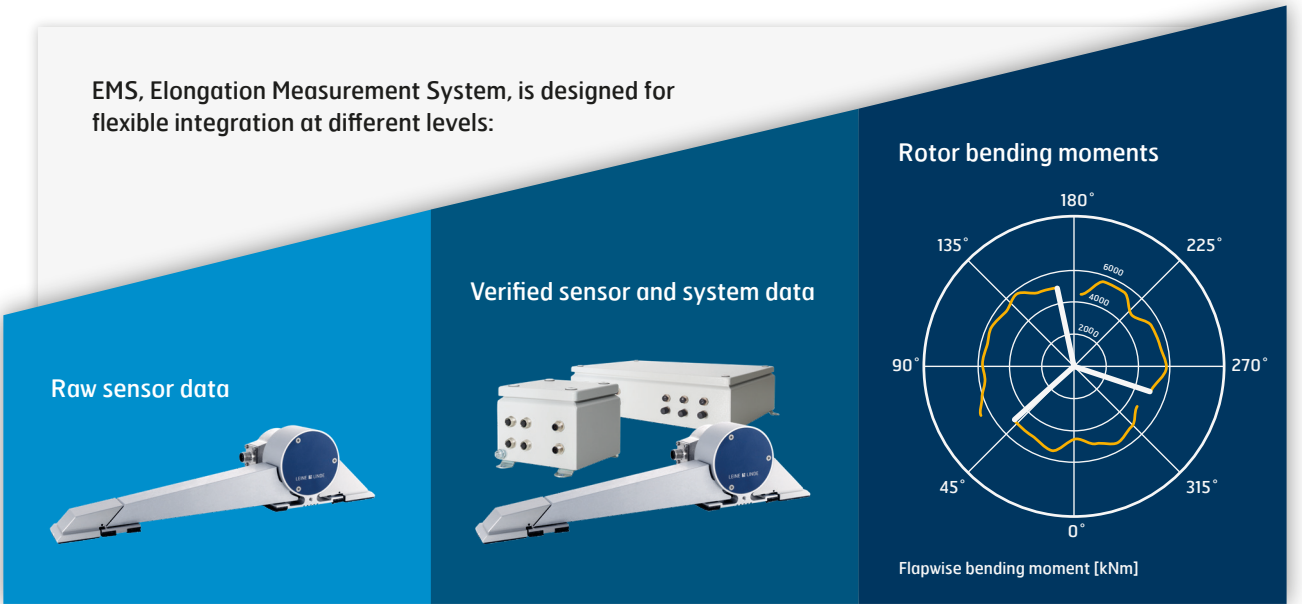
Cost reduction through EMS

— From integration to operation of wind turbine generators



Cost reduction through EMS strain measurement system — From integration to operation of wind turbine generators

Current wind turbines in the 4-MW class and larger increasingly use rotor blade based strain sensor systems in order to reduce operation-related loads of the turbine and at the same time increase energy production. Various factors play an essential role in selecting the right measurement system. The Elongation Measurement System (EMS) offers here a comprehensive approach that attempts to optimally support all involved interfaces of the wind turbine manufacturer – from integration to operation – on the basis of a seven-phase concept.

The seven phases comprise the following sections:

1. Presentation of the strain measurement system
2. Guidance throughout system installation
3. Support in system design and integration
4. Integration during production
5. Prototype testing and certification of the wind turbine design
6. Guidance during the 0-series introduction
7. Technical assistance during series operation

Phase 1: Presentation of the strain measurement system

Our application specialists leverage their long-standing experience in the wind industry to help customers familiarize themselves with the EMS (figure 1) and scope of functions available as well as to become aware of the system's limits already during the first exploratory talks.

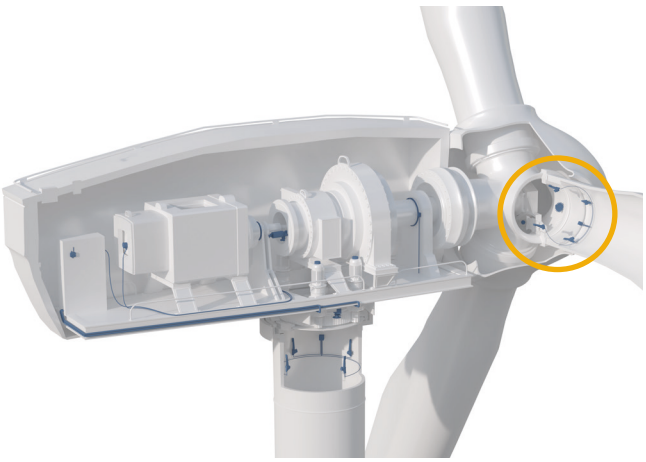


Figure 1. EMS installation in the rotor blade

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Phase 2: Guidance throughout system installation

On the customer's request, our application specialists provide support directly at the turbine for initial installation of the sensors including connection of the hardware to the data loggers. For this purpose, they regularly attend the necessary trainings such as "GWO Working at Heights" to continually meet the requirements for access and climbing of WTGs.

Phase 3: Support for system design and integration

During system design and integration, customers can choose from a wide variety of different combinations of strain sensors + gateways + evaluation unit (figure 2) available for system operation. In the process, the experiences gained in the broad-based phase of system tests feed into the integration of the EMS in the WTG design.

Along with positioning of the strain sensors, usually installed in the rotor blade's root area, it is also possible to install system components like gateways and evaluation units in separate housings in the blade root and hub.

A central connection for power supply and the fieldbus gateway are only prerequisites. This solution is very useful for retrofitting already installed WTGs, if there is not enough space in the pitch system's cabinets available.

Another option is to integrate gateways and evaluation units as a whole into the existing pitch system's cabinets. Such a system that is highly integrated into the WTG design is also capable of facilitating the use of all metrological and evaluative capabilities. Moreover, this is the cost optimized solution which is perfectly suited for the equipment of the wind turbine ex works.

Even lightning strikes that penetrate into the tip or the middle segment of the rotor blade, which could set off induced loads in the sensor or sensor cable, are no risk for the sensors installed in the blade root. This evidence was gained in tests of the system design and/or electromagnetic compatibility (EMC) according to 61400-24:2010 conducted in the high-current laboratory.

Figure 2. ESR sensor, VRG Gateway and PDB evaluation unit

Phase 4: Integration during WTG-manufacturing

Integrating the measurement system during manufacturing and here specifically rotor blade manufacturing is a major sensitive step. If requested by the WTG manufacturer, application specialists can support correct and process reliable installation, also on site.

The ESR strain sensors can be installed in the rotor blade factory (figure 3) as well as during retrofitting of already installed wind turbines. The sensors then are usually bonded in the root area of the rotor blades. Testing devices for process-reliable progress and finish are available, which can directly be connected to each individual strain sensor. Two of the devices available with their respective functionality are listed below:

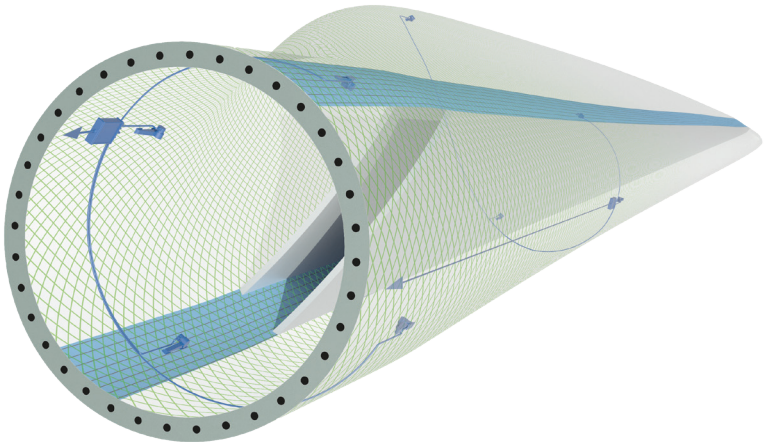

Figure 3. Sensors in the rotor blade

	PWT 101	SCM 1000
Interface to sensor	EnDat 22, D-Sub Adapter cable available	EnDat 22, 8pM12 Direct connection to the sensor
Interface to subsequent electronic	-	W-LAN / OPC UA
Number of connectible sensors	1x	1x, several sensors can be simultaneously displayed and managed in the app
Display	Yes	No / display via Android or iOS App
Power supply	24 VDC, external power supply	5 VDC, external power supply
Integrated sensors	No	3-axis accelerometer sensor, temperature, humidity, air pressure
Functions	Display of current measured value, internal temperature, electronic type plate (name, part number, serial number), current sensor condition (rating figure), setting the zero-/reference position of the digital signal	Current measured value, internal sensor temperature, electronic type plate (name, part number, serial number), current sensor condition (rating figure), setting the zero-/reference position of the digital signal, current acceleration values, temperature/humidity/air pressure of the SCM 1000. Display type plate information of the strain sensor, display of the measurement arm material, display sensor resolution during elongation, path

The PWT 101 (figure 4) is a simple display device which allows a single installed strain sensor to be tested in the final step of rotor blade production and/or before the commissioning of the system.

The SCM 1000 can be integrated considerably deeper into production system and quality control, since a direct connection is available for recording, inspecting and documenting of each individual sensor installation in the production environment thanks to the standardised W-LAN/OPC UA interface.

With both the PWT 101 and the SCM 1000, especially setting the zero/reference position of the digital signal is a very practical function, as it allows the OEMs to determine a uniform and defined starting point. This facilitates for example the later system calibration, in which the transfer function for the conversion of the measurement signal into physical quantities is determined

Figure 4. PWT 101

Phase 5: Prototype testing and certification of the wind turbine design

The phase of prototype design and WTG type certification is a further critical milestone during system integration. Thanks to the extensive information prepared relating to sensors and components, all relevant documents are already available for this phase. This has the benefit of eliminating waiting periods due to pending documentation and therefore prevents delays in the overall project progress.

Sensors, accessories and spare parts can also be made available for WTG prototype installation in a fast and straightforward way.

Testing operation of the wind turbine, and the application and adaptation of the controls to the strain sensor signals is usually easy. Measuring results produce significantly lower noise compared to analogue strain sensors due to the measurement signals directly digitalized in the sensor, thus leading to a greater signal quality which allows to better integrate the useful signal for the turbine controller.

Phase 6: Guidance during the 0-series introduction

During the 0-series introduction of the system into the WTG design, the OEM can draw on our application specialists. Last optimization steps are jointly taken in the installation process to ensure a progress suitable for the series. Their design allows strain sensors to be installed in the rotor blade very easily, also by semi-skilled personnel. If in this phase, training may still be needed to ensure faultless installation, which can be carried out by our experts both directly in the rotor blade factory but also in the installed turbine.

Phase 7: Technical support during serial operation

In the longest of the stated phases, serial operation, we support the OEM performing various activities and functions.

Firstly, the strain sensor provides a diagnosis of its own which continually informs about the electronics own condition. This information can additionally be queried from the WTG-control via the digital interface, which is the fastest and most simple way to evaluate each individual sensor's condition and carry out a planned replacement if necessary. Here we rely on a sensor rating value that is easy to understand and implement, which evaluates its own condition on the basis of 0...100% and comprises various condition performance indicators. Sensor replacement is recommended when threshold values are undershot.

Moreover, the OEM's own service division can be equipped with the SCM 1000 + app for Android and iOS operation systems. The service thus boasts an easy and cost-effective tool to inspect the strain sensors. Programming the zero position allows for setting a defined zero position with an installed WTG, even when the strain sensor has already been replaced. This facilitates rapid on-site replacement with simple means.

The fact that the ESR sensor series is based on industrially manufactured encoder technology enables quick supply of spare parts and thus facilitates parts stock holding. Especially for short-term demand of replacement sensors, our service division maintains some devices in our own stock in order to keep downtimes of a wind turbine as short as possible.

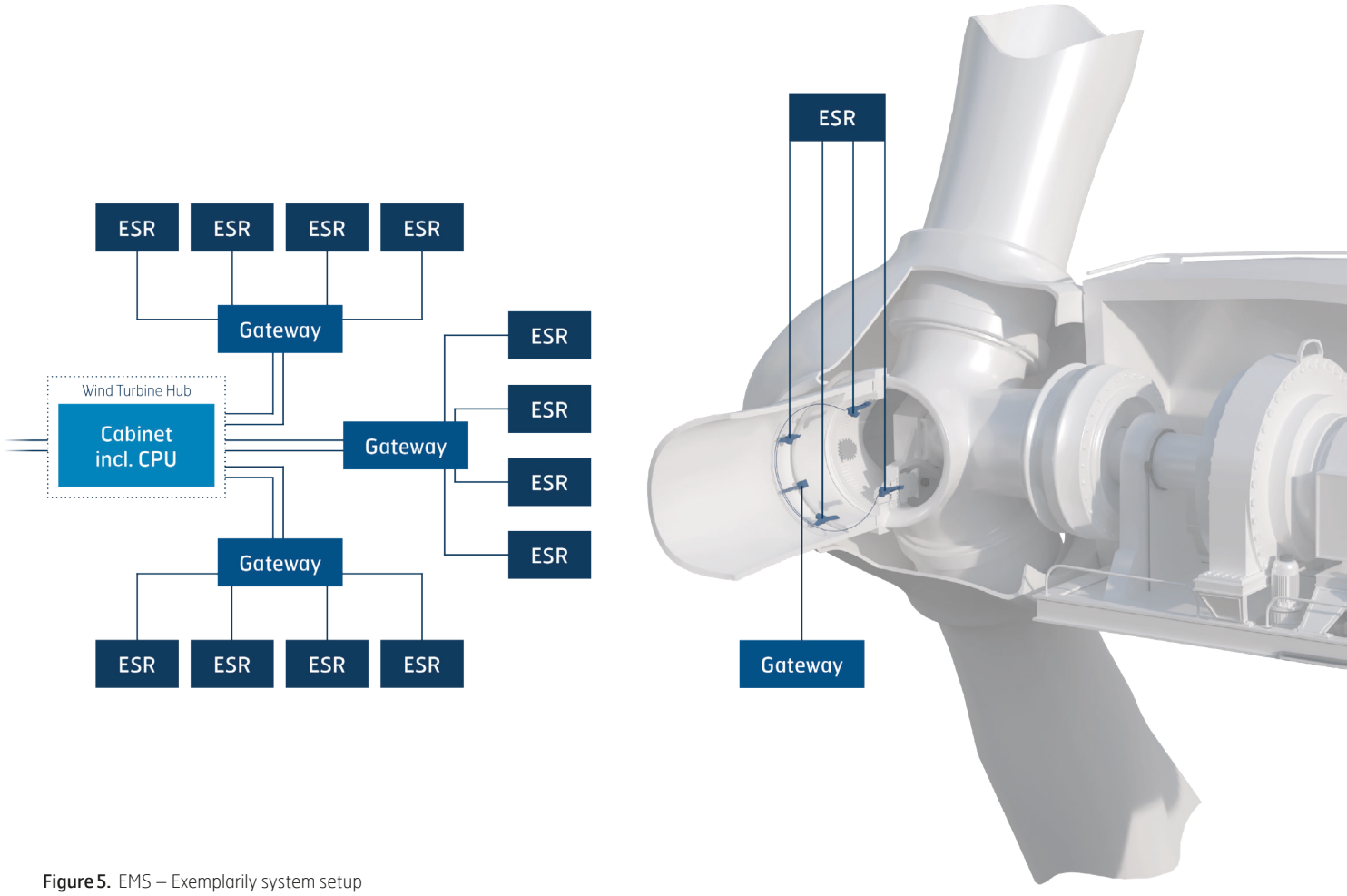

Figure 5. EMS – Exemplarily system setup

Summary

Our comprehensive approach provides optimal support to wind turbine manufacturers in each phase of both EMS integration and operation (figure 5). System integration can thus be performed expediently and efficiently and the operation managed over the entire service life as free as possible of unplanned downtimes. All this together reduces the costs incurred for integration, manufacturing and operation of the wind turbine when using the Elongation Measurement System (EMS).

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