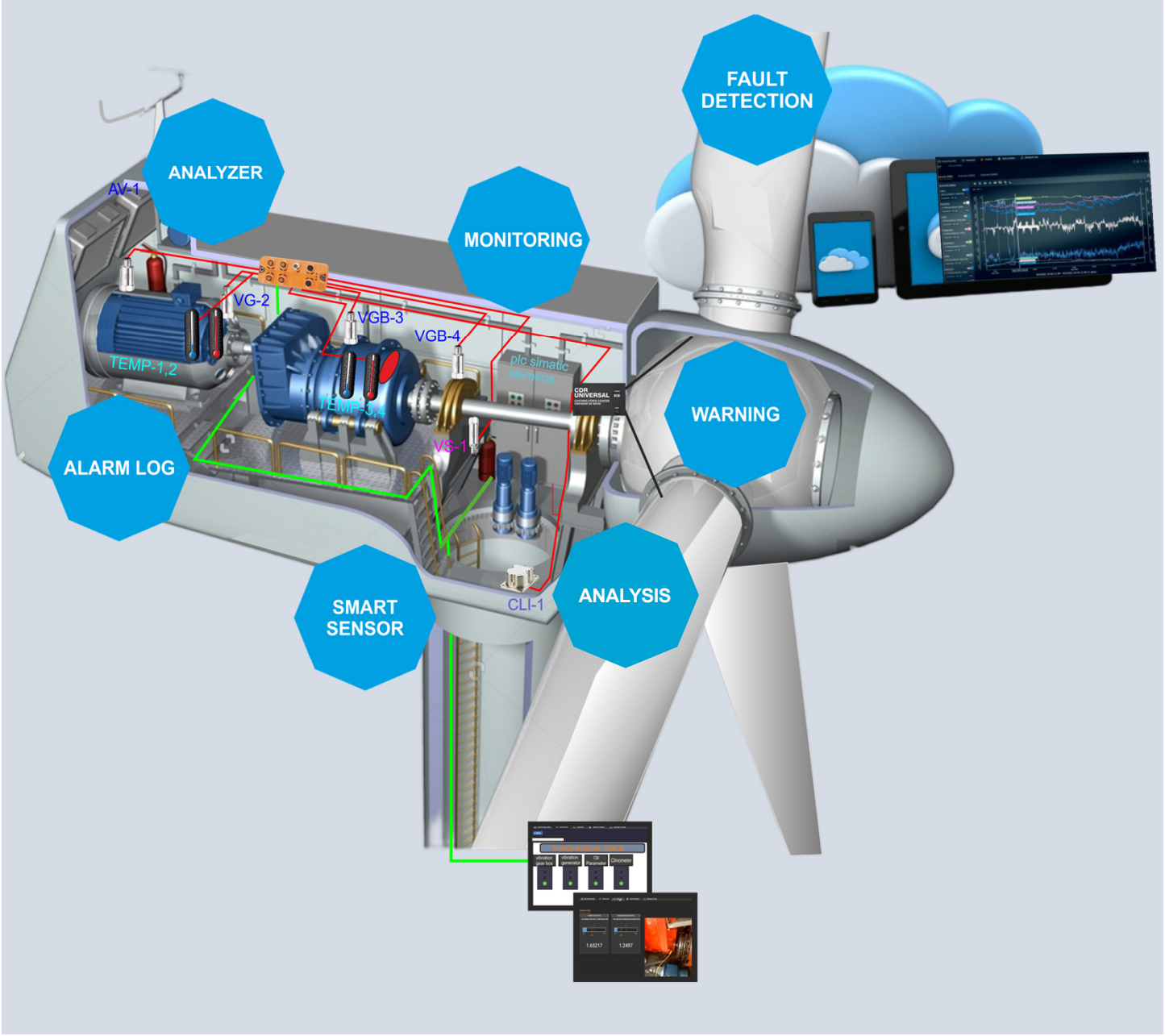
DUNE
ENERGÍA Y SISTEMAS

SHAI Monitoring System

IMPROVEMENT
AEROGENERATOR
HARDWARE & SOFTWARE

Automated real-time monitoring, data acquisition, and management system for physical parameter control in wind turbines



General Description:

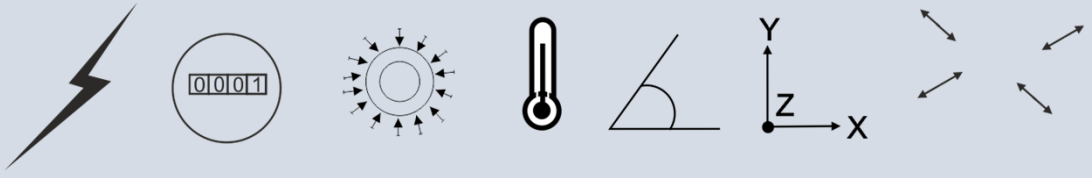
The SHAI system is an automated real-time monitoring, data acquisition, and management system specifically designed to control and analyze physical parameters in wind turbines.

It primarily focuses on monitoring older turbines from repowered wind farms, with the purpose of anticipating failures in advance to enable prompt corrective actions, thereby maximizing the service life of these second-use turbines.

Being a modular system, it can be adapted to the client's specific needs by monitoring different parameters according to each application's requirements. It allows for expansion of instrumentation points to areas beyond those presented in this dossier, including the monitoring of other parameters such as stresses through strain gauge techniques.

Main Monitoring Parameters:

- Vibrations and temperatures
- Various gearbox oil parameters
- Tilt/inclination
- Lightning strike counter
- Foundation to-tower base movements



Vibration Monitoring of the Gear Box and Generator

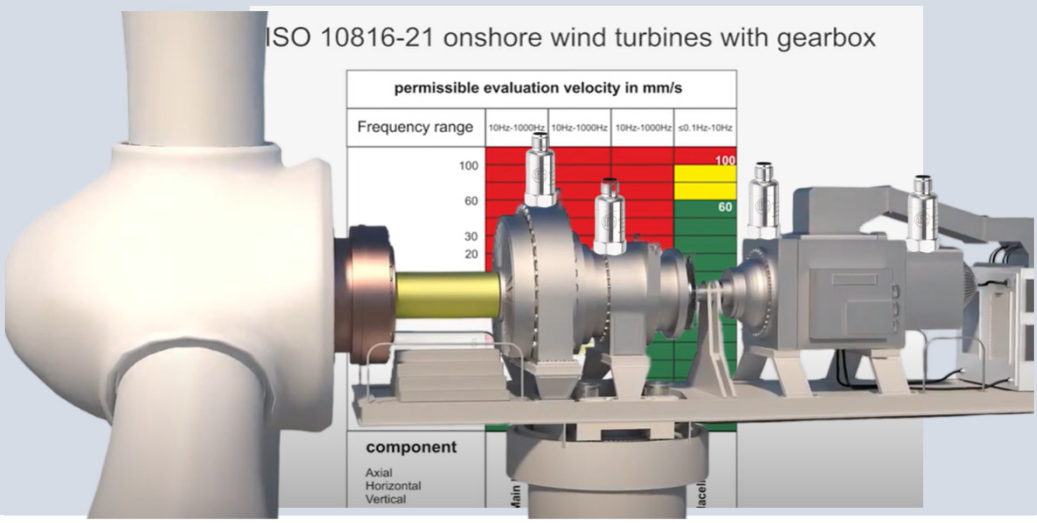
The vibration monitoring of the gear box and generator is carried out using intelligent accelerometers with IO-Link technology, with local data processing and network transmission to a central station.

The 4 accelerometers are of two types:
Unidirectional (1-axis)
Three-directional (3-axis),
with frequencies adapted to each application based on the zones where they will be installed. Each accelerometer incorporates a temperature sensor. Temperature is thus also recorder. Installation is performed by gluing with appropriate resins the sensor-holder elements housing the accelerometers.

The intelligent sensors equipped with artificial intelligence (AI) process the wind turbine's vibration data, applying algorithms to analyze its mechanical behavior. Unlike a simple measurement of momentary peaks, these systems calculate aggregate values based on preconfigured parameters, such as:

Maximums (critical vibration levels that could indicate imminent failures)
Averages (vibration trends over time to assess normal wear)
Minimums (reference values to detect anomalies under low-activity conditions)

This characteristic-value approach (v-RMS, a-RMS, a-Peak, Crest, and Temperature) constitutes the fundamental indicators for machine problem detection. The characteristic value of vibration velocity, v-RMS, is established in the ISO 10816 standard and measures the energy acting on the machine, enabling predictive and precise monitoring while avoiding false alarms from temporary variations



Measurement of Main Shaft Speed:

By means of an optical or inductive encoder installed on the main shaft, a precise RPM signal is recorded in real time. The data is integrated into the database together with the vibration measurements (uniaxial or triaxial) to generate the frequency analysis referenced to speed.

Measurement of Tilt Angle:

In the nacelle, a clinometer is installed to measure the tilt angle in real time, detecting rolling movements and dynamic stability under wind conditions, rotor rotation, or braking.
The sensor is directly connected to the central control station and is also integrable will also be integrable with the system for alarms and adjustments.

Oil Analysis System in the Nacelle

The system can monitor multiple oil parameters in real time, adapting to the specific nacelle type and requirements through the installation of specialized sensors.
The data is also directly integrated into the central monitoring platform, enabling early alarms for abnormal changes..

Lightning Strike Counter

It is a compact and robustly designed device for detecting lightning strikes in the lightning protection systems of wind turbines.

Displacement and Settlement Monitoring

Between 4 and 8 displacement sensors of the LVDT or non-contact type are installed on anchor points at the tower base to detect movements in the N, S, E, W directions, as well as Z-axis measurements. These are monitored similarly and equally integrated into the system.

System Architecture and Operation:

This is a distributed system with acquisition units based on IO-Link (sensor network) and two independent Ethernet networks: Profinet control network and IoT external monitoring network.

The central PLC control station is connected to the control network and is responsible for monitoring and determining whether thresholds have been exceeded, as well as managing the system's traffic light status indicator.

The system is designed to monitor the status of various components by continuously measuring values from sensors installed on the wind turbine. Based on predefined threshold criteria, it indicates whether a mechanical failure may be occurring and its severity level.

The system implements a traffic light status scheme:

Green: Normal operation
Yellow: Abnormal values detected requiring analysis
Red: Values detected that, if machine operation continues, could lead to significant damage.

During commissioning of each machine, a vibration-temperature-movement mapping will be performed according to operational regimes, using the RPM detectors from the main shaft (low speed) and generator (high speed - 750 rpm) as reference.

During normal wind turbine operation, the PLC will monitor the acquisition values. If any value exceeds the mapped reference curves by 25% (or customer-defined values) for a specified duration, it will generate an alarm condition, signaling and transmitting this value.

Values in engineering units and detected alarms will be shared with the wind farm network through industrial protocols OPC-UA, ModBus/TCP or IEC-104 as needed.

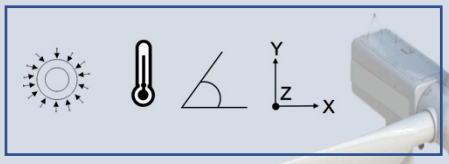
The system operates as an open architecture using industrial protocols and is capable of expansion to additional control points.

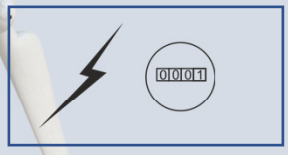
Our in-house developed SCADA system offers simple and adaptable data flow configurations, enabling local data storage (e.g., at the wind farm's control center) or remote transmission to cloud platforms or external databases. There are no limitations on flow configuration, ensuring seamless integration with existing systems.

Furthermore, our unrestricted license allows unlimited connections for visualization clients, whether desktop-based or web-accessible, for real-time monitoring at no additional cost.

System Architecture and Operation

Nacelle Parameters





Blade lightning strike counter

Dune´s Cloud Hosting

Monitoring System

Tower
Foundation
Displacement
Measurement

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