Numerical Data Analysis of Wind Turbine Systems

NDA of Wind Turbine Systems
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Numerical Data Analysis of Wind Turbine Systems

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Introduction

- Wind is caused by huge convection currents in the Earth's atmosphere, driven by heat energy from the Sun

- Wind energy is the kinetic energy of the large mass of air over the earth surface

- A Wind Turbine is a device that converts kinetic energy from the wind into electrical power

- Wind energy use is increasing about 2-5% of the domestic energy consumption at developed countries

- Wind power is not continuous, variable and non-dispatchable

- Industry has witnessed tremendous growth in Wind Turbine capacity & increase in wind farms across globe
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Problem Statement – Wind Turbine

- Blades, Hub, Nacelle & Tower typically forms the main components of wind turbines. Wind Turbine components are subjected to various kinds of failures like Sensor malfunctioning & component failures.

- Performance of wind turbines is measured based on turbine power output and input wind speed.

- Voltage fluctuations across wind turbines need to be monitored by adopting suitable numerical data analysis of the past data to predict the desired quality.

- Proper maintenance & early fault detection plays an important role during Wind turbine life cycle.

- Need of data-driven approach to ensure a continuous performance monitoring to be used for turbine fault prognosis and maintenance management.
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Why NDA?

- Overcome Limitations of DAQ systems
- Data-driven approach for performance monitoring & Forecasting.
- Techniques to reduce maintenance costs & Effort
- Sensor data Trend Analysis & Visualization
- Big Data Analysis, Wind Power forecasting & Predictive Analysis
- Data Mining & Data warehousing

Numerical analysis involves the study of methods of computing numerical data
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NDA Architecture

Feature List

- Import Data Files
- Data Analysis
- Early Fault Detection
- Range & Limit Check
- Trend Visualization
- Covariance Method
- Export Data Sources
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Wind Data Measurements

Model the wind data with various statistical Analysis techniques

Wind Data Measurements (SCADA) or Offline data (.txt & .csv) → Data Exchange with Matlab via OPC → Wind measurement Data @ Matlab Workspace

Wind Power Forecasting & Component Fault Prediction

Analysis Reports → Apply Statistical Analysis Techniques

Forecasting wind power and Component Fault Prediction using Wind Data
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NDA Flow for monitoring Systems

- Sensor Data
- History Data (data measured over past few years)

Configuration setup

Trend Visualization

Apply Statistical Techniques
- FFT
- Min, Max, Mean & Stdev
- Correlation Techniques
- Persistence checks
- Distribution checks
- covariance method

Reports
- Live Indicators

Faulty Sensors

Prediction about Sensor Behavior for next few months
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NDA Techniques for Wind Power Forecasting

- Wind power forecasting is a vital parameter in wind power operation
- Need to estimate short, medium, and long term power production
- Spectral analysis to estimate the power quality
- Forecasting are performed using time-series prediction & neural networks
- FFT & Power Spectral Density Analysis methods
- Step Change analysis techniques
- Distribution of Wind Speeds at various Hub Height
- Comparison of manufacturer's Power Curve & Calculated Power Curve
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Results: WindSpeed vs Models
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Infrastructure

- Matlab R2014a
- Data Acquisition Toolbox
- Signal Processing Toolbox
- Matlab Compiler
- Curve Fitting Toolbox
- OPC Toolbox
- Sensor Data
Benefits

- Reduce maintenance costs during operation
- Trend Visualization
- Early Fault detection & assisting Engineers in corrective measures
- Help design engineers to simulate the behavior with various data trends
- Easy to identify & calculate threshold values for various sensors
- Accurate results & Flexibility in handling data
### Future Scope of Work

- Fitting few more probability density functions to the measured probability distributions on regular basis
- More statistical checks before predicting sensor behavior
- Interfacing with database & managing data
- More flexibility to choose wind speed in mph & m/s
- More flexibility to choose wind Power units in Watts & Kilowatts
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