An Energy Efficient Requirement Optimization Model Based Power Switching for Improved Performance in Smart Grids

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Abstract: Power switching in smart grid has been identified as the key issue in literature. There exist number of models to handle this problem which consider the residual energy of grids in performing power switching. However, the performances of the models are not up to the expected rate. To handle this issue, an efficient Requirement Optimization based Power Switching Model (ROPSM) is presented in this article. The model focused on optimizing the selection of power grids towards maintaining the power stability in smart grids. To perform this, the model monitors the incoming voltage level and maintains the voltage production capability of various grids at all the duty cycles. Based on that, the method computes Power Requirement Support (PRS) value for various grid units. According to the value of PRS, a subset of grids are selected to optimize the power stability and allowed to regulate the power. The proposed model improves the performance of power stability in smart grid environment.

Keywords: Smart Grids, Power Switching, ROPSM, PRS, Requirement Optimization.

1.Introduction:

The usage of electricity has been getting increased at each second which support the day to activity of human society. This increases the power sector in producing huge volume of electricity for the smooth functioning of the society. On the other side, there are many plants which run with the electricity which need the support of power generation sector highly. Smart grids are the environment which combines number of power generation units to support the steady voltage supply for various electrical plants. The smart grid are capable of turning and streaming the electricity according to various constraints. For example, the smart grids are able to identify which grid would support the current state of electrical needs. However, the methods consider only the limited parameters like residual energy in the selection of power grid to meet the requirement.

Performing power stabilization according to residual energy is not enough and it will not be an efficient one. It is necessary to consider various factors like voltage required,

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voltage produced by various grids and so on. Also, the voltage produced by any grid will not be a constant one and there will be little fluctuation in the value of power production. It is necessary to consider the requirement of the current state. By considering such requirement state, the power stabilization can be performed effectively.

Requirement optimization is the process of optimizing the power requirement by considering number of other factors like power generation by various grids, required value of voltage, and so on. Also, a single power grid does not support entire power regulation and it is necessary to identify a subset of grids which are able to support the power requirement. The ultimate aim is to choose efficient power grids in supplying required power for the electrical system. The selection of power grids plays vital role in identifying optimal efficient power grids to meet the requirement.

With all these consideration, an efficient Requirement Optimization based based Power Switching Model (ROPSM) is presented in this article. The model focused on optimizing the selection of power grids towards maintaining the power stability in smart grids. To perform this, the model monitors the incoming voltage level and maintains the voltage production capability of various grids at all the duty cycles. Based on that, the method computes Power Requirement Support (PRS) value for various grid units. According to the value of PRS, a subset of grids are selected to optimize the power stability and allowed to regulate the power. The detailed approach is sketched in this section,

2.Literature Survey:

There exists number of approaches in power switching problem in literature. This section details set of methods around the problem.

A V2G scheduling with power flow routing is presented in [1], to provide regulation service. The power flow router decides the optimal power flow according to the semi definite programming (SDP) relaxation. The power flow routers are efficient in detecting the power flow according to the semi definite programming tools which support the performance of voltage scheduling.

A Meta heuristic grid planning algorithm with fast scheduling is presented in [2], which uses Delaunay triangulation and an ant colony systems approach for effective scheduling. The method performs scheduling according to the meta data available and applies ant colony systems to identify the most suitable schedule for the system.

An integrated auctioning-scheduling scheme is presented in [3], to schedule energy in cloud centers. The auctioning scheduling algorithm monitors the set of clouds for their power factor and based on the action event the method perform scheduling of the grids to support power regulation.

A two-stage joint optimal scheduling scheme is presented in [4], which consider the user demand response obtained from the interaction between IESs. By adapting the user demand with the power supply scheduling, the two stage model improves the scheduling performance and maximize the steady voltage in the network.

A dynamic voltage and communication channel scheduling co-design scheme is presented in [5], to support active distribution networks (ADNs). The method uses a unified mathematical model which works based on an uncertain discrete time-delay switched system towards scheduling and voltage control.

A delay-tolerant Kalman filter (DTKF) based dynamic state-aware scheduling is presented in [6], which perform scheduling according to the state of channels and sensors. By using the state aware scheduling, the model monitor the state of various units and based on that the method applies the DTKF algorithm to identify the most suitable units to support power regulation and performs scheduling.

An optimization reactive power planning model is presented in [7], to handle multi-period optimal reactive power dispatch (MP-ORPD) problem. The model consider various constraints of the other end and based on that the method performs periodical power dispatch to maintain higher power stability.

A new virtual power flow based automatic solution to adaptively perform control mode switching for the SOPs in faulted DS is presented in [8]. By monitoring the power flow in the various grids, the method identifies suitable grids to maintain higher power stability.

A multi-agent soft actor-critic (MASAC) algorithm is presented in [9], to support PV inverters in voltage regulation and scheduling. The method uses various agents in collecting the meta data from various grids and use them to perform regulation and scheduling.

An optimal scheduling method for a zero net energy community microgrid with customer-owned energy storage systems (CES) is presented in [10], which uses aggregated CES (ACES) towards scheduling. The model monitors and consider the energy system maintained by the consumer in regulating the power supply which in turn would reduce the voltage loss.

A novel distributed coordinated control framework is presented in [11], to handle uncertain voltage in scheduling. The coordinated framework combines the voltage to be shared between various units and monitors the uncertain voltage in the network to perform efficient power stability. A stochastic optimization algorithm is presented in [12], which consider the dynamic capabilities of sources in scheduling.

A model-free deep reinforcement learning (DRL) framework is presented in [13], to support scheduling in PV systems.

All the above discussed methods suffer to achieve higher performance in voltage scheduling and power factor maximization.

Requirement Optimization based Power Switching Model (ROPSM):

The proposed Requirement Optimization based Power Switching Model (ROPSM) which focused on optimizing the selection of power grids towards maintaining the power stability in smart grids. To perform this, the model monitors the incoming voltage level and maintains the voltage production capability of various grids at all the duty cycles. Based on that, the method computes Power Requirement Support (PRS) value for various grid units. According to the value of PRS, a subset of grids are selected to optimize the power stability and allowed to regulate the power.

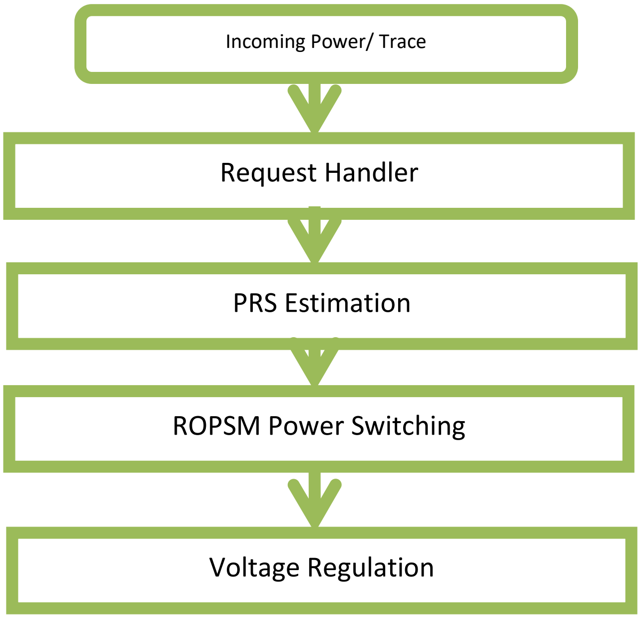

Figure 1: Architecture of proposed ROPSM power switching model

The functional architecture of proposed ROPSM power switching model is presented in Figure 2 and the functions of the model are detailed in this section.

Request Handler:

The request handler function always waits for the new arrival of request. Any request contains the required voltage according to the requirement of various electrical systems. According to the voltage required, the method calls the ROPSM power switching function which in turn measures the PRS value for different grids to perform voltage switching.

Algorithm:

Given: Power Trace PT
Obtain: Null
Start
    Read power trace PT.
    While true
        Receive power request Poreq.
        Extract voltage requirement Vreq = Vreq ∈ Poreq
        Perform ROPSM power switching (PT, vreq)
    End
Stop

The request handler algorithm receives the power request and extracts the voltage requirement value and performs ROPSM power switching.

ROPSM Power Switching:

The ROPSM power switching algorithm receives the voltage requirement value and identifies the set of power grids available. Accordingly, the method computes PRS value for various grids according to the requirement. The power requirement support (PRS) is the measure which represent the strength of grid in supplying required voltage for the electrical systems connected with the power distribution system. It has been measured based on the voltage required vreq and the average voltage produced and regulated by the grid unit g. Using both the values, the method computes the PRS value to support the power switching.

Based on the value of PRS, the method selects a subset of grids to perform voltage regulation. Selected grid units are scheduled for voltage regulation.

Algorithm:

Given: voltage required Vreq, Power Trace PT

Obtain: Null

Start

Read vreq, PT.

Grid set grs = $\left(\sum_{i=1}^{size(PT)} PT(i).grid \ni grs\right) \cup grs$

Initialize grid selected set Gss.

For each grid g

Collect grid trace Gts = $\sum_{i=1}^{Size(PT)} PT(i).grid == g$

Compute mean voltage production Mvp = $\frac{\sum_{i=1}^{Size(gts)} Sum(gts(i).voltage\ produced)}{size(gts)}$

Compute mean voltage regulated Mvrg = $\frac{\sum_{i=1}^{Size(gts)} Sum(gts(i).voltage\ regulated)}{size(gts)}$

Compute PRS = $\frac{Vreq}{Mvp} \times Mvrg$

Prs = PRS_Estimation(PT, vreq)

If Prs>($\frac{1}{3} \times$ vreq) then

Gss = Gss$\cup$ g

end

End

For each grid g in Gss

Schedule g towards voltage regulation.

End

Stop

The ROPSM power switching algorithm receives the request and features to find the set of grids initially. Further, the method computes the PRS value for the grids and identifies a subset of grids to perform power switching.

3.Results and Discussion:

The proposed Requirement Optimization Power Switching Model (ROPSM) has been implemented with Simulink. The method has been evaluated for its performance under different circumstances. Obtained results are compared with the results of others.

Factor	Value
Tool Used	Simulink
No of grids	200
Time	10 minutes

Table 1: Experimental setup

The experimental setup considered for the performance evaluation of proposed algorithm is given in Table 1.

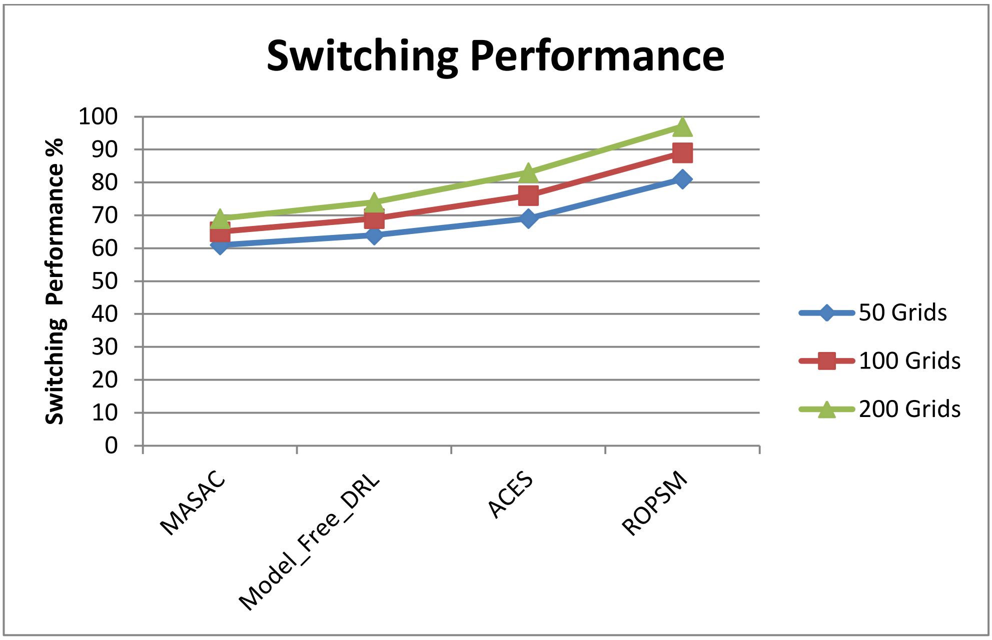

Figure 2: Power Switching Performance

The performance of methods in power switching has been measured and compared in Figure 2, where the proposed ROPSM model has produced higher switching performance than others. The path switching performance of the models are measured by varying the number of grids in the environment. In each case, the proposed ROPSM model has achieved higher performance than others.

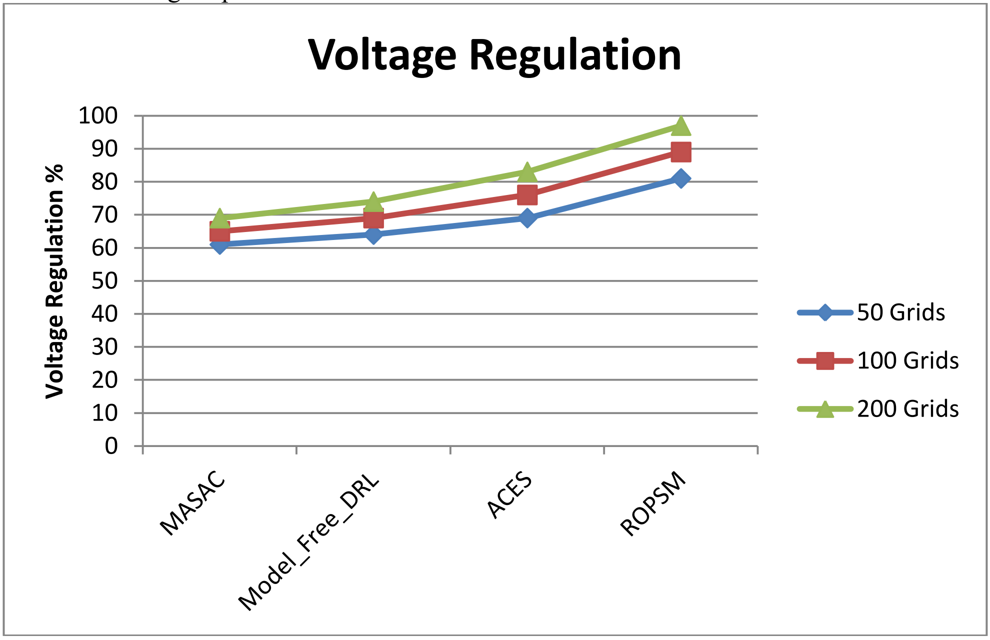

Figure 3: Voltage Regulation

The performance of methods in voltage regulation has been measured and presented in Figure 3. The proposed ROPSM model has produced higher voltage regulation performance than others. The voltage regulation performance is measured for various models with the variance in number of grids in the environment. In each case the proposed ROPSM has achieved higher regulation performance.

4.Conclusion:

This paper presented a Requirement Optimization based Power Switching Model (ROPSM) which focused on optimizing the selection of power grids towards maintaining the power stability in smart grids. To perform this, the model monitors the incoming voltage level and maintains the voltage production capability of various grids at all the duty cycles. Based on that, the method computes Power Requirement Support (PRS) value for various grid units. According to the value of PRS, a subset of grids are selected to optimize the power stability and allowed to regulate the power. The proposed model improves the performance of power stability in smart grid environment.

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