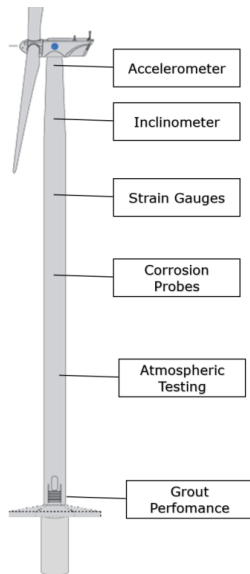




## CMSSHM Structural Health Monitoring

Structural Health Monitoring software (CMSSHM) is a plugin to our standard Condition Monitoring Software, which enables the continuous measurement and recording of raw data. The software also postprocesses the data to give a continuous on-line record of the condition of towers and sub-structures.

The system comprises measurement hardware as well as the CMSSTD software. At the simplest level, the system can operate from a single 2D MEMS Accelerometer. However a much more detailed assessment can be built by incorporating a range of different sensor types measuring at various levels and locations within the support structure (tower, transition piece and foundation).



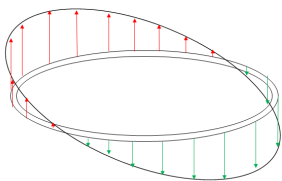
A Finite Element Model converts data from a small number of measurement positions into an overarching model of the whole structure, providing a Digital Twin which calculates motion, loading and eigenfrequencies of the structure from a continuous stream of live data.

Rainflow counting and damage equivalent loads are used to assess ongoing fatigue damage to the structure. Through comparison with particular damaging events (e.g. storms) and operating conditions future operation can be optimized.

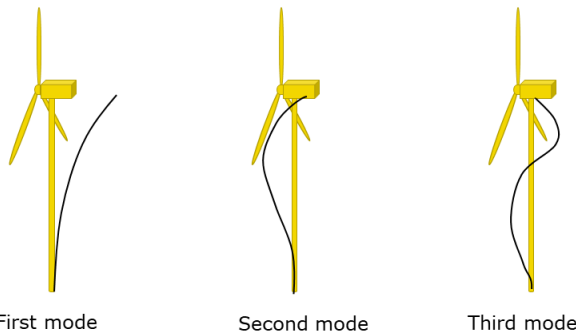
Knowledge of how the structure is aging also leads to a focused inspection regime, allowing longer periods between routine inspections on structures which have not experienced significant events.

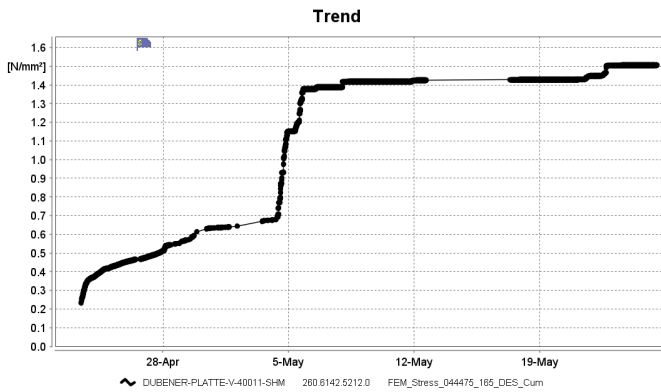
This gives a mechanism for plant protection and lifetime extension, which can be applied with minimum effort and integrated with other condition monitoring functions.

Tension



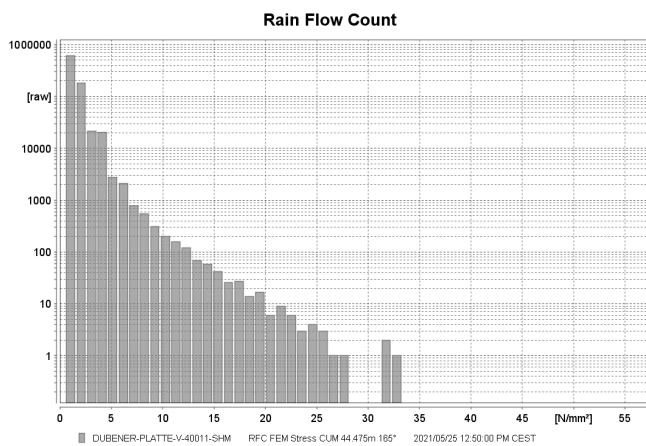
Compression





### Key benefits

- Fully integrated solution from Bachmann
- Achieved with minimum sensor set
- Online Structural Health Data allows:
  - Design verification
  - Review of extreme loads
  - Fatigue loading
  - Identification of extreme events
  - Eigenfrequency monitoring
- Information can be used to:
  - Extend inspection intervals
  - Alter operating parameters to optimise structural response
  - Detect and solve problems earlier



### System features

- Fully Integrated with Bachmann solutions
- Plugin to Standard Condition Monitoring Software running on the controller
- Extensive set of input sensor possibilities, using GIO212 module
- Continuous raw data record
- Digital Twin based on continuous input data stream
- Finite Element Model converts sensor data into load, stress and motion of the support structure
- Achieved with minimum feasible sensor numbers
- Produces outputs that can be related back to operating conditions
- Builds an ongoing estimate of remaining useful life
- Summary output data available on-line
- Engineering consultancy available from within Bachmann Monitoring

## Structural Health Monitoring (tower and foundation)

Prerequisites	
Engineering software	CMSSTD V2.02 or higher
Hardware	GIO212
Compatible sensor types <sup>1)</sup>	MEMS Accelerometers Inclinometers Strain gauges / Cantilever sensor strain measurement Humidity Temperature Counters SCADA data via bus connections (various protocols)
Positioning	Selection of heights within the tower
Mathematical model: To build the FEM model, Bachmann Monitoring GmbH issue a questionnaire to cover the required inputs. Typical requirements include:	Height of tower Thickness of wall (in segments) Material properties (Young's modulus and density) Mass of nacelle Mass of rotor Ground properties (stiffness around foundation)

<sup>1)</sup> Note: Only a small number of sensors are required. However the hardware can interface to various different sensor types. The software can use different signal types to calculate the results. The SHM algorithm can run from a single 2D MEMS Accelerometer, if first mode results are considered sufficient.

Evaluation	
Vibrations	Converted to motion of structure by mathematical model
Strain	Calculated from motion
Fatigue	Rainflow counting of fatigue cycles
Damage equivalent loads (DEL)	Reduction of the rainflow matrices to damage equivalent loads
Continuous measurement	Raw data stored locally
Summary results	10-minute values: <ul style="list-style-type: none"> <li>● Maximum strain</li> <li>● Direction of maximum strain</li> <li>● Number of fatigue cycles</li> <li>● Damage equivalent loads (DEL)</li> <li>● Eigenfrequency</li> <li>● Events</li> </ul>

## Order data and Accessories

Part type designation	Part number	Description
CMSSTD V2.02 Download	00032041-00	CMS Standard Software for M200 controller used to drive condition monitoring modules, including configuration tools. From this version also includes plug-ins for various extensions to the basic condition monitoring capabilities.
CMSSTD + GIO Runtime License	00032042-63	Allows the CMSSTD software to run with a GIO212 module, to drive data acquisition and analysis.
CMSSHM Plugin Runtime license	00033249-63	Structural Health Monitoring plugin enables the continuous recording of raw data and creates a number of values for long term trending of the structural condition alongside the raw data storage. This RT license must be stored on the controller in addition to the CMSSTD RT.
MEMS Sensor fitting kit	00032187-00	Kit of parts for installation of 2D MEMS Sensors
	00032187-00	Kit of parts for installation of 3D MEMS Sensors

## Related modules

Part type designation	Part number	Description
GIO212	00020620-00	Universal input/output module; 12x analogue inputs $\pm 10$ V $\pm 20$ mA Pt TE; 16 bit; analogue outputs $\pm 10$ V 20 mA; 14 bit; digital inputs DI 5 V / 24 V, 125 kHz, sink/source, counter; digital outputs 24 V/100 mA, 10 kHz, high-side/lowside/push-pull, PWM; DI/AI filter configurable; 100 $\mu$ s sampling and refresh time; value monitoring; insulated