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A Power Management Strategy for Photovoltaic-Based Microgrids Employing PSO

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ABSTRACT

Research into Microgrids and Distributed Generation (DG) is gaining traction as a consequence of the advantages that might accrue from using renewable energy sources. Renewable microsources located near to the load centre form the basis of a typical microgrid. The actual and reactive power of each DG must be managed in a microgrid, and this can only be done with a combination of Voltage-Frequency control and a Power management technique. This project includes research on the effect of adding renewable energy based generating sources to the current distribution network on load sharing. This study introduces maximum power point tracking (MPPT) using a genetic algorithm (GA) for a photovoltaic (PV) array that incorporates a battery storage unit (BSU) as an independent power producing unit. PV production is affected by solar irradiation, site location, and ambient conditions including temperature. For this reason, PV production is inherently erratic, and the addition of nonlinear load just exacerbates the problem. In summary, PSO-based MPPT for PV generating is effective for local optimum solution. To get the required rated voltage, a DC/DC and boost converter were employed. As a result, the DC-link voltage is kept relatively stable and near to the setpoint using a PI controller. The outcomes of simulations conducted under various operational and environmental parameters are shown.

1. INTRODUCTION

As large conventional power plants become economically unfeasible owing to rising operating and fuel costs and stringent environmental regulation [1], interest in distributed generations (DGs) has increased.

There are several benefits to using DGs, including decreasing peak demand, decreasing emissions, and enhancing dependability and power quality with the right kinds of controls [2].

To a greater extent than any other renewable energy source now in use, PV array systems are expected to contribute to future electricity generation. In order to generate electricity, PV systems convert the energy contained in light particles. Fuel cells, wind generation, and solar systems all provide low voltage output and need large step-up dc/dc converters to meet their various application requirements. Due to rising power demands and the scarcity and high cost of traditional energy sources, renewable alternatives like the photovoltaic (PV) energy conversion system are becoming more and more attractive. PV systems, both those operating independently and those linked to the power grid, need to have their use boosted accordingly. As a renewable energy source, photovoltaic (PV) is inherently unstable due to factors such as location, time, season, and weather, and it also has a relatively high installation cost. Operating the system at maximum power point (MPP) to acquire around maximum power of PV array is an essential aspect for improving the efficiency of PV systems. In order to get the greatest amount of energy from a solar array.

In addition to high efficiency power converters that are made to extract the most possible power from a PV panel, maximum power point tracking (MPPT) methods are also utilised to boost the efficiency of PV systems. The Maximum Electricity Point (MPP) is the point on the V-I curve where the PV system as a whole operates most efficiently and generates the most power [l5-17]. The MPP's location is a mystery, but it can be determined using either search techniques or computational models. MPPT is utilised to keep the PV array running at its optimum power output point [26–28]. Perturb and Observe (P&O) [2–5], Incremental Conductance (lC) [2–6], Artificial Neural Network (ANN) [7], Fuzzy Logic (FL) [8], etc. are only few of the MPPT algorithms that have been examined in the literature. Standard practises include P&O and IC. In this study, four MPPT algorithms—P&O, the Incremental Conductance (lC) technique [2-6], the Fuzzy Logic method [8], and the Particle Swarm Optimization method [l0]—are examined. These strategies are simple to deploy and have had extensive uptake for low-cost applications because of this. Sliding Mode [9] and other similar techniques are beyond the scope of this work due to their complexity and lack of practical application.

In order to build and scale the hybrid system appropriately for different loads and weather situations, this work focuses on constructing a simulation model. Matlab and SimPower Systems are used to run a simulation model, and the resulting data is used to prove that the proposed system works as intended. Figure 1 depicts the planned hybrid energy generating system that is linked to the grid.

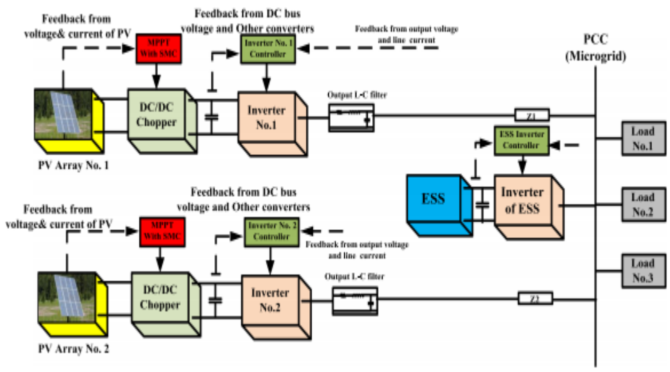

Figure 1: Configuration of proposed Parallel connected PV system

2. SOLAR SYSTEM:

To put it simply, solar cells are the workhorse of every photovoltaic (PV) system. A photovoltaic array (PV array) is simply a collection of solar cells that have been linked in series or parallel to generate high current, voltage, and power. Similar to a diode, each solar cell has a p-n junction made from semiconductor material [5]. The photovoltaic effect is responsible for the production of currents when light is incident upon the junction. The PV array's characteristic curves for power production at an insulation level are shown in Figure 3. Each output power characteristic curve displays a maximum power point. The (I-V) and (P-V) properties of the PV array at varying solar intensities are shown in Figure 3. A solar cell's equivalent circuit consists of a forward-biased diode connected in series with the cell's current source. The terminals at the end of the output are where the load is attached. The solar cell's governing equation at the moment is:

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

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

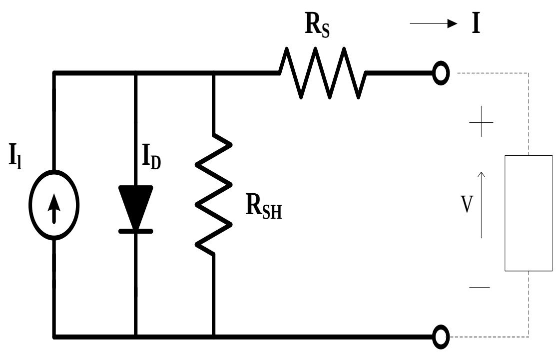

Figure 2: Equivalent circuit of PV Module

Power output of solar cell is $P = V * I$

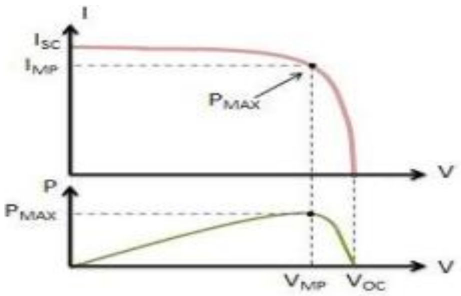

Figure 3: Output characteristics of PV Array

MAXIMUM POWER POINT TRACKING METHOD:

Critical elements that affect the output power characteristics of a PV system are the irradiance and temperature curves. This duo is temporarily supported by the sun's heat and light. Sharp shifts in solar radiation levels are expected throughout the day, as stated and shown in Fig. 1. 30–40% of the solar irradiance that hits a typical solar panel is converted into usable electricity. The thevenin impedance of a circuit (the source impedance) must coincide with the thevenin impedance of the load in order for the Maximum Power Transfer theorem to hold. Therefore, it is necessary to apply the Maximum power point tracking approach to increase solar panel efficiency.

INCREMENTAL CONDUCTANCE METHOD:

Reaching the highest power point using this technique involves utilising 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? When the Vpp is more than around 1V over the battery voltage, we get a useful current increase. This may not be the case in warm temperatures if the batteries aren't fully charged. In contrast, the Vpp may increase to 18V in very cold conditions. Most households experience peak energy use during the winter, so if you live somewhere with frigid winters, you may be able to take advantage of this phenomenon to your advantage. An application of MPPT on a wintry day:

The current ambient temperature is 20 degrees Fahrenheit (-7 degrees Celsius). Because of the little breeze, the maximum temperature at which PV cells operate is only around 32 degrees Fahrenheit, or 0 degrees Celsius. Vpp = 18V There are some loads running, thus the battery voltage is at 12.0

The battery voltage (18.12V) is 1.5 times higher than the power supply voltage (Vpp) (1.

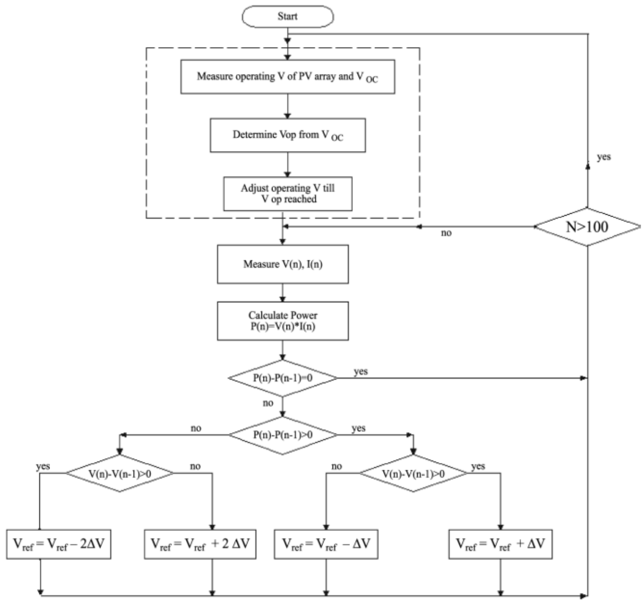

Figure 4: Incremental Conductance Method Algorithm

A flawless MPPT (one with no voltage drop in the array circuit) would potentially double the charge current under these circumstances. It's a fact that, similar to the losses caused by friction in a car's gearbox, there are some in the conversion process. According to field reports, rises of 20-30% are common.

3. ANALYSIS OF PSO TECHNIQUE:

The typical PSO algorithm's convergence criterion looks for the best solution or the success of the largest number of repetitions. In a PV system, however, the sweet spot moves about depending on factors like the ambient temperature and the resistance of the load. To find a solution, the proposed PSO algorithm will reset and look for a new MPP whenever the following are true:

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

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

The new PV power is denoted by pi (k+1), whereas the old maximum power was denoted by pi (k). Consequentially, in the aforementioned equations, and denote the agent's observation of a convergence and the rapid change in insolation, respectively. The V option is connected to two different issues:

Using smaller numbers improves MPPT stiffness but slows down the tracking response, whereas using larger values speeds up the tracking reaction but increases the oscillations. As a result, a moderate interest rate should be used. Although the agents' rate of initialization is low when P is large, this is because smaller changes in real power make fulfilment of the following constraint less likely.

Figure 5 depicts the whole flowchart for the suggested technique, and the following concepts form the basis of the proposed algorithm:

First, decide on the relevant parameters. As the fitness value assessment function, the output power of the PV modules is used in the proposed MPPT algorithm, with the computed duty cycle of the converter serving as the particle position.

Second, start the PSO: In a typical setup, particles in a PSO are started at random. The particles in the proposed MPPT method are first seeded at predetermined, equally spaced coordinates relative to the GP.

Evaluation of Physical Capacity, Step 3 After the digital controller transmits the PWM instruction based on the duty cycle, which also indicates particle i's location, the particle's fitness will be assessed.

Determine optimal fitness levels for both the individual and the whole population. Particle values are re-evaluated in terms of their global and local best fitness (Pbest and gbest, respectively). When required, they are swapped out with new members at the appropriate ranks.

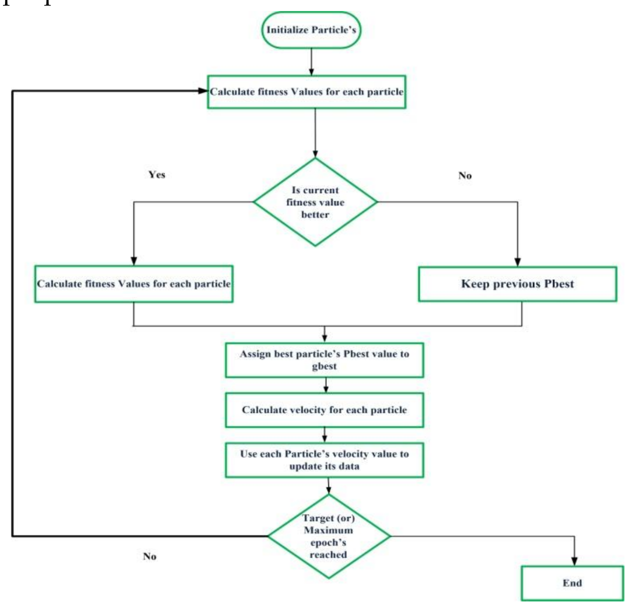

Fig.5. Algoritham for PSO Technique

4. ENERGY MANAGEMENT STRATEGIES AND POWER FLOW MANAGEMENT

Batteries and supercapacitors are the two most common forms of energy storage, and they have found widespread application in home nano-grids that link to larger power grids. Supercapacitors may control power fluctuations in a nano-grid system during a transient state, capitalising on enormous power density and quick reaction, whereas batteries are used to relieve power fluctuations in a steady-state, grid-connected, residential nano-grid system. Instructed by EMS, an energy storage system may mitigate power fluctuations on the tie-line caused by variations in distributed energy production and home demand.

The process of obtaining the PV voltage standard is shown in Figure 6. If the Maximum Power Point Tracking (MPPT) method is disabled, the PV-curtail algorithm will serve as the PV voltage reference, and vice versa. With the maximum power point tracking (MPPT) method, the PV power (PPV) is defined by Equation, whereas with the PV-curtail approach, PPV is defined by Equation. The power flow management procedure yields the maximum power point (mpp) PV voltage (VPV), maximum power point (mpp) PV current (IPV), maximum power point (curtail) PV voltage (VPV), and maximum power point (curtail) IPV.

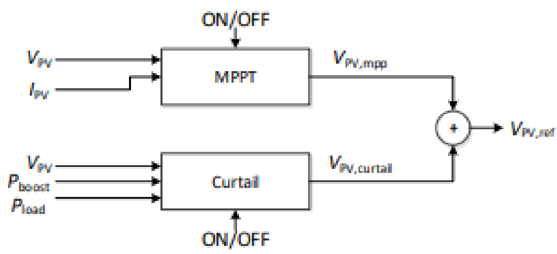

Figure 6: Schematic of the PMS System's Controls

5. RESULTS AND DISCUSSION:

Matlab is used to realise the whole parallel-connected PV system, as shown in Figure 1. The photovoltaic system is made up of a series-connected array of PV modules and a boost converter.

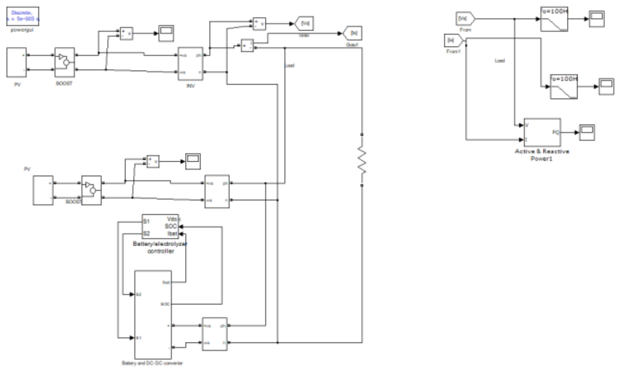

Figure 7: Graph of Proposed Parallel-Connected PV System Simulations

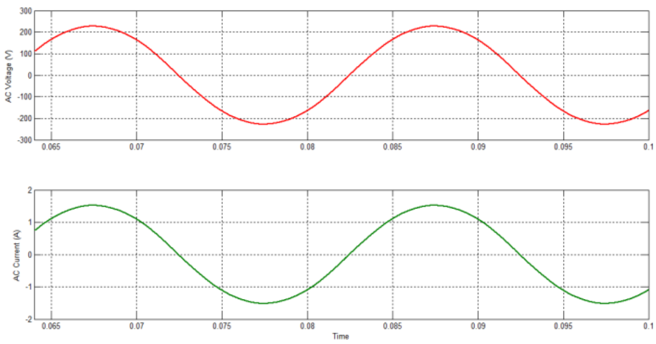

Figure 8: The AC voltage and current simulation result

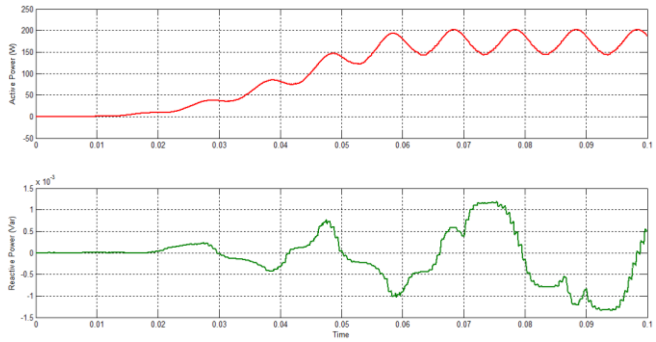

Figure 9: Active and Reactive Power in the Grid: A Simulation Result

6. CONCLUSION

This review article categorises MPPT methods according on the amount of adjustable parameters. For each MPPT method, it specifies the converter type and whether the method should operate in grid-tied or standalone mode. In this article, we will go through the latest hybrid MPPT approaches and their advantages. This analysis is meant to serve as a resource for PV system designers and industrial producers alike. Both INC and PSO were founded on the extreme value theory, as this research shows. In an ideal world, they'd be able to pinpoint the apex of the power curve with pinpoint accuracy. However, due to noise and quantization error etc., it is challenging to ensure the stability and accuracy of the numerical approximation of differentiation upon which both methods depend. Algorithms have the inherent difficulty of continuously oscillating about the optimum operating point.

The efficiency of power isolation systems is assessed using MATLAB on a personal computer. In order to satisfy the load, solar panels are being investigated because of the many benefits they provide for loads that are difficult 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. Isolated system performance is superior and economically advantageous to consumers as a whole, and it is particularly useful for rural regions to handle distant loads.

Conflict of interest statement

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

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