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Real time Wind Based Power Approximation Model for Improved Performance in Power Distribution Systems

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Abstract:

Towards maximizing the performance of power distribution systems, there are number of methods being discussed in literature. The existing methods perform power distribution based on the holding energy in the wind power grids. Such selection metric introduces poor performance in power distribution and affects the performance of other grids as well. To handle this, an efficient Real time Wind based Power Approximation (RWPA) model is presented in this article. The proposed method maintains the tracks of power supply contributed by various wind power grids. Using the data available, the method computes wind regulation support (WRS), Power Generation Support (PGS) according to the voltage produced, supplied and so on. Using these two factors, the method computes the value of Power Distribution Support (PDS) for various grids. According to the value of PDS, the method selects the grid for power supply. The proposed method improves the performance of power distribution and energy utilization of grids.

Keywords:

Power Distribution, Power Production, RWPA, PGS, WRS.

INTRODUCTION:

The increased use of electricity by the human society introduces great challenge for the power generation and distribution system. The power distribution system of any country has the responsibility in streaming and regulating electric power for the country. There may be number of industries, commercial sectors and residential units present in the country. The distribution system has the responsibility in maintaining the electric supply for various locations. But in general, the electric power has been produced from limited sources like water, thermal, wind and solar and atomic sources. The most sources are more scarcity one and does not available throughout the year. This claim the requirement of efficient approaches in power distribution according to the requirement.

The wind mills are installed around the area where there is higher wind source throughout the year. The energy produced by the wind mills are regulated through the power grid to the different locations of the country. The energy produced by the wind power stations must be optimally used and the energy available should be utilized in full swing. This would improve the performance of the distribution systems.

In general, the power distribution systems are linked with number of wind power stations. Each wind power plant produces different energy to support the distribution systems. Such fluctuating power source must be regulated to the society and the distribution system has the responsibility in maintaining the seamless and steady voltage. There exist number of approaches to maintain the steady voltage but consider only the residual energy of wind plants. They does not produce effective results in power steady voltage. With the consideration to maintain steady voltage, an efficient Real time Wind based Power Approximation (RWPA) model is presented in this article. The proposed method maintains the tracks of power supply contributed by various wind power grids. Using the data available, the method computes wind regulation support (WRS), Power Generation Support (PGS) according to the voltage produced, supplied and so on. Using these two factors, the method computes the value of Power Distribution Support (PDS) for various grids. According to the value of PDS, the method selects the grid for power supply. The RWPA model is focused to improve the performance of voltage regulation and power stability. The detailed working of the model has been presented in detail in the next section.

LITERATURE REVIEW:

There exists number of approaches discussed in literature to maintain power stability. Some of the methods are discussed in detail.

A superconducting magnetic energy storage (SMES) integrated current-source DC/DC converter (CSDC) (SMES-CSDC) is presented in [1], which performs voltage stabilization in multi-farious transient disturbances and power regulation under wind speed variations. The model consider the disturbances present in the conduction lines and consider the speed variation in the wind to perform voltage stabilization.

A two-stage optimization of superconducting magnetic energy storage (SMES) integrated into hybrid wind/photovoltaic (PV) system is presented in [2] towards effective stabilization. The model focused on monitoring the capacity of energy storages and integrates the photovoltaic and wind systems towards power stabllization.

A doubly fed induction generator (DFIG)-based wind turbine systems is presented in [3]. The wind turbines are coupled with the induction generator to maximize the voltage stability and support the power stabilization greatly. A grid-connected solar photovoltaic and wind energy (PV-WE) system is presented in [4] towards power enhancement. The PV grids and wind grids are coupled and integrated to maintain the power management and selects the optimal sources to maintain the power stability.

A wind power medium-voltage direct-current (MVDC) transmission system is presented in [5], which realize the DC transmission of offshore wind power and eliminate offshore platforms. The wind sources are monitored for the output voltage and by incorporating various grids and wind power sources, the method improves the power stability.

A impedance model of Grid connected inverters is presented in [6]. The inverters connected with various grids are optimized for their energy and optimal inverter has been selected to regulate and maintain the power stability.

A frequency regulation and stabilization control architecture is presented in [7] to support wind turbine generator (WTG) integrated power grid. The frequency of turbines connected has been monitored and efficient turbine selection is performed to maintain the power stability.

A real time field reconstruction model is presented in [8], which analyze the distribution of wind speed and direction towards power stabilization. By considering the wind speed and the direction of wind, the method performs wind selection to maximize the power stability. A doubly fed induction generator (DFIG)-based wind farm via retarded sampled-data control (RSDC) is presented in [8], to support power stabilization. The method selects the optimal wind farm for the voltage stabilization and improves the power stability.

A nonparallel distribution compensation (PDC) control is proposed in [9], to support permanent magnet synchronous generator (PMSG)-based wind energy conversion systems (WECS).

A hybrid ac-dc impedance model with network partitioning method is presented in [11], to analyze the stability of the point-to-point HVdc system. A reinforcement learning-based adaptive optimal fuzzy controller is presented in [12], to maximize the power stabilization.

All the methods discussed above struggle to achieve higher performance in power stabilization and voltage regulation.

Wind based Power Approximation (RWPA) model:

The proposed real time wind based power approximation model (RWPA) focused on maintaining the power stability and voltage regulation. The proposed method maintains the tracks of power supply contributed by various wind power grids. Using the data available, the method computes wind regulation support (WRS), Power Generation Support (PGS) according to the voltage produced, supplied and so on. Using these two factors, the method computes the value of Power Distribution Support (PDS) for various grids. According to the value of PDS, the method selects the grid for power supply.

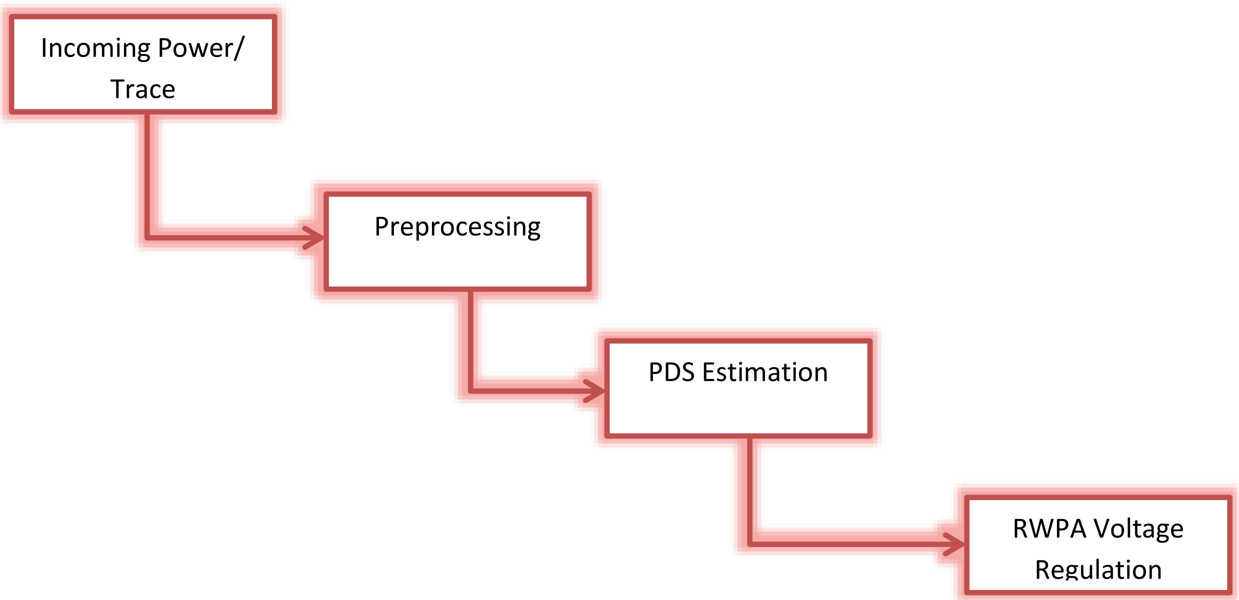

Figure 1: Architecture of RWPA Model

The working model of proposed RWPA model is presented in Figure 1, where the functions of the model are detailed in this section.

Preprocessing:

The proposed method performs power stabilization according to the power trace being maintained. The trace maintained has been preprocessed by normalizing the data set. The traces are read and identify the set of incomplete tuples according to the presence of absence of the features identified. The normalized data set has been used to perform power stabilization.

Algorithm:
Given : Power Traces PT
Obtain: Preprocessed Trace PrT
Start
Read PT.
Initialize feature set Efs = $(\sum_{i=1}^{size(PT)} Features(PT(i) \ni Efs) \cup EFS$
For each trace T
If T $\in \forall Features(Efs) then$ has all features of Efs
PrT =$(\sum Traces \in prT) \cup T$
Else
PT = PT$\cap T$
End
End
Stop

The preprocessing function detects the set of features from the power trace and verifies each record for the presence of all the features. If the trace does not contain any of the features then it has been considered as incomplete and will be removed from the trace. Such noise removed data set has been used to perform power stabilization.

PDS Estimation:

The power distribution support (PDS) is the measure which represents the efficacy of any wind power plant in maintaining the steady voltage and support the distribution system. It has been measured based on the value of voltage produced, voltage supplied and residual voltage. Using these factors the method computes wind regulation support (WRS), Power Generation Support (PGS) according to the voltage produced, supplied and so on. Using these two factors, the method computes the value of Power Distribution Support (PDS) for the grid which has been used towards power stabilization.

Algorithm:
Given: Power Trace PT, Grid G, wind source ws
Obtain: PDS
Start
Read PT, G, ws.
Find grid traces GT = $\sum_{i=1}^{size(PT)} PT(i).gridset \in G$
Identify wind source set Wis =$\sum_{i=1}^{size(PT)} PT(i).windsource == ws$

Compute WRS = $\dfrac{\sum_{i=1}^{size(wis)} Sum(wis(i)PowerRegulated) \Big/ size(Wis)}{\sum_{i=1}^{size(wis)} Sum(wis(i).Residal\ Energy) \Big/ size(Wis)}$

Compute PGS = $\dfrac{\sum_{i=1}^{size(GT)} Sum(GT(i).PowerGenerated) \Big/ size(GT)}{\sum_{i=1}^{size(GT)} Sum(GT(i).outputpower) \Big/ size(GT)} \times \dfrac{\sum_{i=1}^{size(GT)} Sum(GT(i).residualpower)}{Size(GT)}$

Compute PDS = WRS×PGS

Stop

The PDS estimation algorithm computes the value of WRS and PGS values. Based on the value measured, the method computes PDS value. Estimated PDS value has been used to perform voltage regulation and power stabilization.

RWPA Voltage Regulation:

The proposed real time wind power approximation model monitor the wind power grid for their energy produced. At each time stamp, method monitors the incoming voltage and based on that the method identifies the set of wind power sources. For each source identified, the computes wind regulation support (WRS) and Power Generation Support (PGS) to measure the value of Power Distribution Support (PDS). Estimated value of PDS has been used to perform power regulation and power stabilization. The method identifies and selects a most suitable wind sources to support voltage regulation.

Given: Power Trace PT

Obtain: Null

Start

Read PT.

While true

Iv = Receive input voltage from wind sources.

Find wind sources set Wss = $\sum_{i=1}^{size(PT)} PT(i).windsource$

Identify idle wind Iw = $\sum_{i=1}^{size(Wss)} Wss(i).windplant.state == idle$

For each wind source w

PDS = Estimate PDS (PT, w)

End

Wind source Ws = $Wss(Max_{i=1}^{Size(Wss)}(Wss(i).PDS)$

Allow Wind source in regulating power.
Wait for next cycle.
End
Stop

The proposed real time wind power approximation model computes the PDS value for various wind power units which are idle at the previous cycle. Based on that, the method identifies most suitable wind source in supporting the voltage regulation.

RESULTS AND DISCUSSION:

The proposed Real time wind power approximation (RWPA) model has been implemented with Simulink. The performance of the model has been evaluated under various parameters and presented in this section.

Parameter	Value
Tool Used	Simulink
No of wind plants	100
Time	10 minutes

Table 1: Experimental Details

The experimental details used towards performance analysis are presented in table 1.

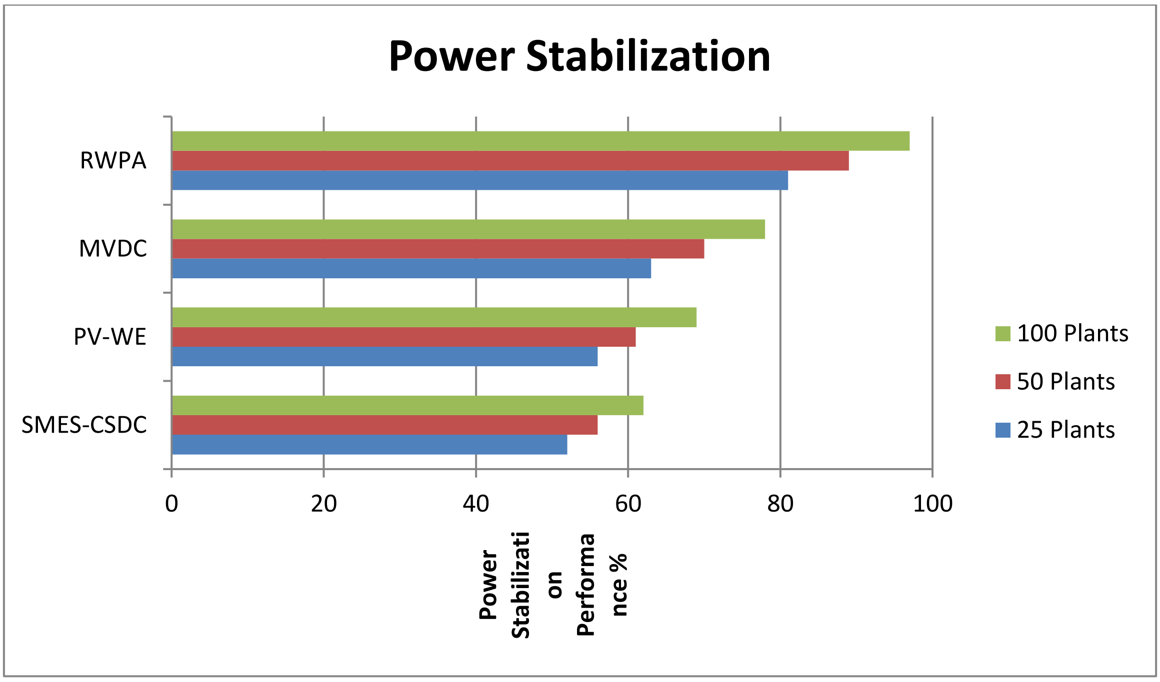

Figure 2: Power Stability Performance

The performance of method in power stabilization is measured and presented in Figure 2. The RWPA model introduces higher performance than others. The performance of power stabilization is measured according to the number of plants available. In each case, the RWPA algorithm produces higher stabilization than others.

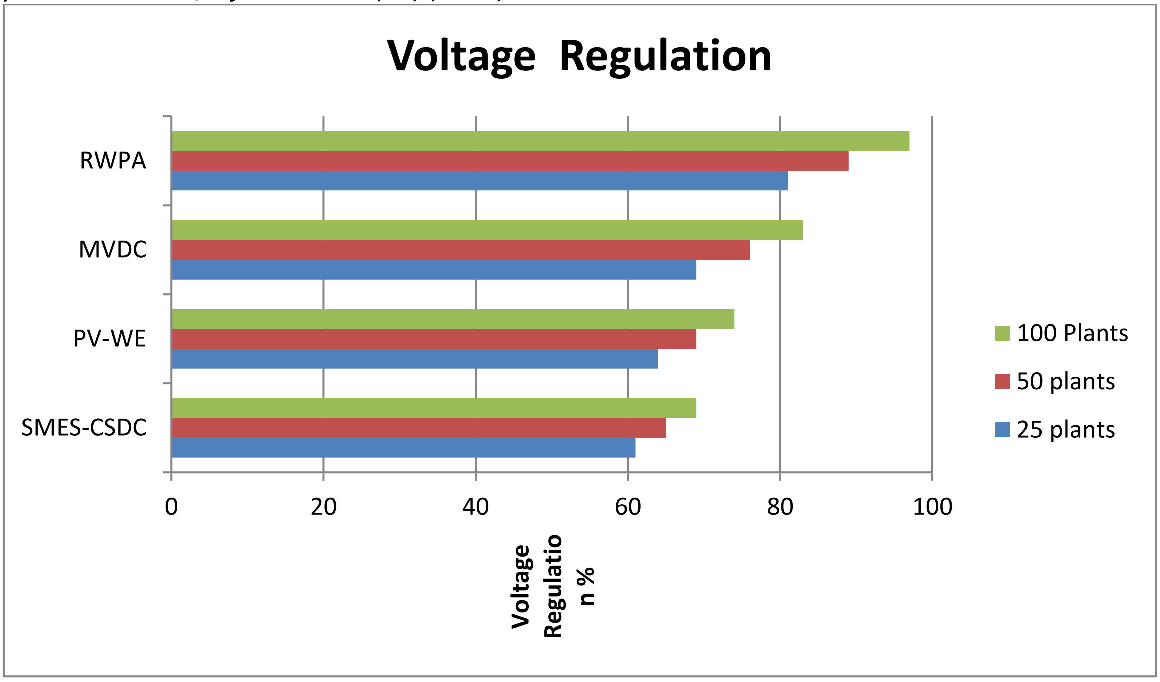

Figure 2: Voltage Regulation Performance

The performance of methods in voltage regulation is measured and presented Figure 3. The proposed RWPA method produces higher voltage regulation performance than others. The performance of voltage regulation is measured according to the number of plants available. In each case, the RWPA algorithm produces higher voltage regulation than others.

CONCLUSION:

This paper presented a real time wind based power approximation model (RWPA) focused on maintaining the power stability and voltage regulation. The proposed method maintains the tracks of power supply contributed by various wind power grids. Using the data available, the method computes wind regulation support (WRS), Power Generation Support (PGS) according to the voltage produced, supplied and so on. Using these two factors, the method computes the value of Power Distribution Support (PDS) for various grids. According to the value of PDS, the method selects the grid for power supply. The proposed method improves the performance of power stability and voltage regulation.

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