A Review on Computational Determination of Global Maximum Power Point (GMPP) for PV Arrays under Partial Shading Condition

Abhilasha Banduni

Assistant professor, Roorkee College of Engineering, Uttarakhand, India

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Abstract - *Photovoltaic (PV) system performance is greatly dependent on the solar irradiation and operating temperature. Due to partial shading condition, the characteristics of a PV system considerably change and often exhibit several local maxima with one global maxima. Conventional Maximum Power Point Tracking (MPPT) techniques can easily be trapped at local maxima under partial shading. This significantly reduced the energy yield of the PV systems. In order to solve this problem, this paper proposes a Maximum Power Point tracking algorithm based on use of Das-Saetre model of PV characteristics that is capable of tracking global MPP under partial shaded conditions.*

Key Words**: Maximum power point, Photovoltaic, Partial shading**

1. INTRODUCTION

Energy is a vital requirement for social and economic development of a nation. One of the major indices of improved quality of life is per capita energy consumption which has been rising steadily in India, though a considerable amount of villages are without power even today. Due to the socio-economic development, the demand of energy has multiplied manifold and this demand can be no longer satisfied by the traditional energy technology using local resources only and to envision energizing the rural and urban area with high energy demand, renewable energy is being seen as a transformative solution to meet energy demand as well as economic challenges. For a sustainable energy future, not only the energy demand but amount of emission of pollutants from commercial energy generation is a crucial issue; and considering National Action Plan on Climate Change, Nationally Determined Contributions (NDCs), renewable energy (RE) goals, India's national policies and other initiatives encourage renewable and clean energy for various applications. At present, India has a target of 175 Giga Watt (GW) of installed capacity from renewable energy by 2022, of which 100GW is to come from solar, 60GW from wind. In addition, India's NDC goal is to achieve 40% of total installed capacity (power generation) from renewable energy by 2030 and therefore, a great interest in adopting green energy technologies in the country[1].The electricity generated from photovoltaic (PV) solar generating system is one of the best options for the sustainable future energy requirements. The solar energy is converted into electrical energy which is transferred in to the electrical grid system. PV modules have non-linear voltage current characteristics and the energy generation affected by solar insolation, temperature, total resistances etc.

Partial Shading Problems

- At the time of partial shading conditions, the conventional MPPT techniques are unable to identify the global maximum power point (GMPP) as multiple maxima points occur due the presence of the bypass diodes, used to reduce the risk of hot spots formation in the PV strings. To handle the multiple maxima during partial shading conditions, many modern optimized MPPT techniques are proposed considering the efficiency, computational cost, accuracy, implementation complexity etc.

Literature Review on computational determination of Global Maximum Power Point for PV arrays under partial shading condition

Meta-heuristics methods like Modified PSO, Simulated annealing Grey-Wolf optimization, DEPSO, Firefly colony, Artificial bee colony etc. can be used to identify the GMPP. In few experimental cases fuzzy logic based methods like Hill-climbing based FL, FL based experimental evaluation show satisfactory results. Computational techniques using Lambert W function, Voltage window, Kalman filter, Analytical modelling of PV system used for exact search of GMPP mathematically and some conventional methods are modified for better accuracy like Modified P&O Modified INC P&O based PSO. To reduce the computational complexities, hardware solutions like Neutral point clamped techniques, Switching PV modules PV SuDoKu configuration LLC resonant can be used for GMPP in partial shading condition. The different computational GMPP techniques can be categorize as,

Analytical	Meta-heuristic	Fuzzy-based
✖ Lambert W function ✖ Voltage window ✖ Kalman filter ✖ Analytical modelling of PV system	✖ Modified Particle Swarm Optimization ✖ Simulated annealing ✖ Grey-Wolf optimization ✖ DEPSO ✖ Firefly colony ✖ Artificial bee colony	✖ Hill-climbing based FL ✖ FL based experimental evaluation

Conclusion

In the proposed work, the computational techniques can be studied and analytical methods can be used for betterment of algorithm. Since Lambert-W function can be used for finding GMPP, similar approach can be taken using Das-Saetre model, of PV V-I Characteristics. Das and Saetreindependently proposed a simple explicit model PV module and showed that (1) can be converted into the following model like,

$$\left(\frac{V}{V_{OC}}\right)^{M} + \left(\frac{I}{I_{SC}}\right)^{N} = 1$$

The model parameter M and N can be obtained from the two point measurement similar to Karmalkar-Haneefa model. Using the proposed model Das showed that this model can be derived from (1) using algebraic manipulation giving the physical implication of the explicit model. The explicit model (2) can be used in searching GMPP under partial shading condition of PV modules. This technique can be used to reduce the computational complexity of previous approach using Lambert W function. The computational code will be written in MATLAB and the data can be obtained from actual solar plant data. The solar power data can be obtained from 4 MW Solar plant at Bidar, Karnataka. Using proposed functional equations different local maxima can be generated and GMPP can be obtained using meta-heuristic methods also.

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