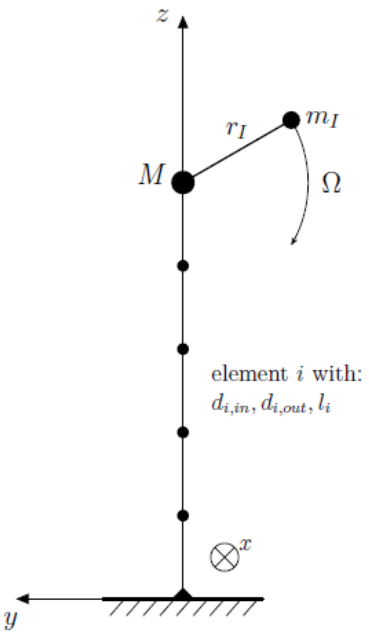

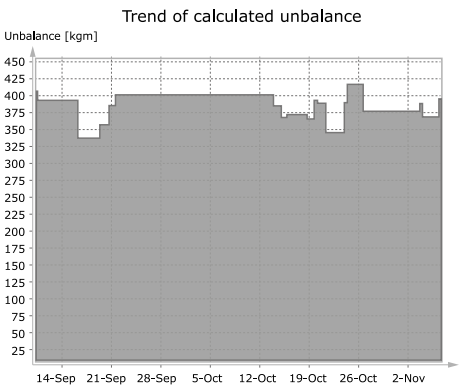

Blade Unbalance Calculator

Detecting unbalance in the rotor of a wind turbine

The mechanical unbalance of a wind turbine rotor can exert considerable forces on the drivetrain and the tower, thereby driving "fatigue". Typically the specification requires a value barely better than G16 [1]. In practice, a much better tolerance can be achieved. This aspect is all the more important because unbalance can change over time due to blade erosion/damage, and ingression of moisture into the structure of one or more blades. To correct this, operators must arrange for mechanical balancing of the turbines, which requires access to the blades and the consequent loss of availability.

To optimize the on-site work, some method of identifying those turbines in need of attention regarding unbalance anomalies would be useful. Although mass unbalance provides a clear 1/rev signal, on a wind turbine this option is complicated by …

- variable speed operation
- natural frequency of the tower
- an aerodynamic imbalance of the rotations can just as well originate from the axial force.

The necessary differentiation between mechanical and other other causes of unbalance requires software that can can differentiate between the triggers of rotational vibrations and display them.

The "Blade Unbalance Calculator" – a plugin for the CMSSTD software from Bachmann Monitoring – allows the calculation of the mechanical rotor blade unbalance and a regular determination of the rotor mass unbalance. This allows you to identify those turbines which require mechanical balancing. An examination of the entire wind farm operation with corresponding productivity losses is no longer necessary when using the "Blade Unbalance Calculator".

The mechanical balance is calculated by a model-based algorithm using basic build data. The model is built once and is valid for all the similar turbines on your farm. Using real-time information from a 2D MEMS sensor in the centre of the nacelle, the output from the module is a measure of the actual mechanical unbalance in kgm. With the addition of an extra position sensor on the main shaft the module will also identify the angular location of the required correction mass.

[1] For a 30 t rotor revolving at 20 rpm, G16 is equivalent to an unbalance of ~230 kgm.

The plugin also displays whether a unbalance results from aerodynamic or mechanical effects. Observing the change of the turbine record – for example a continuous deterioration of the balance – allows you to plan the appropriate corrective action in advance. There is also full visibility of whether rotor blade balance is degrading.

The "Blade Unbalance Calculator" is based on Bachmann Monitorings 20 years of experience in the field of Condition Monitoring. Numerous case analyses have been incorporated into the development of the algorithm. This gives the software a high degree of accuracy when it comes to diagnosing the condition of turbine rotors.

Blade Unbalance Calculator

Prerequisites	
CMS application	CMSSTD V1.05 or higher
Hardware	2 analog inputs for acceleration sensor (GIO212 or AIC21x)
Acceleration sensor	Mems Sensor placed close to centre of nacelle
Positioning	One axis parallel to shaft in axial direction One axis perpendicular to shaft in transverse direction
Mathematical model	To build the model, the following inputs are required: • Height of tower • Thickness of wall • Material properties (Youngs modulus and density) • Mass of nacelle • Mass of rotor • Measured first natural frequency of tower • Measured tower damping (only required for optional phase measurements of the mass unbalance)
Phase relation mass unbalance (optional)	Position detector fitted to main shaft for detecting the rotor position
Evaluation	
Axial vibration	Indication of aerodynamic unbalance
Mass unbalance rotor	Results generated only in specific speed range Displayed in kgm
Position/phase mass unbalance (optional)	Calculated with reference to the zero point of the rotor position

Order data

Part type designation	Part number	Description
CMSSTD V1.05 Download	00032041-00	CMS Standard Software for M200 control system used to drive condition monitoring modules, incl. configuration tools. From this version also includes plugins 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.
CMSSTD + AIC Runtime License	00032043-63	Allows the CMSSTD software to run with a AIC206 or AIC214 module, to drive data acquisition and analysis.
CMSUNB Plugin Runtime License	00032047-63	Blade Unbalance Calculator plugin allows the calculation of balance quality of the rotor, and distinguishes between mass unbalance and aerodynamic unbalance. 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 sensor
Zero Position Sensor	00026838-00	Sensor BMF00C7 (M12-PS-C-2-S4)
	00026841-00	Magnet BAM TG-MF-006
CMSUNB Tower Model	On request	Mathematical model required to generate inputs to the CMSUNB plugin configuration

Related modules

Part type designation	Part number	Description
AIC214	00028808-00	Analog measuring module for Condition Monitoring; 9x In IEPE; 3x In IEPE ±10 V; 24 bit; 0.1 %; > 95 dB dynamic range; 20 µs sampling time; 1x INC HTL; 300 kHz; A,A/B/N; 512 MB measured data ring buffer; real time continuous output of values
GIO212	00020620-00	Universal input/output module; 12x analog In ±10 V ±20 mA Pt TE; 16 bit; analog Out ±10 V 20 mA; 14 bit; digital In DI 5 V / 24 V, 125 kHz, sink/source, Counter; digital Out 24 V / 100 mA, 10 kHz, highside/lowside/ push-pull, PWM; DI/AI filter configurable; 100 µs sampling and refresh time; value monitoring; isolated
AIC212	00014151-00	Analog measuring module for Condition Monitoring; 9x In ICP; 3x In ±10 V; 18 bit; 0.1 %; > 95 dB dynamic range; 20 µs sampling time; 1x INC HTL; 36 kHz; A,A/B/N; 128 MB measured data storage
AIC206	00031353-00	Analog measuring module for Condition Monitoring; 4x In IEPE; 24 bit; 0.1%; > 95 dB dynamic range; 20 µs sampling time; 1x INC HTL; 300 kHz; A,A/B/N; 512 MB measured data ring buffer; real time continuous output of values