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Applications of SCADA in Wind Power Plant- An Overview

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Abstract

In this paper the various applications of SCADA system in wind farms, challenges and implementing SCADA system in wind power plant were overviewed. This paper shows the usage of SCADA systems to monitor the turbine parameter from the remote terminal area. This paper also gives view on overcoming the challenges in SCADA implementation, control system considerations and contractual requirements for SCADA. In this paper SCADA reliability and reliability standards were overviewed.

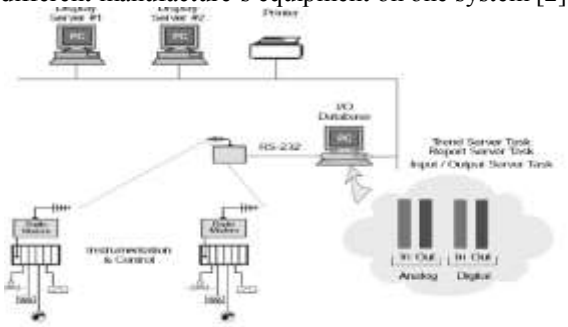
Keywords: SCADA, PLC, RTU, PPC, WEC, PRC, CIP, NERC

Introduction

Wind energy is one of the fastest growing sources of renewable energy in the world, which could reduce the emission of carbon dioxide in order to improve the current severe situation of environment. Therefore, more and more special treatments are focused on wind power generation. A room consists of system analysis of every turbine at every wind farm and looks like a NASA mission control. SCADA system is used to monitor the performance and efficiency of every wind turbine and it detect any danger or failure. PLC, power converter, control board and Input/ Output device all the elements are enclosed in a control box, which is kept in every wind turbine. Sources are used for wind speed, wind direction, shaft rotation speed

The wind turbine can be turned into the proper direction for obtaining maximum power generation by detecting the wind direction; the control system can use a motorized yaw gear to turn it. All wind turbines are connected to a LAN which is connected to remote control station running a control system which manages and collect data and detect failures [1].

In general, SCADA is a mixture of data acquisition and telemetry which consists of remote measurements, reporting data and monitoring information. Hardware and software are the major parts of SCADA systems. Hardware SCADA systems consists of RTU which provides interface to the analogue and digital sensors located at each site and RTU is made in number to collect and sends data back to the main station. Software SCADA systems are divided into two types as open source and proprietary. The companies use proprietary hardware to communicate to the specific hardware. Open source system software consists of important feature as inter-operability which is use to mix different manufacture's equipment on one system [2].



SCADA systems records error signals availability and energy output and control the following factors like power factor, voltage, reactive power production. The advantage of using PcVue in the SCADA system is that it provides free data reporting irrespective of wind turbine because it is not tied to any PLC vendor. It provides capability for the management and traceability for various version of application. The automatic updating of station is also

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done by PcVue GUI interface and provides information about the turbine signals [1].

Requirements and functions of SCADA

Requirements

1. To increase reliability and availability through analysis and monitoring
2. Optimum utilization during operation
3. Consistent compliance with grid
4. Cost efficiency of operations through secure access
5. Scalability and integration through approach of SCADA

Functions

Monitoring and data acquisition:

The monitoring and data acquisition system provides the following features:

1. Alarm notification, event view, online production view PPC measurements are the consistency of monitoring views.
2. Integration of monitoring of turbines and substation into the operation centre.
3. S upports easy interface.
4. Allows plant control functionality into control centre and simple integration of wind turbine.

Reporting and diagnostics:

It provides the following factors for reporting. They are

Availability:

- The changes in data is done by shadow data correction

Time based availability

- The values are calculated based on service and availability agreement
- Collecting data's at specific site

Production:

1. Additional data's are added with already existing data to show correction
2. At curtailment, the lost production is calculated
3. In case of missing data look at neighboring turbine
4. Over a custom period, shows detailed production

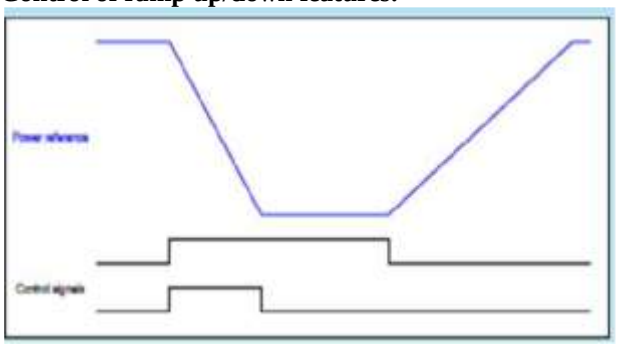
Performance:

Power curves are drawn for wind and power distribution, exclusion of sectors, periods with curtailments, air density correction etc

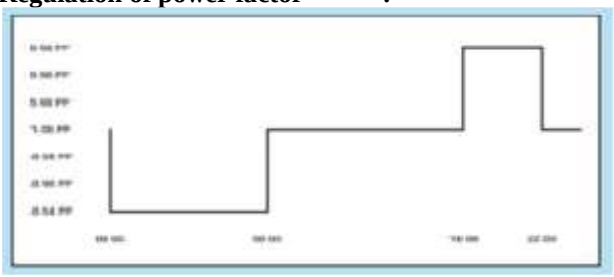
Compliance and control:

Power plant controller (PPC) offers advanced wind power plant control and ensures compliance. Advanced wind power plant control also offered by SCADA system.

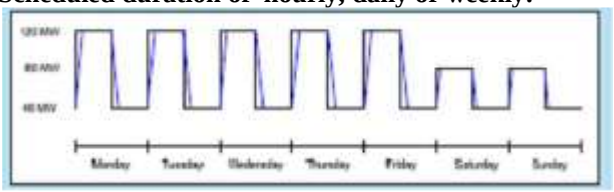
Control of ramp up/down features:



Regulation of power factor :



Scheduled duration of hourly, daily or weekly:



[Source: vestasOnline world wide grid compliance][4]

Functionalities of wind farm

- Online visualization of all the parameters and whole wind farm can be monitored in a single screen.
- Controlling the WECs (wind energy converter).
- With remote and also setting limits with help of remote.
- Error occurred is diagnosed and alarms and warnings are given.
- Analysis and generation of reports.
- The wind farm is controlled as per the requirement utility.
- Wind farm optimizing and wind forecasting for maximum output .

Challenges in developing and implementing SCADA

According to paper [7], challenges in developing SCADA are as follows,

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- Interfacing with turbine controller
- Protocol development and implementation
- Setting up the communication network
- Developing the SCADA software
- Database
- Report and analysis
- Open interface
- Remote connectivity
- Central sever
- Web interface

The way to thrash the challenges:

Interfacing with turbine controller:
Some typical interfaces are RS232, which can communicate only up to 2 or 3 meters, RS485 which can communicate up to 800 meters or 5km with repeaters Ethernet (RJ45) communicate up to 5km in wireless and in OFC.

Protocol:
There are two types of protocol such as proprietary protocol and an open protocol like Modbus, Profibus, Canbus, and Tcp/ip etc...

Setting up the communication network:
A proper communication should be done in different types of network by using different technology like wireless, optical fiber, copper cable, GSM, VSAT to get maximum efficiency.

Developing the SCADA software:
The SCADA software with different options can be developed. Some of them are as follows

- The communication software protocol with languages like VB, NET, C, C++
- Third party available drivers for communication protocol like Modbus and SCADA tools like wondeware, movicon, IFIX.

Database:
For every 10 minutes, all data's should be recorded without any errors and alarms, by implementing the database in text or proprietary files or with Microsoft SQL server, MY SQl, oracle.

Reports and analysis:
Generation reports of daily, weekly, monthly, yearly, periodic parameters at any time by customized reports, error and alarm analysis, power curve analysis, graphs and charts of plf, machine and grid availability are the reports and analysis.

Open Interface:
OPC interface is implemented for taking online and historic data to and from other systems like substation, metrological.

Remote connectivity:
By using different options like VSAT, high speed GSM, WI-MAX, broadband, VPN, ISDN lines different wind farm is connected to a central server.

Central server:
It is used to connect different wind farms to a central server where data is connected and analyzed.

Web Interface:
This is used as web application to run wind farm server or central server for collecting data's.

Wind turbine reliability

For improving wind turbine reliability SCADA alarm analysis should be used. In paper [5] to detect and locate wind turbine failure, the analysis of SCADA alarms are very much user. The cross-correlation between alarms by using probabilistic model and alarm optimization analysised and discussed.
In paper [5], example of wind turbine SCADA alarms to optimize alarm collection. Thus alarm analysis will help to improve the wind turbine reliability and in maintenance.

NERC reliability standards
The mission of North American electric reliability corporation (NERC) is to ensure the reliability of bulk power system and established specific series of standards for communications, transmission, critical infrastructure protection control(PRC).
The FERC approved the standards under provisions of 2005 energy policy act and also it approve the NERC CIP which governs cyber security under order 706 in January 2008.other standards like PRC-012-0 regarding RAS/SPS procedures and NISTIR-7628 v.10 which produce smart grid efforts[6].

IEC standards:
According to paper[7].IEC standards are as follows, the communications between wind power plant components such as wind turbine and SCADA system is provided by the series IEC 61400-25[7].The application of this area not only covers the wind turbine but also the wind power plant management system and others.

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It extends its development to technology of the IEC 61850 which includes data objects that describe power system equipment and services that provide data communication functions. The particular data types and services of communications technology is mapped using the data model.

IEC 614500-25 is further consists of two more areas of extensions of one which is the extension to cover equipment in wind plants such as switches, breakers, protective relays and transformers and 61850 objects.
The other extension area provides additional technologies except which is found in 61850.XML based web services is used to facilitate to exchange the data and gives improved compatibility with communication[6].

Advanced Wind Turbine Health Monitoring system

Advanced wind turbine health monitoring from SCADA done in Reliawind-super wind gen joint side event. According to their respect SCADA information should be used for the following purposes.

An unsupervised learning method for SCADA alarm clustering has been developed to facilitate automatic extraction of data from SCADA and an illustration of identifiable faults.
According to paper [8], the no of expression was created and analyzed for alarm clustering which is as follows

S.NO	EXPRESSION 1	EXPRESSION 2	EXPRESSION 3
1	TOP	TOP	
2	GROUND	GROUND	
3	CONNECTIONS	UPS CONNECTION	
4	LIGHT	LIGHTING	
5	RELAY AND BASE	RELAY BASE	
6	BLADE REPAIR	BLADE REPAIRING	BLADE REPAIRING
7	VIBRATIONS SENSOR	VIBRATION SENSOR	
8	YAW SENSOR	YAW SENSOR	
9	COMMUNICATION FAILURE	GROUND COMMUNICATION	
	GROUND	FAILURE	
10	GEARBOX FILTER REPLACEMENT	GEARBOX FILTERS REPLACEMENT	
11	LOW BUS VOLTAGE	LOW VOLTAGE IN BUS	
12	COOLING MOTOR FROZEN	FROZEN COOLING MOTOR	
13	ELEVATOR	ELEVATOR REPAIRING	

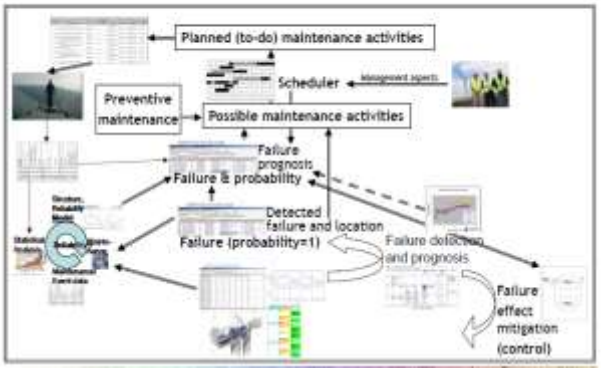
Signals used for failure location

According to the paper [8], SCADA signals have two major classifications to locate the failures. They are operational signals and functional signals .The operational signals of SCADA such as wind speed, shaft speed and power produced and the functional signals such as bearing and winding temperature and lubrication oil temperature, pressure and pitch angle.

Fault prognosis

In paper[8],to find the reliability of a system, the main factor to be considered is the estimation of the residual life time of a component. The life time of component of wind system is analyzed along with cumulative SCADA data. Thus the estimation of reliability of SCADA components is updated continuously.

System architecture



Wind turbine control

The systems within the turbine are controlled by the turbine controller. Some of the systems are pitch, yaw, generator and supervisory control systems. In addition to it, safety system protects the turbine hardware from damage in the event of a controller failure.

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Pitch:
According to the paper [6], stall regulated and pitches regulated are the two types of turbines. The function of stall regulated is to slightly vary the pitch angle of the blade and to limit the rotor speed and aerodynamic power.

By changing the pitch of the turbine's blades through electrical or mechanical linkages. The aerodynamic power and rotor speed of pitch regulated machine is varied. Blades can be pitched in three ways as collectively, independently or individually. Movement of all the blades at the same time to same pitch angle collectively pitched systems. Independent pitch systems use separate systems for each blade although blade angles are set to same pitch angle. An individual system is similar to that of independent system in which the pitch angle of each blade is varied to reduce aerodynamic loads [6].

Yaw:
The rotation of wind turbine into or out of the wind using drive motors called yaw system. Monitoring the time-averaged difference between the turbine yaw angle and wind direction by turbine control system will adjust turbine yaw angle into the wind once the difference becomes great enough over a set period of time.
The yaw system also unwinds the power and control cabling that is run between the nacelle where different component of yaw system can be placed and equipment located at the base of towers such as transformers and controllers [6].

Generator:
Variable speed turbines are capable of controlling the generator torque, which effectively controls the rotational speed of the turbine. The turbine controller is used to monitor the rotor speed and regulates the generated torque to get maximum output power and maintain the rotor speed below its rated rotational speed [6].

Supervisory:
According to paper [6], the supervisory control consists of logic and hardware necessary to operate autonomously from one operational state to another where the operational state consists of start-up, power production, shut down and stopped when faulted. Other functions is to cool the equipment like gear box, generator, power converter's fans, pumps, heaters and lubrication pumps.

Conclusions
SCADA in modern wind power plant is to predict wind power plant performance and to meet the contractual obligations including strict security requirements. Generally the efficiency of wind turbine is reduced due to faults. But with the usage of SCADA systems, wind turbine parameters are recorded to monitor their performance. Thus the SCADA system provides maximum power output, high efficiency and fault diagnostics and prognostics.

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