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

Dr. Rahul Mishra[1], Dr. Vinay Chandra Jha[2]

[1]Assistant Professor, Department of Mechanical, Kalinga University, Naya Raipur, Chhattisgarh, India, ku.rahulmishra@kalingauniversity.ac.in
[2]Professor, Department of Mechanical, Kalinga University, Naya Raipur, Chhattisgarh, India, ku.vinaychandrajha@kalingauniversity.ac.in

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.

1. Introduction

The increased use of electricity by the human society introduces great challenge for the power generation and distribution system[2]. The power distribution system of any country has the responsibility in streaming and regulating electric power for the country[10]. 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[7]. 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[18].

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[15]. The energy produced by the wind power stations must be optimally used and the energy available should be utilized in full swing[9]. This would improve the performance of the distribution systems.

Typically, power distribution networks are connected to multiple wind power stations. Each wind power plant generates varying amounts of electricity to sustain the distribution systems. The society must regulate such variable power supply, and the distribution system is responsible for ensuring a consistent and stable voltage[13]. There are several methods to regulate the consistent voltage, but we will just focus on the remaining energy of wind power plants. They are not capable of generating consistent voltage levels that yield effective outcomes in terms of power[17]. This article presents an efficient Real-time Wind-based Power Approximation (RWPA) model, with the aim of maintaining a stable voltage. The proposed method tracks and monitors the power supply generated by different wind power networks. The method utilizes the available data to calculate wind regulation support (WRS) and power generation support (PGS) based on factors such as voltage production and supply[22]. The approach utilizes these two criteria to calculate the Power Distribution Support (PDS) value for different grids. The grid for power delivery is selected based on the value of PDS. The primary objective of the RWPA model is to enhance the efficiency of voltage regulation and power stability. The intricate functioning of the model has been thoroughly elucidated in the subsequent section.

2. Literature Review:

Several ways have been discussed in the literature to provide power stability. Several methods are thoroughly explained.In [1], a superconducting magnetic energy storage (SMES) integrated current-source DC/DC converter (CSDC) (SMES-CSDC) is introduced. This converter is designed to stabilize voltage during various transient disturbances and regulate power in the presence of wind speed fluctuations[4]. The model takes into account the disruptions in the conduction lines and incorporates the fluctuations in wind speed to achieve voltage stabilization.In [16], a two-stage optimization approach is proposed for effectively stabilizing a hybrid wind/photovoltaic (PV) system that incorporates superconducting magnetic energy storage (SMES). The model primarily emphasizes the monitoring of energy storage capacity and the integration of solar and wind systems to provide power stabilization.The paper introduces a wind turbine system that is based on a doubly fed induction generator (DFIG) [23]. The wind turbines are connected to the induction generator in order to optimize voltage stability and significantly enhance power stabilization. In reference [18], a grid-connected solar photovoltaic and wind energy (PV-WE) system is introduced with the aim of increasing power output. The photovoltaic (PV) grids and wind grids are interconnected and merged to ensure efficient power management and determine the most suitable sources for maintaining power stability.In [5], a wind power medium-voltage direct-current (MVDC) transmission system is described. This system enables the transmission of offshore wind power using DC and eliminates the need for offshore platforms[25]. The output voltage of wind sources is monitored, and the method enhances power stability by integrating different networks and wind power sources.An impedance model for grid-connected inverters is described in reference [6]. The inverters linked to different grids have been adjusted for their energy efficiency, and the most suitable inverter has been chosen to regulate and ensure the stability of power. In [14], a control architecture is proposed to regulate and stabilize the frequency of a power grid that includes a wind turbine generator (WTG)[8]. The monitoring of turbine connectivity frequency and the implementation of optimal turbine selection are carried out to ensure power stability.In [24], a model for real-time field reconstruction is described. This model analyzes the distribution of wind speed and direction in order to achieve power stabilization. The method utilizes wind speed and wind direction to optimize power stability through wind selection. In [24], a wind farm based on a doubly fed induction generator (DFIG) is described. The wind farm utilizes retarded sampled-data control (RSDC) to stabilize power[3]. The approach identifies the most suitable wind farm for voltage stabilization and enhances power stability. In, a nonparallel distribution compensation (PDC) control is suggested for wind energy conversion systems (WECS) that use permanent magnet synchronous generators (PMSG).In [11], a hybrid ac-dc impedance model is introduced along with a network partitioning mechanism. This model is used to assess the stability of point-to-point HVdc systems. In [20], a novel adaptive optimal fuzzy controller is introduced, which utilizes reinforcement learning to maximize power stabilization.None of the solutions mentioned above are able to effectively achieve superior performance in power stability 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[12]. 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.

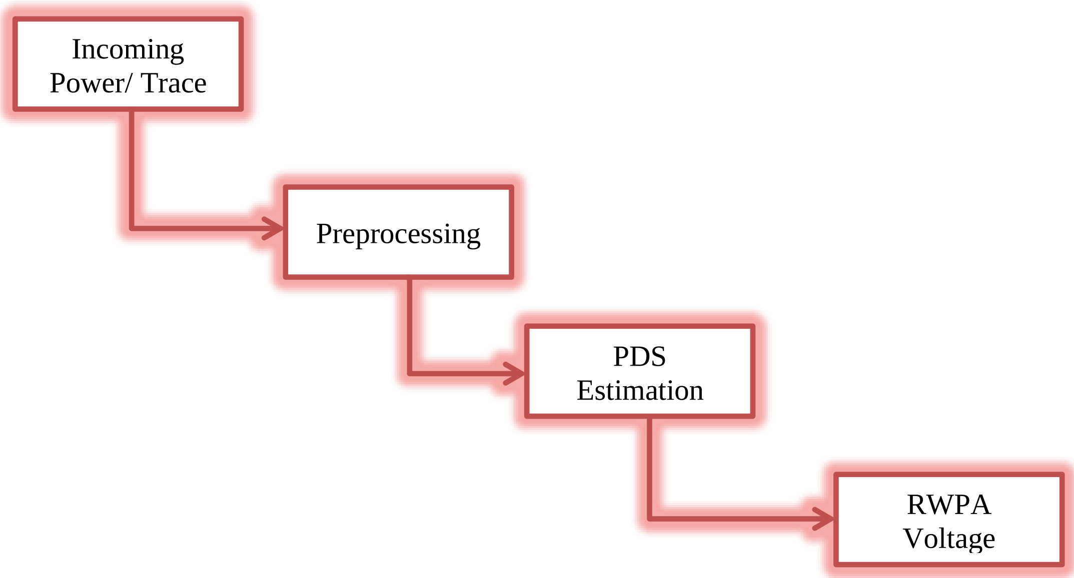

Figure 1: Architecture of RWPA Model

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 = $\left(\sum_{i=1}^{size(PT)} Features(PT(i) \ni Efs\right) \cup EFS$

For each trace T

If $T \in \forall Features(Efs) then$ has all features of Efs

PrT =$\left(\sum Traces \in prT\right) \cup T$

Else

PT = PT∩ 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 = $\frac{Sum_{i=1}^{size(wis)}(wis(i)PowerRegulated) / size(Wis)}{Sum_{i=1}^{size(wis)}(wis(i).Residal\ Energy) / size(Wis)}$

Compute PGS = $\frac{Sum_{i=1}^{size(GT)}(GT(i).PowerGenerated) / size(GT)}{Sum_{i=1}^{size(GT)}(GT(i).outputpower) / size(GT)} \times \frac{Sum_{i=1}^{size(GT)}(GT(i).residualpower)}{Size(GT)}$

Compute PDS = WRS×PGS

Stop

The PDS estimate algorithm calculates the WRS and PGS values. The approach calculates the PDS value based on the measured value. The estimated PDS value has been utilized for the purpose of voltage management and power stability.

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 = $\overset{Size(Wss)}{\underset{i=1}{Wss(Max(Wss(i).PDS)}}$

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.

3. Results and Discussion:

The Simulink platform has been utilized to implement the suggested Real-time Wind Power Approximation (RWPA) model. The model's performance has been assessed using different parameters and is reported in this section.

Table 1: Experimental Details

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

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

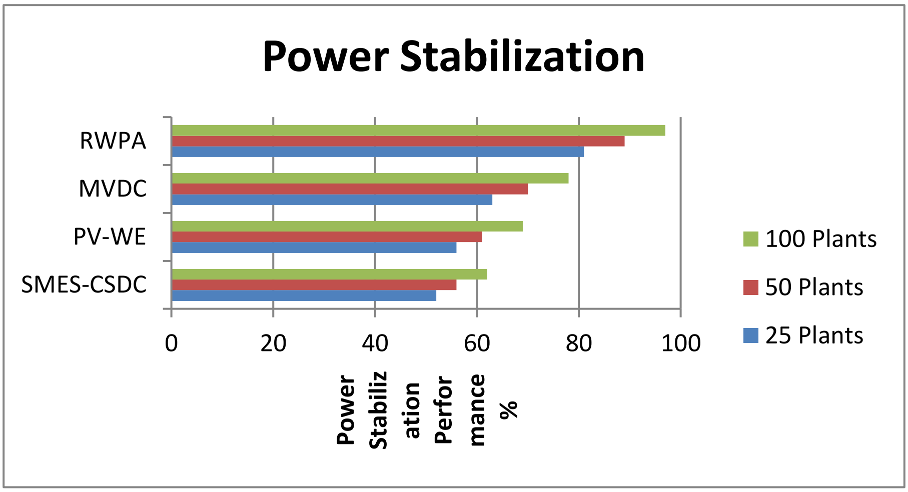

Figure 2: Power Stability Performance

The efficacy of the strategy in power stabilization is assessed and displayed in Figure 2. The RWPA model exhibits superior performance compared to other models. The assessment of power stability performance is based on the quantity of operational power plants. The RWPA algorithm consistently achieves superior stabilization compared to other algorithms in every scenario.

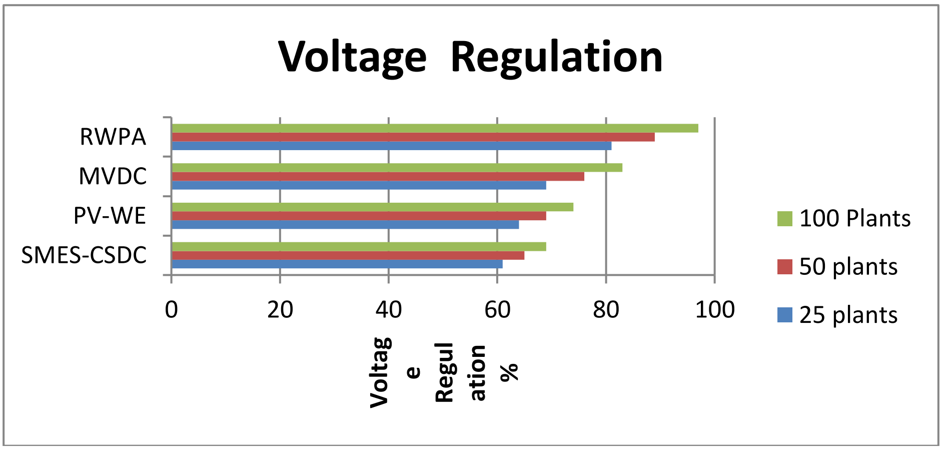

Figure 2: Voltage Regulation Performance

The efficacy of voltage regulation techniques is evaluated and displayed in Figure 3. The suggested RWPA approach exhibits superior voltage control performance compared to other methods. The assessment of voltage regulation performance is based on the quantity of power plants that are accessible. The RWPA algorithm consistently achieves superior voltage control compared to competing algorithms in all scenarios.

4. Conclusion:

This work introduced a real-time model called the Real Time Wind Based Power Approximation (RWPA) model. The main objective of this model is to ensure power stability and voltage management. The proposed method tracks and monitors the power supply generated by different wind power networks. The method utilizes the available data to calculate wind regulation support (WRS) and power generation support (PGS) based on factors such as voltage production and supply. The approach calculates the Power Distribution Support (PDS) value for different grids based on these two criteria. The approach chooses the power supply grid based on the value of PDS. The proposed method enhances the efficacy of power stability and voltage adjustment.

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