Optimized Solar Potential Maximization Model for Improved Power Stability in Photovoltaic systems

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Abstract: The power stability in power distribution systems are well studied. There exist numbers of models towards maintaining the power stability which consider the residual energy of PV systems. However, there are not efficient in maintaining the power stability and suffer to achieve higher efficiency in potential maximization. Towards maintaining higher potential maximization, an efficient Optimized Solar Potential Maximization Model (OSPMM) is presented in this article. The model considers the factors like Mean Voltage Generation, Mean Voltage Supply and Residual Voltage as the key in the selection of PV system towards power stability. To perform this, the method monitors the incoming voltage produced by various PV systems and collects such factors mentioned above. According to the factors identified, the method estimates Potential Maximization Support (PMS) for various PV systems. Based on the value of PMS, the method selects the PV system towards maintaining power stability. The proposed approach improves the performance of solar potential maximization and power stability maximization.

Keywords: Power Grids, PV Systems, Power Stability, PMS, OSPMM.

1.Introduction:

The human society uses the electricity at every moment of their life which increase the requirement of producing enormous unit of electricity. This challenges the power distribution systems of any country to produce huge electric power from limited sources. In general, the electric power has been produced from limited sources like water, coal, wind and solar. However, the other electric sources are highly scarcity one which are available at limited time but the solar energy has been identified as the most dominant one which is available throughout the year.

The photovoltaic systems (PV) generate the electric power from the sunlight through set of panels which are connected to the converters. Such generated electric power are stored in the inverter connected to the PV systems which can be utilized by the power distribution systems to supply and regulate electric power to various consumers. In general, the electric power produced by any power generation unit is not constant at all the times.

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There will be fluctuation in the unit of power being produced by the system. However, the power distribution system has the responsibility to maintain the output power which is going to be an input voltage for various electrical systems. Consider there are N number of PV systems connected in serial with the distribution system, which produces k unit of electric power in each duty cycle. By regulating the electric power in efficient way, the performance of power distribution system as well as power grid PV systems can be improved.

To perform such voltage regulation, there exist number of power stability algorithms available which consider only the residual unit of the system. However, this approaches suffer to achieve higher power stability and introduces poor performance. In order to improve the performance of power distribution systems, the selection of PV system to meet the output voltage should be performed with set of strategic algorithms which should consider the average voltage being produced, average voltage being supplied and residual voltage of the PV system.

On the other side, the performance of the entire system is greatly depending on potential of the PV system. It is necessary to improve the potential of the PV system by scheduling the PV system at the voltage distribution. By maximizing the potential of the PV system, the performance of entire power distribution and power stability can be improved. With this consideration, an Optimized Solar Potential Maximization Model (OSPPM) is presented in this article. The model is focused to monitor the voltage of any PV system and identifying the suitable PV system for the support of power stability by computing Potential Maximization Support (PMS). By doing so, the performance of the power distribution system can be improved.

2.Related Works:

Number of power stability algorithm is discussed in literature and this section discusses set of methods around the problem.

A renewable energy source based solar photovoltaic inverters (SPVI) is presented in [1], to maximize the voltage stability of active distribution system. The model considers the effectiveness of renewable energy in different times to trigger the inverters of photovoltaic systemsto maximize the power stability. A probabilistic multi-objective optimal reactive power distribution (PMO-ORPD) model is presented in [2], for the wind farms (WFs) and solar PV to support power systems with renewable energy. The model computes the probability value for various PV systems in supplying steady voltage and elects the most optimal one to support the output voltage.

A power grid voltage stability analysis model is presented in [3], which consider the uncertainties of PV power generation and load demand. The stability analysis algorithm monitors the uncertainty in the PV system and considers the load demand in the power stability management. A Lyapunov function analysis based adaptive tuning laws is presented in [4], to support PV control parameters in the sense to improve power stability. The model uses tuning laws in the selection of PV system and support maximizing the power stability.

A fault ride through control scheme is presented in [5], towards maintaining power stability in PV inverters. The model monitors the fault happening in the PV inverters and based on that the method performs selection of PV system as well as voltage regulation.

A grid forming strategy based transient stability and power protection model is presented in [6], which uses anti windup functionality with two axis proportional-integral regulators. The model performs grid forming by choosing a subset of grid units based on the power stability of different grids. Such selected grids are allowed to perform voltage regulation.

Towards maintaining power stability in PV systems, an optimization control is presented in [7], which uses real-time inverter control to measure the maximum output power of inverter system, with the use of MPPT. The MPPT performs monitoring the incoming power and state of inverter to support power stability.

A Describing function (DF) based stability analysis model is presented in [8], which analyze the stability of different methods. The analysis is performed according to the factors like incoming voltage, uncertain conditions and output requirement. Based on these factors, the models are analyzed for their performance in voltage stability.

A coordination strategy for the Virtual inertia control and frequency damping control in PV systems is presented [9]. A grid connected voltage stability control based Pv generator with DC-link voltage and reactive power control is presented in [10], which is fabricated with Low Voltage Ride Through (LVRT) capability, voltage and frequency support functionalities. The adaption of LVRT in the circuit support the maximization of power stability in the network.

A virtual synchronous generator (VSG) technique based control strategy is presented in [11], to support BES-qZSI PV power system. The VSG scheme synchronizes the incoming voltage with the available PV voltages to maximize the power stability.

A framework is presented in [12], to analyze the stability of various grid-tied photovoltaic inverter systems using impedance models (IMs).A hybrid PV-Wind-FC with electrolyzer with battery energy storage system with the least number of control loops and converters is presented [13].

All the above discussed models suffer to achieve higher power stability.

Optimized Solar Potential Maximization Model (OSPMM):

The proposed optimized solar potential maximization model (OSPMM) considers the factors like Mean Voltage Generation, Mean Voltage Supply and Residual Voltage as the key in the selection of PV system towards power stability. To perform this, the method monitors the incoming voltage produced by various PV systems and collects such factors mentioned above. According to the factors identified, the method estimates Potential Maximization Support (PMS) for various PV systems. Based on the value of PMS, the method selects the PV system towards maintaining power stability.

Voltage Monitoring:

The proposed method monitors the incoming voltage produced by the power distribution system. Accordingly, the method identifies set of PV systems and estimates the PMS value for various Pv systems. Based on the estimated value of PMS, the method performs OSPMM voltage stabilization.

Algorithm:
Given: Power Trace PT
Obtain: PV set Pvs
Start
Read PT.
While true
Monitor incoming voltage Iv.

Identify set of PV systems Pvs = $\sum_{i=1}^{size(PT)}(PT(i).PV \ni Pvs) \cup Pvs$

For each pv

Compute Mean Voltage Generation Mvg= $\frac{\sum_{i=1}^{size(PT)} Sum(PT(i).vg\ ?PT(i).pv==pv)}{\sum_{i=1}^{size(PT)} Count(PT(i).pv==pv)}$

Compute Mean Voltage Supplied Mvs = $\frac{\sum_{i=1}^{size(PT)} Sum(PT(i).vs\ ?PT(i).pv==pv)}{\sum_{i=1}^{size(PT)} Count(PT(i).pv==pv)}$

Compute Mean Voltage Residual Mvr = $\frac{\sum_{i=1}^{size(PT)} Sum(PT(i).vr\ ?PT(i).pv==pv)}{\sum_{i=1}^{size(PT)} Count(PT(i).pv==pv)}$

Pvs= Pvs$\cup$ $\{pv, Mvg, Mvs, Mvr\}$

End

Perform OSPMM voltage stabilization.

End

Stop

The voltage monitoring algorithm monitor the incoming voltage from the power generation systems and collects set of pv systems in the network and applies OSPMM voltage stabilization.

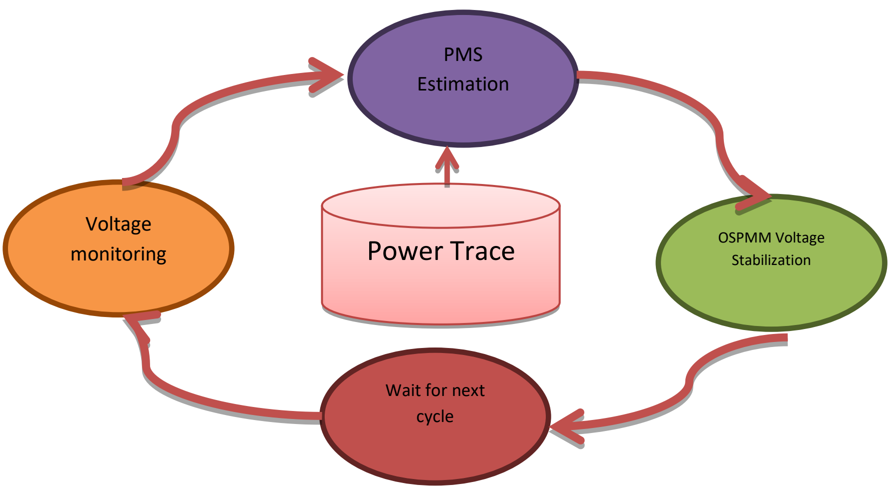

Figure: Architecture of OSPMM Model

The working of proposed OSPMM model has been presented in Figure 1, and the functions of the model are discussed in detail in this section.

PMS Estimation:

The potential maximization support (PMS) is the measure which represents the efficacy of any PV system in contributing the power stability of the power distribution system. It has been measured based on the mean voltage supplied (mvs), Mean voltage generated (Mvg) and Mean voltage residual (mvr) of any pv system. Using these values, the method computes the value of PMS which has been used towards power stabilization and the selection of optimal pv system for the cycle.

Algorithm:

Given: Feature Vector Fv

Obtain: PMS.

Start

Read Fv.

Compute PMS $= \frac{Fv.vs}{Fv.vg} \times Fv.vr$

Stop

The PMS estimation algorithm computes the value of PMS according to the mean values of voltage being generated, supplied and residual. Estimated PMS value has been used to perform power stabilization.

OSPMM Voltage Stabilization:

The proposed model performs voltage stabilization according to various factor of the power distribution system. For any PV grid, the method maintains various traces and computes the value of PMS. According to the value of PMS, the method identifies a unique optimal Pv for the power stabilization.

Algorithm:
Given: Feature Vector set Fvs.
Obtain: Null
Start
    Read Fvs.
    For each pv from Fvs
        Compute PMS = PMS_Estimation (pv)
    End
    Pv = Choose pv with maximum PMS.
    Schedule the pv towards power regulation in distribution system.
Stop

The above discussed algorithm computes the PMS value for various pv system and based on the value of PMS, the method identifies the suitable one to perform voltage stabilization.

3.Results and Discussion:

The proposed Optimized Solar Potential Maximization Model (OSPMM) has been implemented with Simulink and has been evaluated for its performance under various factors. The results obtained have been compared with the results of other methods.

Factor	Value
Tool Used	Simulink
No of Pv grids	100
Simulation Time	10 minutes

Table 1: Experimental setup

The experimental setup considered for the performance evaluation of OSPMM model has been presented in table 1. Obtained results are compared with the result of others.

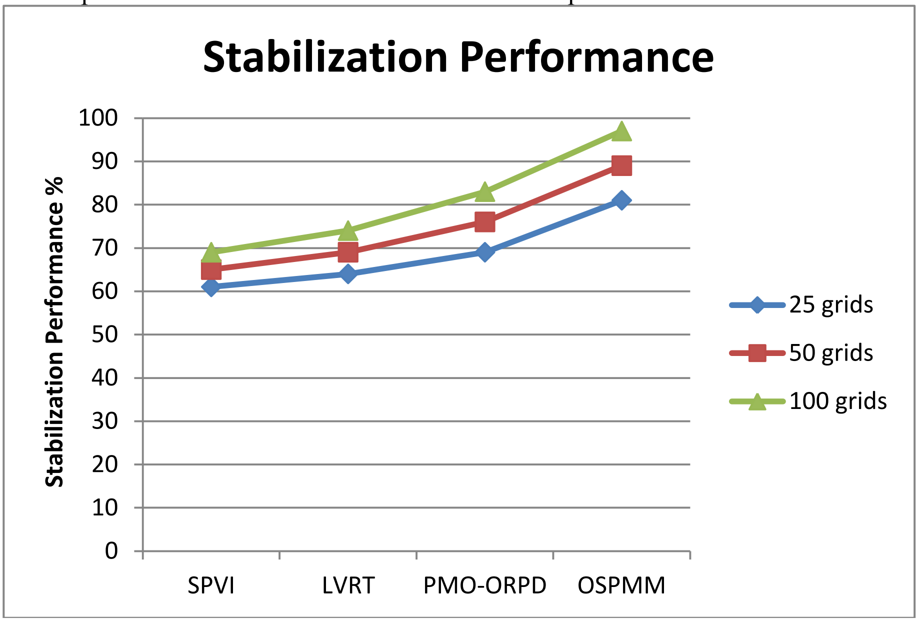

Figure 2: Stabilization Performance

The performance of methods in power stabilization has been measured and compared in Figure 2, where the OSPMM model has produced higher stabilization performance than others.

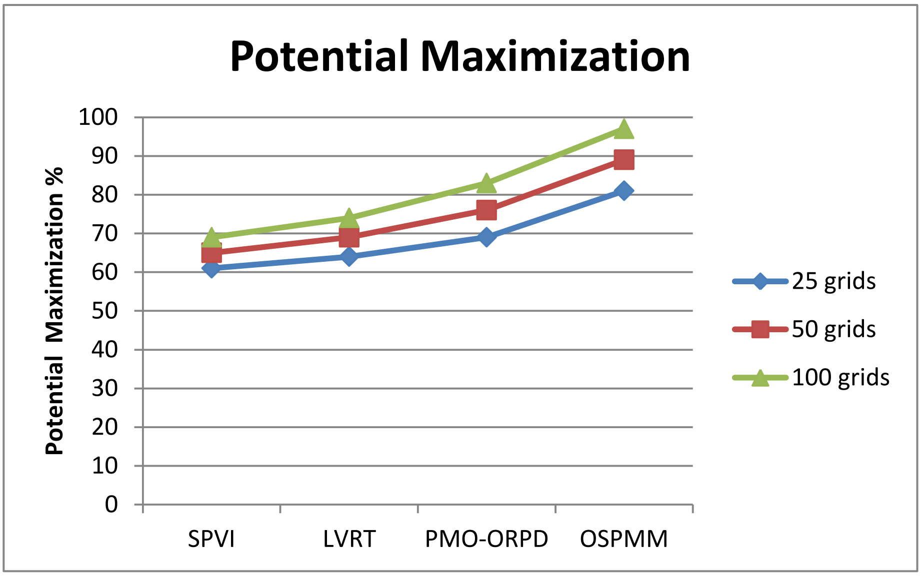

Figure 3: Potential Maximization

The performance of methods in potential maximization has been measured and presented in Figure 3. The proposed OSPMM model has produced higher potential maximization performance than others.

4.Conclusion:

This paper presented a novel Optimized Solar Potential Maximization Model (OSPMM) towards improve the power stability of power distribution systems. The OSPMM model considers the factors like Mean Voltage Generation, Mean Voltage Supply and Residual Voltage as the key in the selection of PV system towards power stability. To perform this, the method monitors the incoming voltage produced by various PV systems and collects such factors mentioned above. According to the factors identified, the method estimates Potential Maximization Support (PMS) for various PV systems. Based on the value of PMS, the method selects the PV system towards maintaining power stability. The proposed model improves the performance in power stability and potential maximization.

5.References:

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