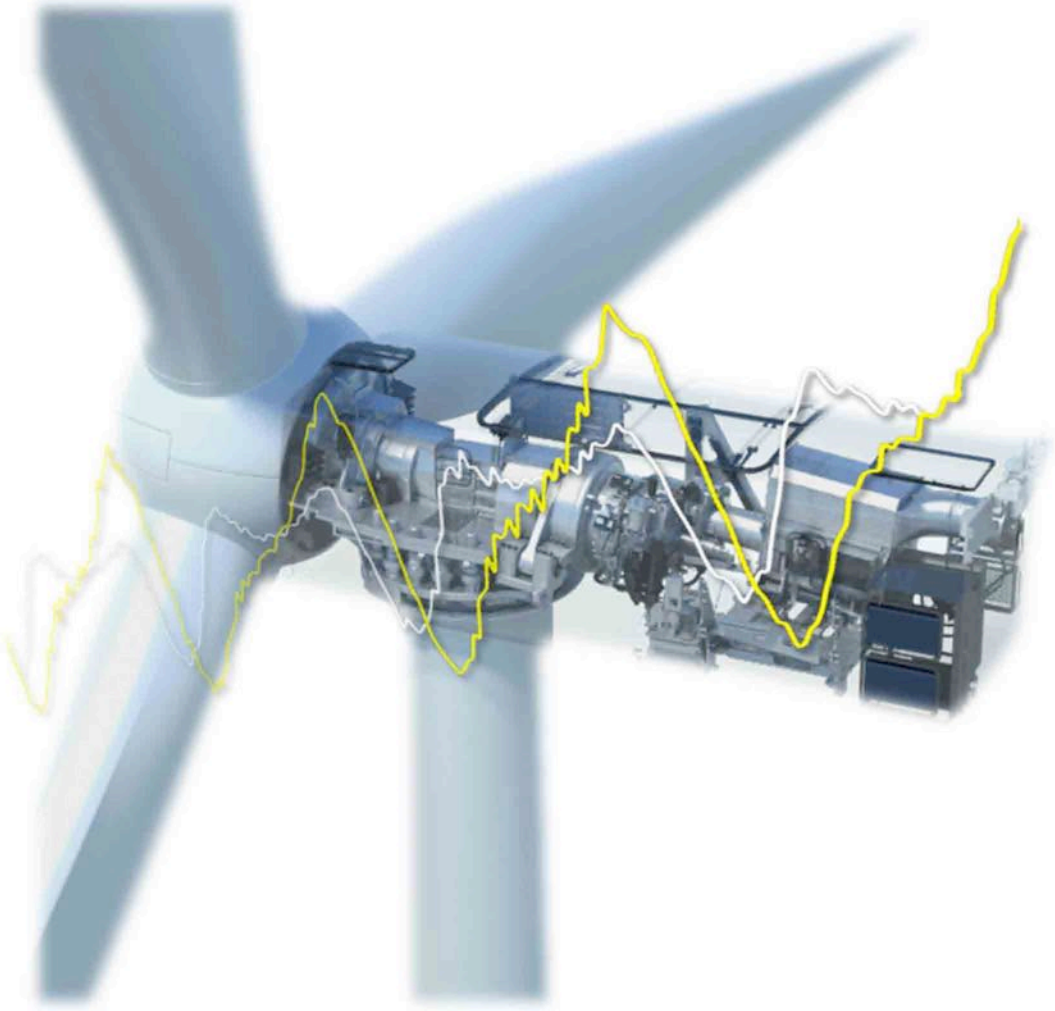
EQUIPMENT SPECIFICATION



1. INTRODUCTION

CUSTOMER is controlling a large fleet of wind turbines. They have showed interest in equipping these wind turbines with advanced monitoring system that can provide more information on equipment condition. Monitoring system will enable local and remote insight into measurement data as well as tracking measurements and events through history database.

2. SYSTEM SCOPE

For each selected machine measured values, number of sensors, sensor installation positions will be provided. Each measurement has unique label according to the legend.

LEGEND:

1 → *measurement zone:*

- ***1*** *- generator*
- ***2*** *– gear box*
- ***3*** *– pitch and yaw control motors*

2 → *measurement type:*

- ***a*** *- absolute vibration* ①
- ***r*** *- relative displacement* ②
- ***t*** *- rotating speed* ③
- ***T*** *- temperature* ④
- ***c*** *- current* ⑤
- ***v*** *– voltage* ⑥
- ***d*** *- displacement* ⑦
- ***SC*** *– shaft current* ⑧
- ***P*** *– process values* ⑨

3 → *measurement direction or sensor number:*

- ***x*** *- x direction*
- ***y*** *- y direction*
- ***z*** *- z direction*
- ***xyz*** *- triaxial measurement direction x and y and z*
- ***1*** *- sensor no. 1*
- ***2*** *- sensor no. 2*
- ***3*** *- sensor no. 3*

Figure 2.1 presents measuring layout. There are 3 main zones in which measurements will be performed.

In Zone 1 (generator zone) fallowing measurements will be performed:

1c1, 1c2, 1c3 – 3 phase current measurement (output of the generator)
1v1, 1v2, 1v3 – 3 phase voltage measurement (output of the generator)
1a1xyz – absolute generator bearing housing vibration measurement
1rx – relative shaft displacement measurement
1ry – relative shaft displacement measurement
1rz – axial shaft displacement measurement
1t – rotating speed measurement

1SC – shaft current measurement
1T1 – generator temperature measurement
1T2 – generator bearing temperature measurement (DE: drive end)
1T3 – generator bearing temperature measurement (NDE: non-drive end)

Detailed description for each measurement from Zone 1 is provided in 2.1 chapter.

In Zone 2 (gear box zone) fallowing measurements will be performed:

2a1xyz – absolute housing vibration measurement
2d – breaking pad wear measurement
2T1 – gear box bearing temperature measurement (GE: generator end)
2T2 – gear box bearing temperature measurement (TE: turbine end)

Detailed description for each measurement from zone 2 is provided in 2.2.

In Zone 3 (pitch and yaw control motors) fallowing measurements will be performed:

3c1 – motor current phase measurement (yaw motor no. 1)
3c2 – motor current phase measurement (yaw motor no. 2)
3c3 – motor current phase measurement (yaw motor no. 3)
3c4 – motor current phase measurement (yaw motor no. 4)
3c11 – motor current phase measurement (pitch motor no. 1 – blade 1)
3c12 – motor current phase measurement (pitch motor no. 2 – blade 1)
3c13 – motor current phase measurement (pitch motor no. 3 – blade 1)
3c21 – motor current phase measurement (pitch motor no. 1 – blade 2)
3c22 – motor current phase measurement (pitch motor no. 2 – blade 2)
3c23 – motor current phase measurement (pitch motor no. 3 – blade 2)
3c31 – motor current phase measurement (pitch motor no. 1 – blade 3)
3c32 – motor current phase measurement (pitch motor no. 2 – blade 3)
3c33 – motor current phase measurement (pitch motor no. 3 – blade 3)

Detailed description for each measurement from zone 3 is provided in 2.3.

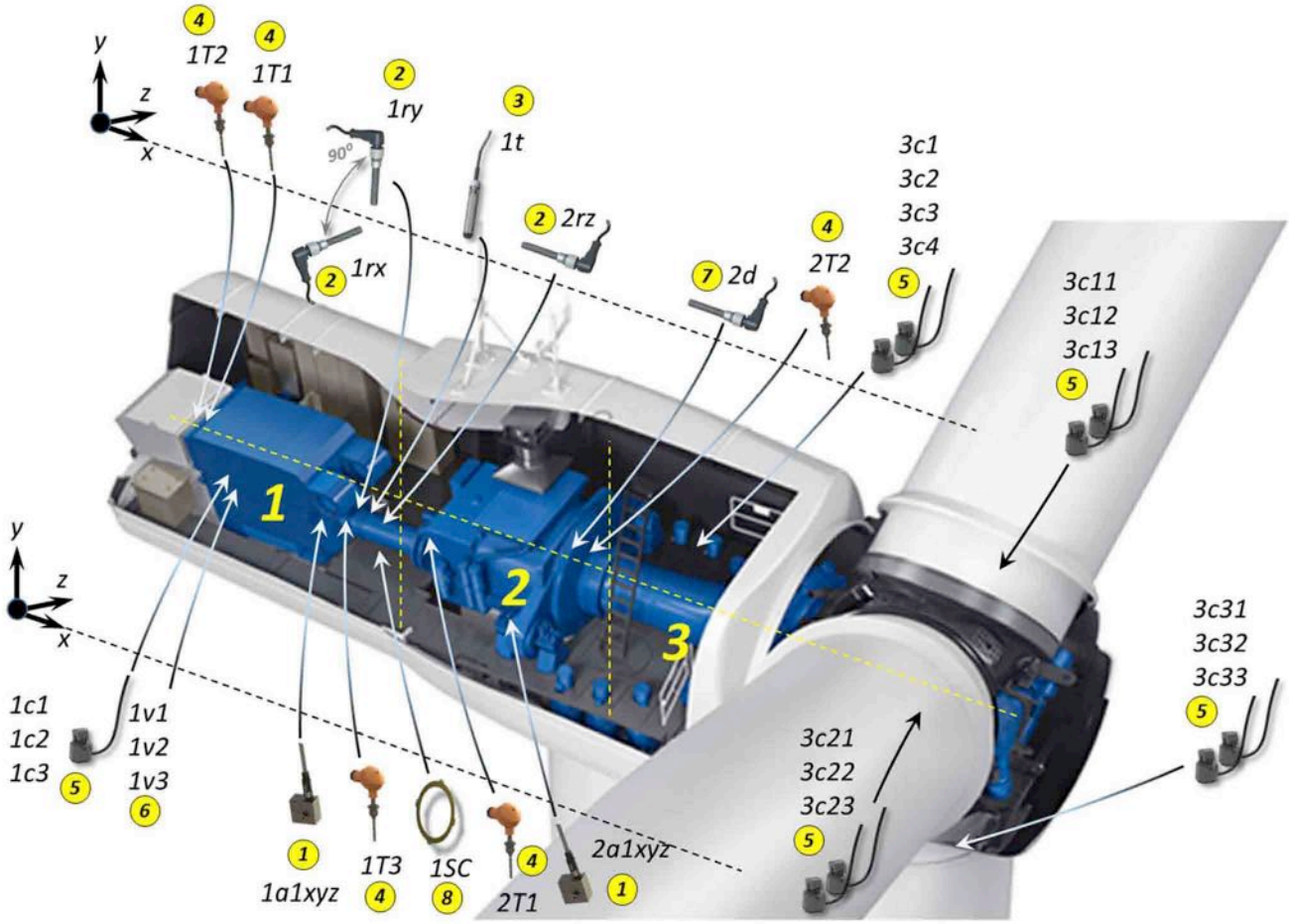


Figure 2.1. Measuring layout

2.1 Zone 1 measurement specification (generator)

2.1.1 Generator current measurement

Generator current is measured with current transformer (split core) like presented on Figure 2.1.1. Current sensor is designed for assembly to an existing motor cable without the need for dismantling bus or cables.

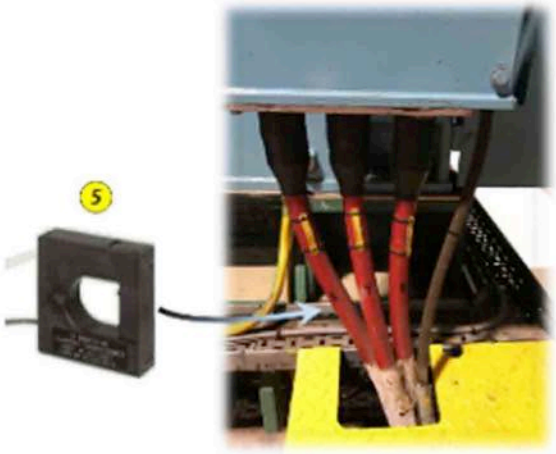


Figure 2.1.1 Generator current measurement sensor

4. SYSTEM CONCEPT AND DESIGN

system is realized as a combination of measurement sensors, programmable processing unit associated with measuring modules, application program that manages the process unit and necessary wiring. The concept of the system is presented in figure 1.

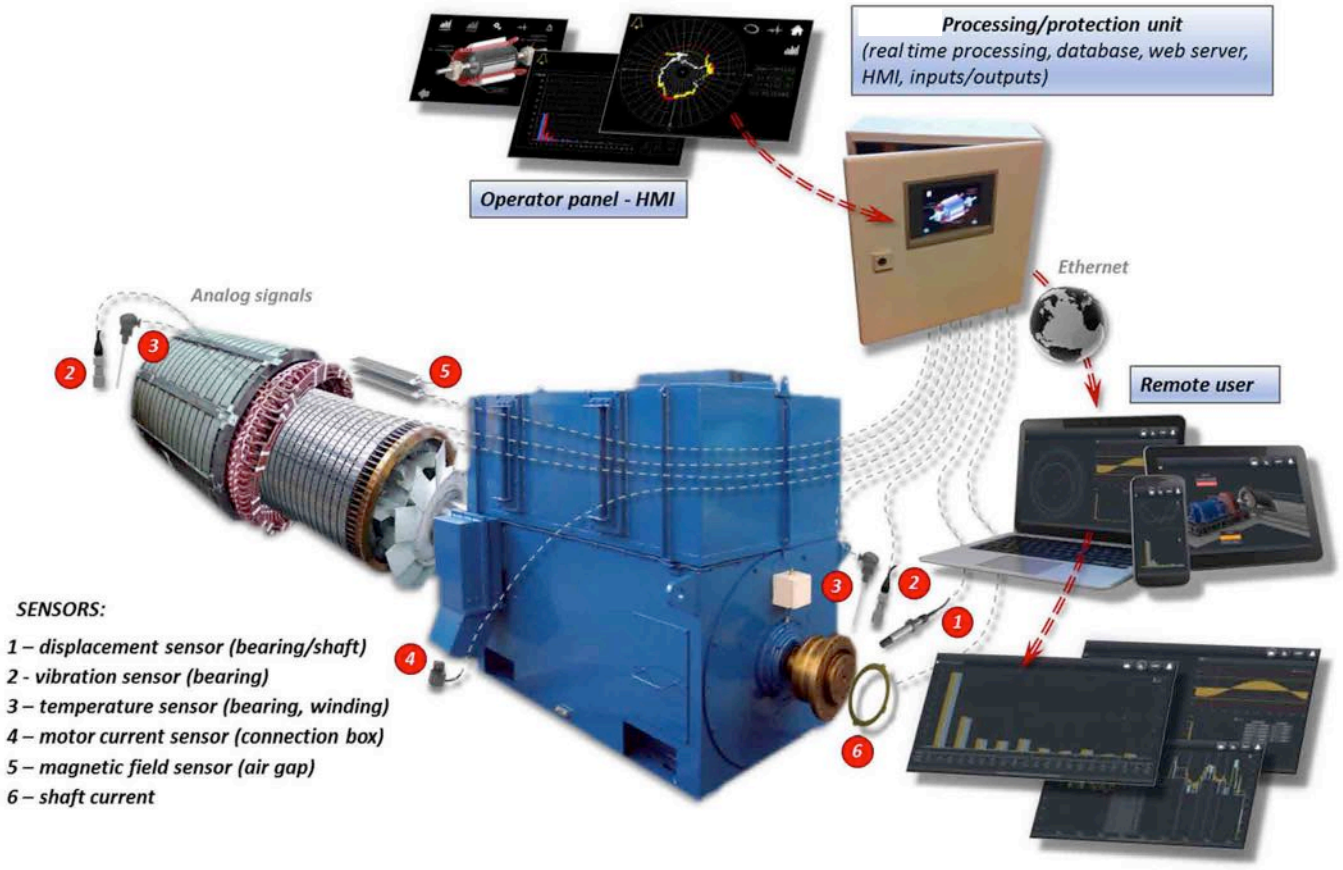


Figure 1. system concept

The system runs automatically as soon as there is the voltage on the input terminals and no additional actions for the system start are needed.

4.1 THE FRONT EDGE (measuring sensors and signal conditioners)

Measuring sensors are installed in such a way that they do not affect the existing measurements or machine construction, and their replacement and adjustment are provided in a simple way. Sensors are installed using the appropriate elements for installation, which include protective covers for sensors that prevent potential mechanical damage to the sensor. Figure 4.1 presents typical installation of the sensors for measuring relative displacement of the machine shaft (position 1) and machine rotation speed (position 2).

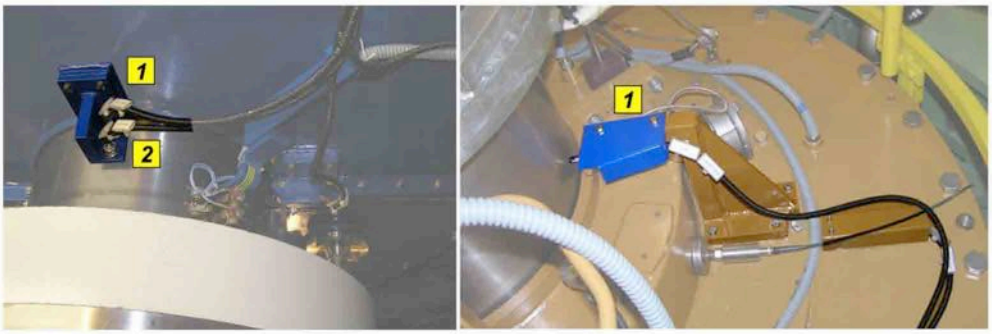


Figure 4.1. Typical installation of the sensor for measuring relative shaft displacement (position 1) and sensor for measuring vibrations of the bearing housing (position 2)

Sensor cables are properly fixed and protected by steel flexible protective tubes to prevent mechanical damage to the cables due to exploitation and thus jeopardize the reliable operation of the monitoring system. Sensor signal cables are led directly to the electrical cabinet i.e. processing unit.

4.2 PROCESSING/PROTECTION UNIT WITH ASSOCIATED MEASUREMENT MODULES

Processing/protection unit receives the signals from the measuring sensors, performs analog signal filtering, analog/digital conversion (digitalization), signal processing, enables a protective function via digital outputs (relays) and communicates with the master and slave systems by a standard-based communication protocols.

Processing unit along with measuring modules, terminals, power supplies, network equipment and related wiring is installed in a processing unit cabinet (Figure 1.3).

Figure 4.2. Electrical cabinet for measuring equipment

Processing unit cabinet is delivered fully examined and tested per the standard procedures and relevant standards. Monitoring system is delivered fully configured in accordance with the system requirements. In addition to standard tests, functionality of the cabinet and processing unit along with measurement modules and sensors will be demonstrated to the Customer during commissioning.

Industrial design of the processing unit ensures a reliable operation in the extended temperature range from -20°C to 70°C.

In addition to measurement and data display through local touch panel, the processing unit enables the analysis of the measured results, diagnostic monitoring, alarm generation,

recording/storing of measurement data and communication with other systems. Standard industrial protocols compatible with the existing power plant systems are used.

All measurement data are available from the database with a complex structure and data compression for a lifetime of the machine. Tools for system administration, user administration, setup and administration of the alarms, system of program help and system of easier navigation through the program are included in the delivery. All software is supplied with the appropriate licenses.

Operator panel with touch screen is used for the local visualization of all the measurements. It is embedded in the front door of the electrical cabinet of the system.

Users can get an insight into measuring data through local touch display (local HMI) and through web server (web application). Local visualization enables insight into real-time data, waveforms, spectrums, trends and setup. All screens can be modified per the Customer's requests which include native language. Figure 4.3 presents a typical user's screens for local HMI (operators display on electrical cabinet).

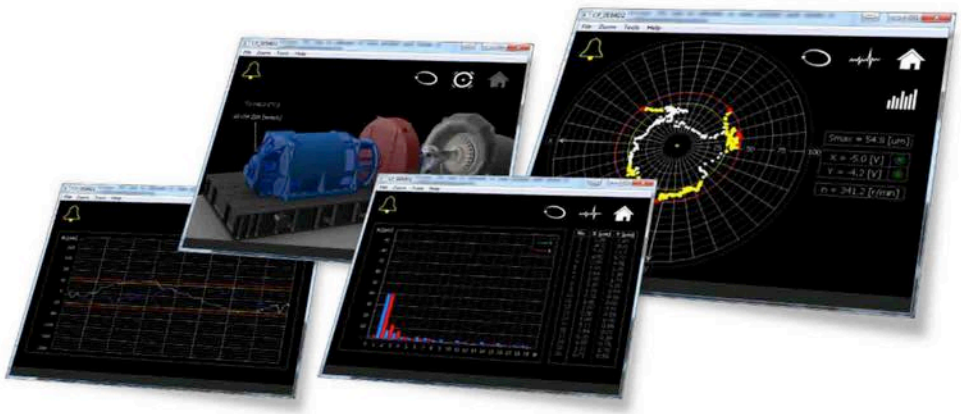


Figure 4.3. Typical user screens of the local HMI

The system is equipped with a multiuser web server that enables a connection and overview of all the system data by using a standard web browser. This web server provides an access to the monitoring system from any desktop or a laptop computer (with Windows or iOS operating system), tablet (with the iOS, Android OS…) or smartphone (with iOS, Android … operating system). System access is provided without the need for installation of additional software by using a standard web browser (Google Chrome, Internet Explorer, Mozilla Firefox, Safari …). Web server can simultaneously serve multiple users (at least 50 simultaneous connections). Figure 4.4 presents a typical user's screens of web application.