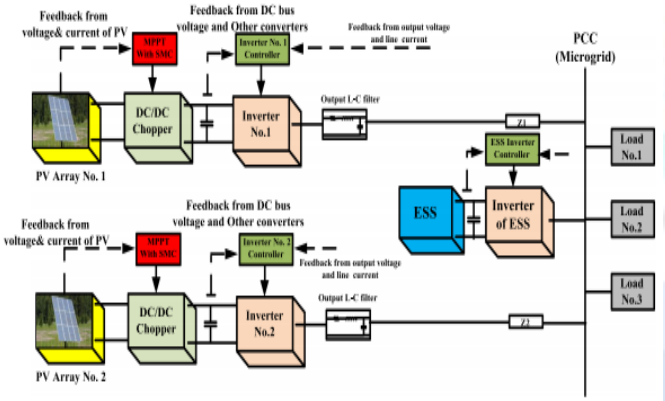

Figure 1: Configuration of proposed Parallel connected PV system

2. SOLAR SYSTEM:

The solar cell is the fundamental unit of a photovoltaic (PV) system. To generate the necessary current, voltage, and high power, solar cells in a PV array are linked in series or parallel. Each solar cell may be thought of as an analogous diode with a p-n junction made of semiconductor material [5]. The photovoltaic effect is responsible for the current production when light is incident on the junction. The PV array's output power characteristic curves at an insulation level are shown in Figure 3. It is clear that any characteristic curve for output power reaches its maximum value somewhere. As can be seen in Figure 3, the (I-V) and (P-V) properties of the PV array change as the solar intensity does. A forward-biased diode is connected in parallel with the current source to form the solar cell's equivalent circuit. The terminals at the outputs have loads connected to them. The solar cell's governing equation at the moment is as follows:

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

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

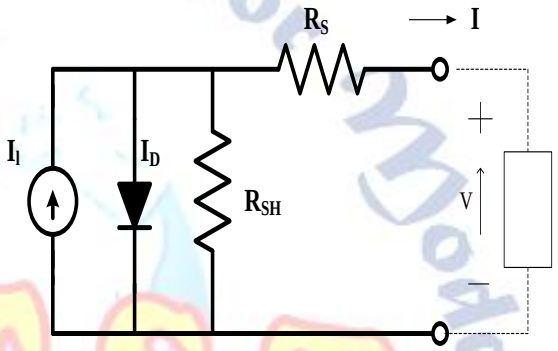

Figure 2: Equivalent circuit of PV Module

Power output of solar cell is P = V * I

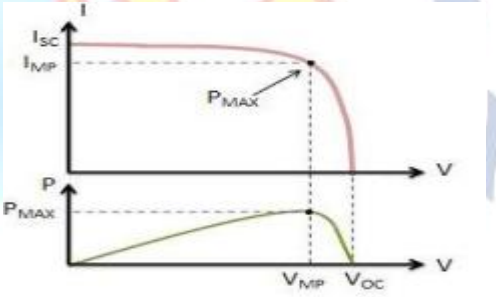

Figure 3: Output characteristics of PV Array

3. MAXIMUM POWER POINT TRACKING METHOD:

When it comes to the output power characteristics of a PV system, the irradiance and temperature curves play the most important roles. In addition, solar radiation and temperature hold these two constant for a short time. The levels of solar radiation, as illustrated in Fig. 1, will fluctuate dramatically during the day, as was previously mentioned. Only around 30% to 40% of the solar irradiance that hits a typical solar panel is converted into usable electricity. The Maximum Power Transfer theorem states that a circuit's power output is maximised whenever the source impedance (thevenin impedance) of the circuit is equal to the load impedance. Consequently, the Maximum power point tracking

approach must be used to raise the solar panel's overall efficiency.

INCREMENTAL CONDUCTANCE METHOD:

Maximal power point is attained by following the slope of the current derivative with respect to voltage [2]. Considering the array's location, weather, and seasonal load pattern, what practical benefit does MPPT provide? Only when the Vpp is more than about 1V higher than the battery voltage do we see a noticeable increase in current. Unless the batteries are very low in capacity, this may not be the case in warm weather. However, the Vpp may go to 18V in the cold. When the temperature drops, heating costs rise, and vice versa, most households' energy use peaks in the winter. If this is the case, then a significant energy boost may be achieved just when it is most needed. An application of MPPT on a wintry day:

The current ambient temperature is 20 degrees Fahrenheit (-7 degrees Celsius). The wind is blowing, so the maximum temperature of the PV cells is only around 32 degrees Fahrenheit, or 0 degrees Celsius. Vpp = 18V Due to limited battery life and active loads, the current battery voltage is 12.0.

The battery voltage is 18 volts, whereas the power supply voltage is 12 volts, for a ratio of 1.5 to 1.

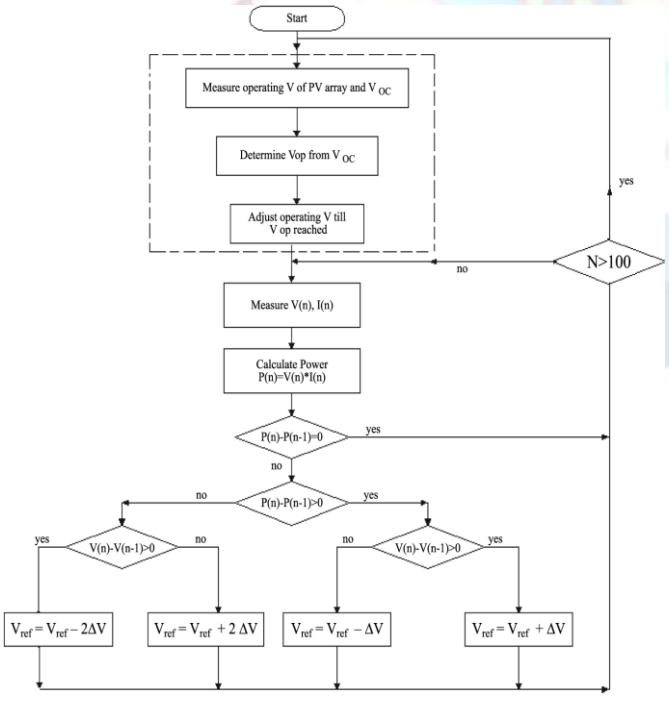

Figure 4: Incremental Conductance Method Algorithm

A perfect MPPT (no voltage drop in the array circuit) would increase charge current by 50% under these conditions. Conversion losses are similar to transmission friction. Field reports show 20-30% increases.

Analysis of PSO Technique:

The typical PSO algorithm's convergence criterion is to maximise the number of successful iterations toward an optimum solution. In a PV system, however, the sweet spot moves around depending on factors like the weather and the load's resistance. Therefore, when the following conditions are met, the proposed PSO algorithm will re-initialize and begin searching for a new MPP.

$$\left| v(i+1) < \Delta v \right|$$

$$(pi(k+1) - pi(k) / pi(k) > \Delta p)$$

The new PV power is denoted by pi (k+1), whereas the old maximum power was denoted by pi (k). As can be seen in the aforementioned equations, and represent the agent's ability to detect convergence and a sudden change in insolation, respectively. Concerning the V option, there are two elements to consider:

There are two main outcomes: 1) lower values improve MPPT stiffness but slow tracking response, and 2) higher values improve tracking reaction speed but increase oscillations. Therefore, a rate that strikes a happy medium must be chosen. However, when P is large, the following constraint may not be satisfied due to smaller changes in real power; hence, the agents' rate of initialization is low.

Figure 5 shows the whole process flow for the suggested technique, and the following concepts form the basis of the proposed algorithm:

Initial Step: Setting the Parameters The fitness value assessment function for the proposed MPPT algorithm is the power output from the PV modules, and the particle location is the computed duty cycle of the converter.

Activating the PSO, the second step: Particles in PSO are typically initialised at random in the conventional initialization. The particles in the proposed MPPT method are first seeded at predetermined, equally spaced coordinates around the GP.

Measurement of Physical Capacity, Step 3: Particle i's fitness is measured when the digital controller issues a PWM command based on the particle's duty cycle, which doubles as a representation of i's location.

Step 4: Find Your Personal Best and World Record Fitness: Particle values are re-evaluated in terms of their global and local best fitness (Pbest and gbest, respectively). If required, they are then replaced with other people in the same roles.

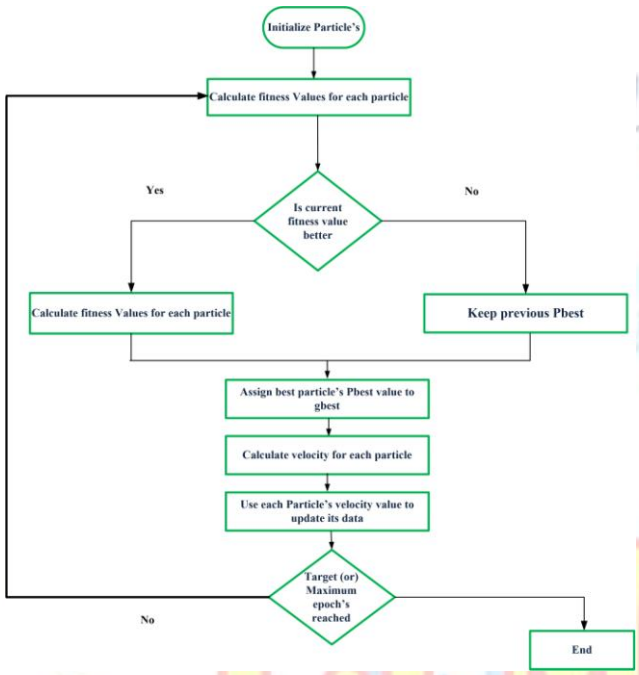

Fig.5. Algoritham for PSO Technique

4. ENERGY MANAGEMENT STRATEGIES AND POWER FLOW MANAGEMENT

Batteries and supercapacitors are employed in grid-connected residential nano-grids. Batteries used to handle power fluctuations of grid-connected residential nano-grid systems in steady state have big capacity and energy density, whereas supercapacitors have huge power density and quick reaction. EMS-directed energy storage may smooth out distributed energy production and home load power variations to avoid tie-line power oscillations.

Figure 6 depicts the PV voltage reference. If MPPT is off, PV-curtail provides the PV voltage reference, and vice versa. The MPPT method defines PV power (PPV), whereas the PV-curtail algorithm defines (PPV). The power flow management method determines the PV voltage at the maximum power point (VPV,mpp), PV current at the maximum power point (IPV,mpp), and PV voltage and current during curtailment.

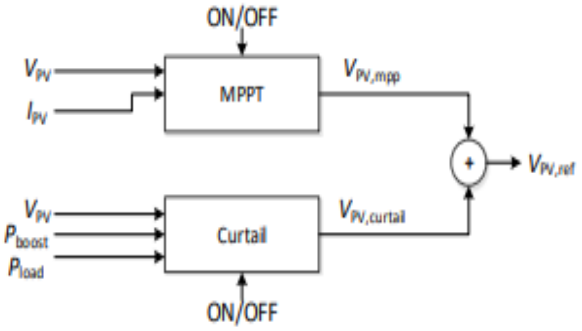

Figure 6: Control Structure for PMS System

5. RESULTS AND DISCUSSION:

Figure 1 shows the whole parallel PV system in matlab. PV system has series-connected modules and a boost converter.

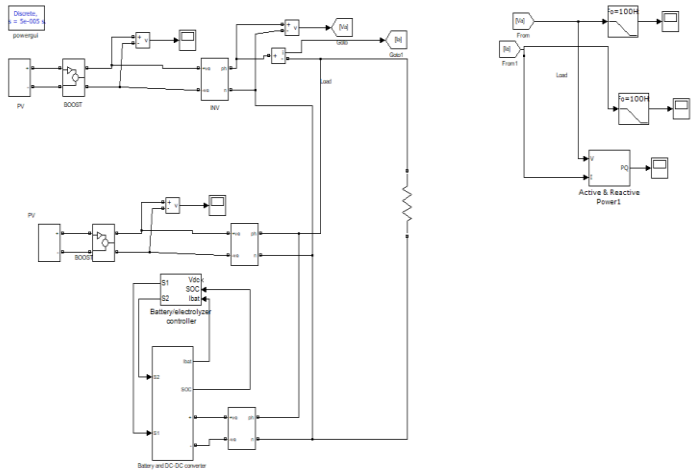

Figure 7: Simulation Diagram for Proposed Parallel Connected PV Systems

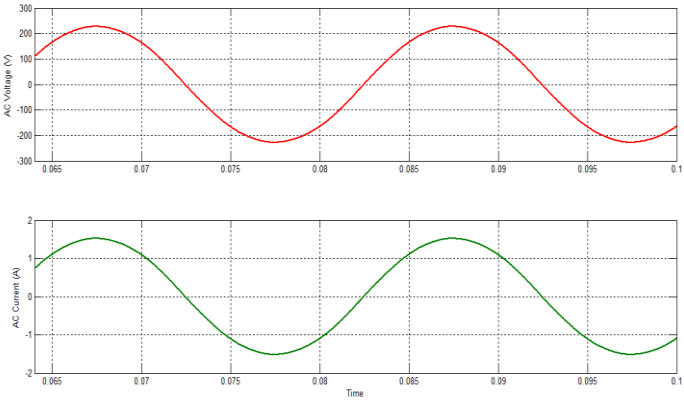

Figure 8: Simulation Result for AC Voltage and Current

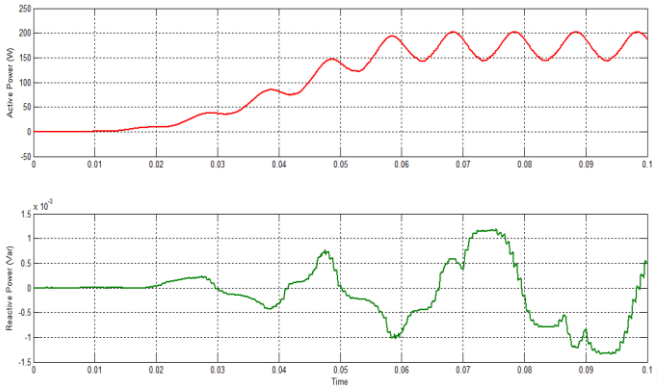

Figure 9: Simulation Result for Grid Active & Reactive Power

6. CONCLUSION

This review article gives a c1assification of existing MPPT approaches depending on the amount of control variables involved. For each MPPT method, it specifies the converter type and whether the method should operate in grid-tied or standalone mode. Some of the most current hybrid MPPT approaches and their advantages have been discussed in this article. MPPT consumers, as well as PV system designers and commercial manufacturers, might find this review to be a helpful resource. This research reveals that the foundations of both INC and PSO are in the extreme value theory. They should be able to precisely monitor the maximum power point if the criteria for maximum value is met. Both methods, however, are dependent on numerical approximations of differentiation, the stability and accuracy of which might be hard to ensure in real-world applications due to noise and quantization error and the like. A fundamental issue with algorithms is that they tend to repeatedly cycle about the optimum operating point.

Isolated power systems are tested and analysed in a MATLAB PC environment. To satisfy the load, solar panels are being examined, which has several benefits for loads that are hard to reach. The recommended arrangement is found to be simple and inexpensive. If disconnected power systems are linked to the gird, the gird may be used to meet their increased power needs. Overall, the isolated system performs better, is more cost-effective for rural regions to satisfy distant loads, and is more popular with consumers.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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