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Condition Monitoring

Condition Monitoring Systems (CMS) in wind turbines



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Intelligent vibration monitoring of wind turbines

▶ Targets

- ▶ Permanent plant/system protection
- ▶ Reduction of maintenance costs
- ▶ Increased availability due to permanent online monitoring
- ▶ Planning of repair
- ▶ Cause analysis by documenting damage events
- ▶ Avoidance of unplanned production downtimes
- ▶ Condition-based maintenance to DIN 31051
"Fundamentals of maintenance"

CMS

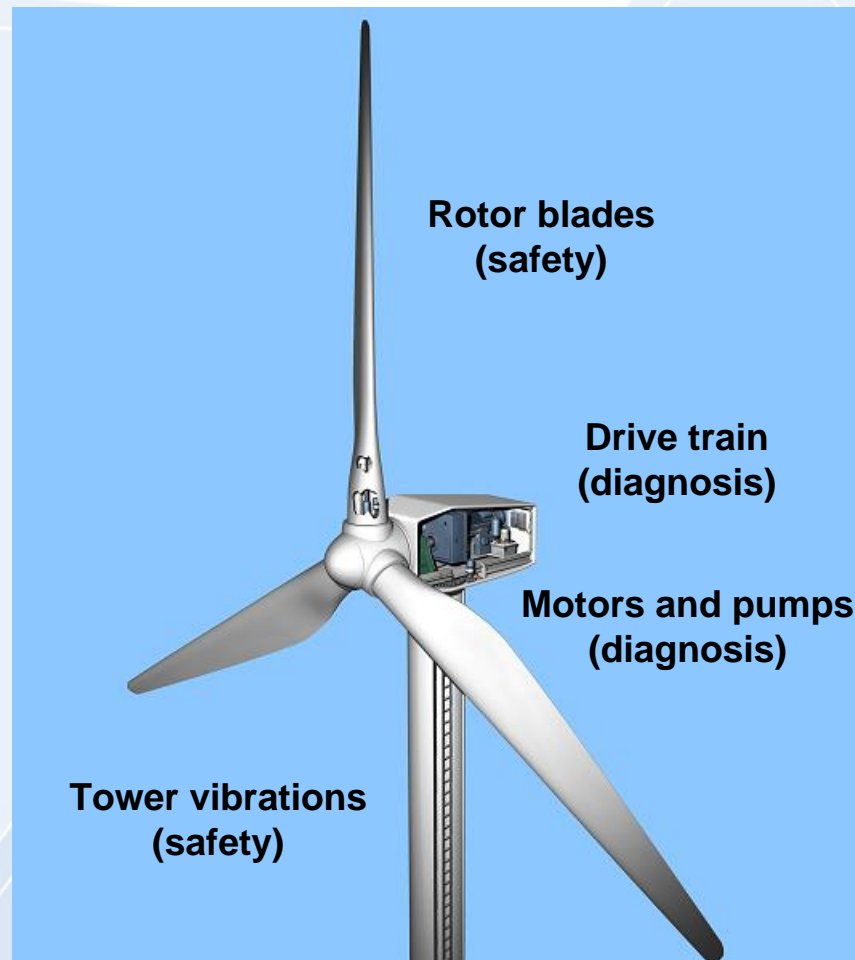




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Monitoring possibilities on wind turbines





Possible failures on wind turbines

- ▶ As stated by the insurer German Lloyd

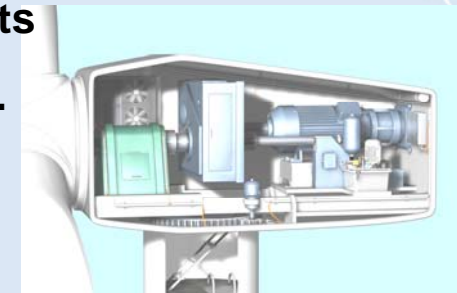


<i>Mechanical Component</i>	<i>Failure Percentage</i>
Main Gearbox	32 %
Generator	23 %
Main Bearing	11 %
Rotor Blades*	<10%
*Blade resonances lead to fatigue failures	



Saving potential using the example of a gearbox on a wind turbine

- ▶ **Cost factors of a gearbox:**
 - ▶ A new gearbox costs approx. 160,000 €
 - ▶ The delivery time for a new gearbox is approx. 6 months
 - ▶ A mobile crane causing the following costs is needed to replace the gearbox
 - ▶ Transport of the crane to the wind turbine: approx. 30,000 €
 - ▶ Daily user costs: 4,000 €
- ▶ **Cost advantages when using Condition Monitoring Systems:**
 - ▶ Damage can be detected in good time
 - ▶ Repair costs are considerably lower than replacement costs
 - ▶ Repairs on the nacelle can be carried out at an early stage.





Possible applications of Condition Monitoring Systems

Gearbox

- Wear, break in teeth
- Displacement, eccentricity of toothed wheels

Generator/network coupling

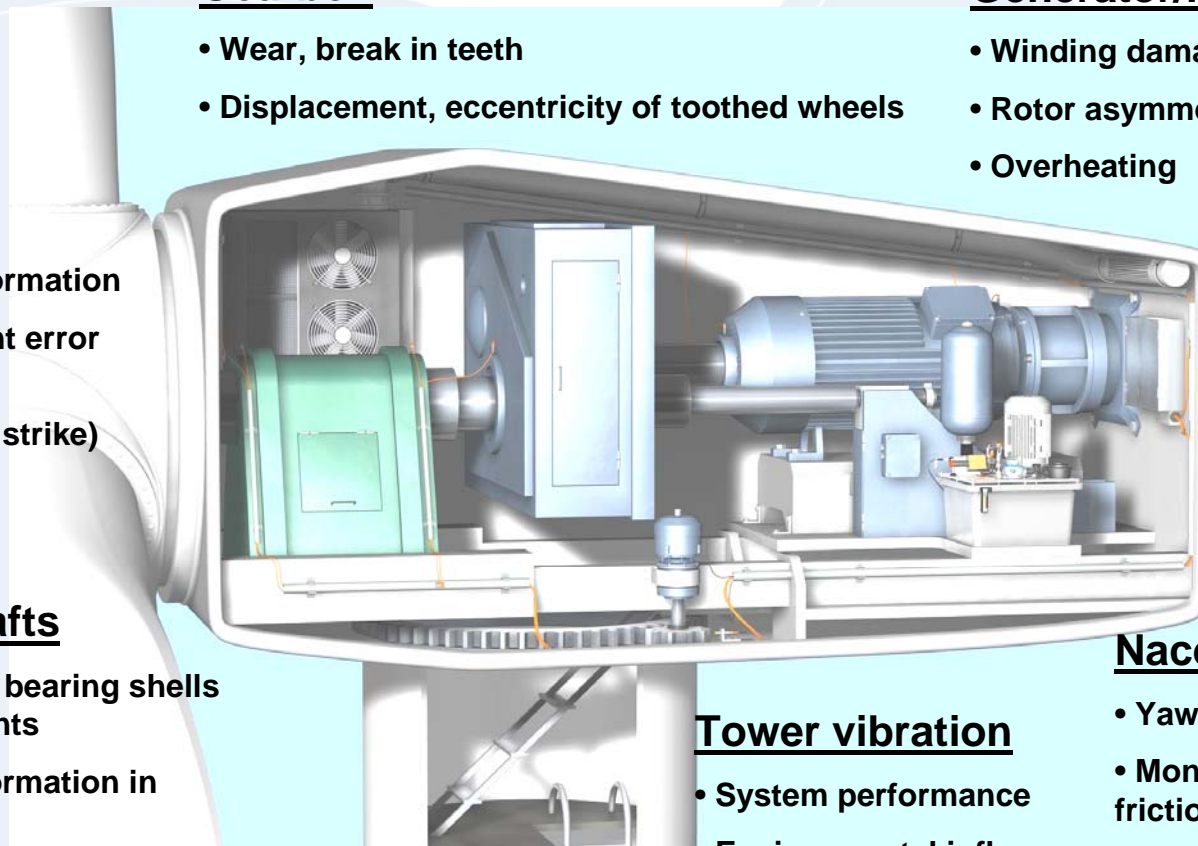
- Winding damage
- Rotor asymmetries, bar break
- Overheating

Rotor

- Fatigue, crack formation
- Blade adjustment error
- Damages
(e.g. via lightning strike)

Bearings, shafts

- Wear, defects of bearing shells and rolling elements
- Fatigue, crack formation in shafts



Tower vibration

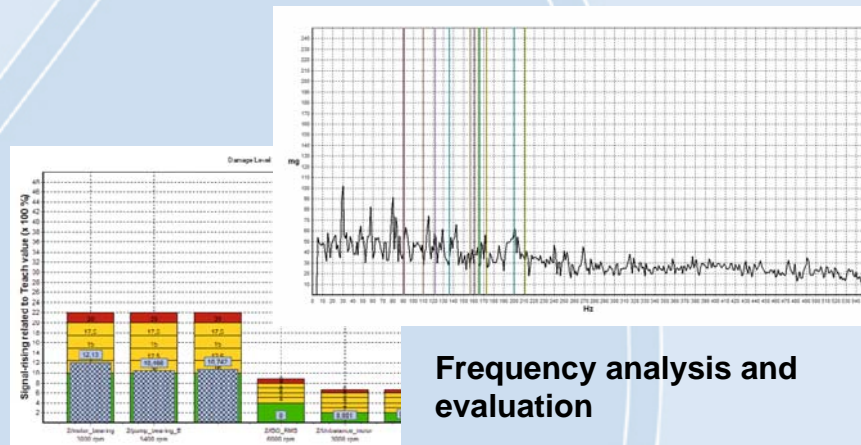
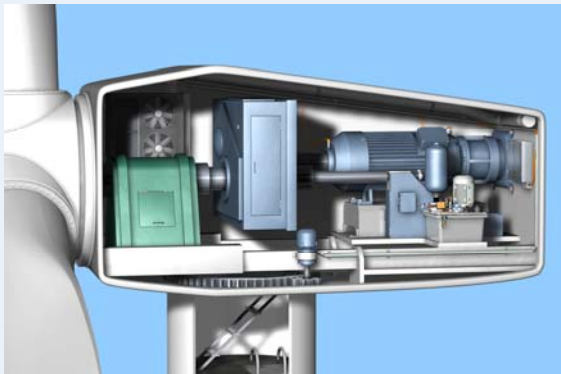
- System performance
- Environmental influences
- Crack formation, fatigue

Nacelle adjustment

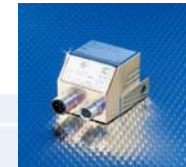
- Yaw error (drive & motor)
- Monitoring of the friction bearing

Basic advantages of the system efector octavis

- ▶ Permanent protection of wind turbines
- ▶ Detailed diagnosis rotor, gearbox, generator and other parts
- ▶ Cause analysis by documenting damage events
 - ▶ Trend recording (route cause analysis, crash recorder)
 - ▶ FFT recorder (FFT: Fast Fourier Transformation)

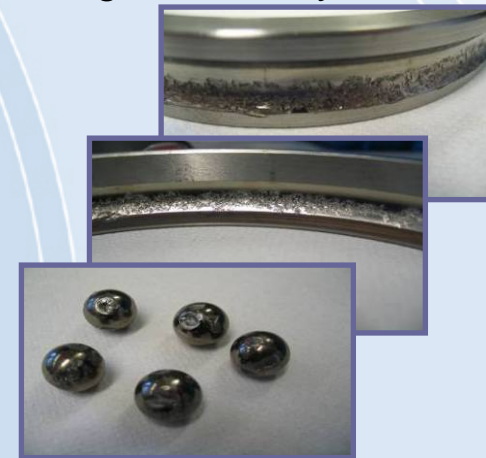
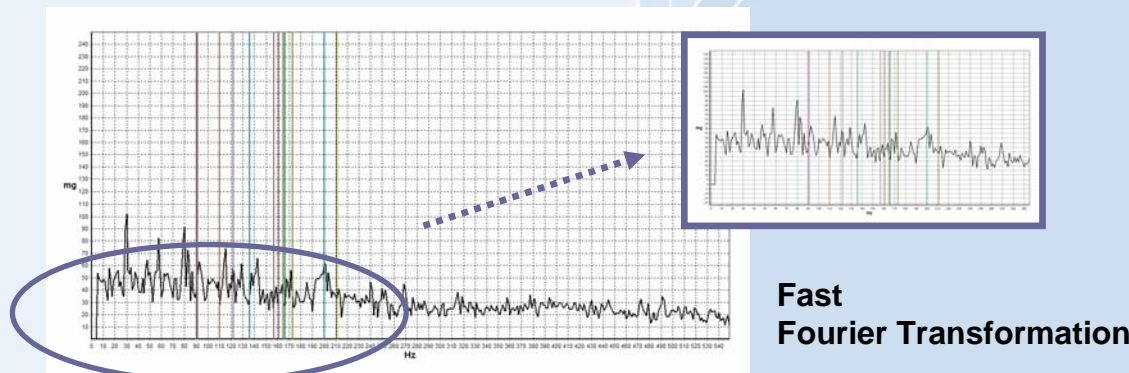


Frequency analysis and evaluation



Technical possibilities of the efector octavis product series

- ▶ Wear/condition monitoring in real time and history
(long-term diagnosis, trend memory / ring memory with freely adjustable time intervals)
- ▶ Frequency-selective diagnosis of the damaged objects in acc. with the following methods:
 - Fast Fourier Transformation / FFT (for e.g. unbalance, meshing frequency, gears)
 - envelope curve analysis / HFFT (for e.g. bearing condition, sideband analysis)
- ▶ Broad-band monitoring of general characteristic vibration values (to DIN ISO 10816)
- ▶ Maintenance message as digital alarm signals or data transfer to higher-level systems
(OPC, visualisation, SCADA)

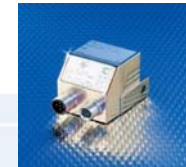
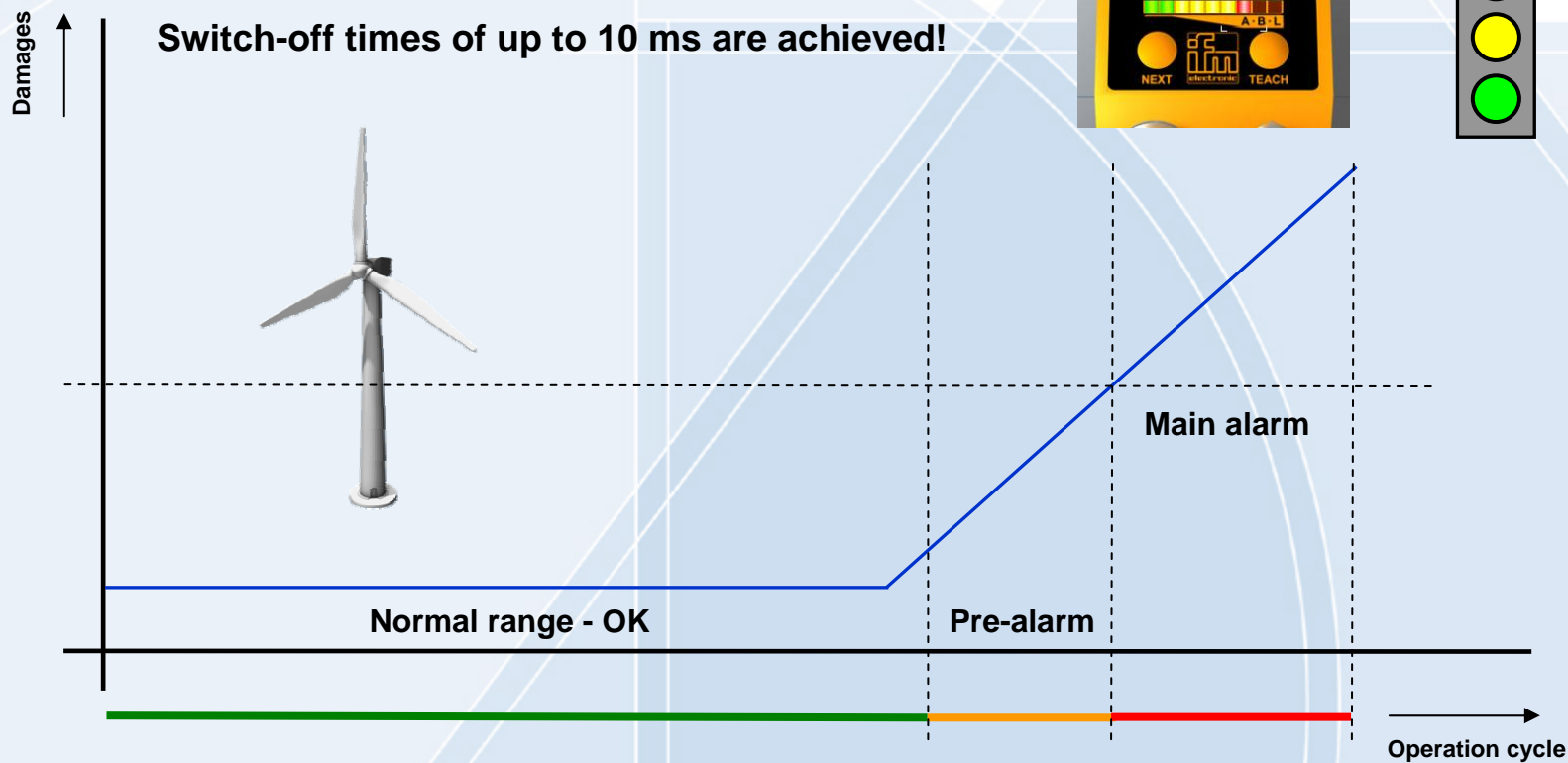




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The digital alarm signals of efector octavis



Technical advantages of the system efector octavis

Online Diagnostics	ifm electronic efector octavis	competitors
Diagnostic values with FFT analysis (FFT: Fast Fourier Transformation)	✓	✓
Diagnostic values with envelope curve analysis (HFFT)	✓	✓
Up to 7 (VE) or 24 (VSE) characteristics can be monitored in parallel	✓	✗
Characteristic values in the time domain (real time diagnosis)	✓	✓
DIN ISO 10816 characteristic values (real time diagnosis)	✓	✓
Observance of process conditions for diagnosis	✓	✓
Observance of process conditions for alarm	✓	✓

Machine protection

Alarms directly to the PLC (without PC software)	✓	✓
Differentiated alarms directly to the PLC	✓	✗
Real-time data acquisition	✓	✗

Trending / Root cause analysis

Internal data recording with time stamp	✓	✗
Open data interface (e.g. for visualisation and databases)	✓	✗

FFT Fast Fourier Transformation)
 Process conditions: e.g. performance and rotational speed

✓	YES
✗	partially
✗	NO



Vibration sensors VSA with extended diagnostic electronics VSE1xx



Product characteristics:

- ▶ Ethernet interface / OPC interface
- ▶ Evaluation of up to 4 vibration sensors (0...10 mA) per diagnostic electronics possible
- ▶ Overall velocity monitoring to DIN ISO 10816.
- ▶ Up to 24 online diagnosis characteristics consisting of max. 80 individual frequencies
- ▶ Internal history memory up to 30,000 entries including time stamp (real-time clock)
- ▶ 2 x static inputs 0/4...20 mA / 0...10 V or pulse 24 V for process quantities (e.g. load and rotational speed)
- ▶ 2 x digital alarm outputs (PNP 100 mA) or 1 x digital alarm output + 1 analogue output 0/4...20 mA / 0...10 V
- ▶ 8 x digital outputs/inputs ((freely configurable) (PNP 100 mA) as trigger or alarm signals



Vibration sensors VSA with separate diagnostic electronics VSE0xx



Product characteristics:

- ▶ Ethernet interface / OPC interface
- ▶ Evaluation of up to 4 vibration sensors (0...10 mA) per diagnostic electronics possible
- ▶ Overall velocity monitoring DIN ISO 10816.
- ▶ Up to 24 online diagnosis characteristics consisting of max. 80 individual frequencies
- ▶ Internal history memory up to 30,000 entries including time stamp (real-time clock)
- ▶ 2 x static inputs 0/4...20 mA or pulse 24 V for process quantities (e.g. load and rotational speed)
- ▶ 2 x digital alarm outputs (PNP 100 mA) or 1 x digital alarm output + 1 analogue output 0/4...20 mA / 0...10 V
- ▶ Use of vibration sensors type VSA001 up to +125 °C



Compact vibration diagnostic units type VE



Product characteristics:

- ▶ Sensor and diagnostic electronics in one housing (no control cabinet required!)
- ▶ LED display on the unit.
- ▶ Overall velocity monitoring to DIN ISO 10816.
- ▶ Up to 5 online diagnosis characteristics consisting of max. 20 individual frequencies
- ▶ History memory / trend curve in the sensor (up to 2,850 values or hours per object)
- ▶ 2 x digital alarm output (PNP 100 mA)
- ▶ Data transfer of diagnostic data optionally also over long distances (RS485 / Profibus DP via gateway)
- ▶ Can be used as a mobile measuring system (analyzer)
- ▶ Available in ATEX 2D/2G



Compact vibration diagnostic units type VK



Product characteristics:

- ▶ Compact vibration monitor with transmitter and switching output
- ▶ For permanent machine protection
- ▶ Permanent vibration monitoring according to DIN ISO 10816.
- ▶ Switching output with adjustable switch point and response delay (PNP 500 mA)
- ▶ Analogue output signal 4...20 mA (4 mA = 0 mm/s; 20 mA = 25 mm/s) for direct display at the control desk
- ▶ LED display on the unit.
- ▶ Easy adjustment via two setting rings allowing optimum read-out.

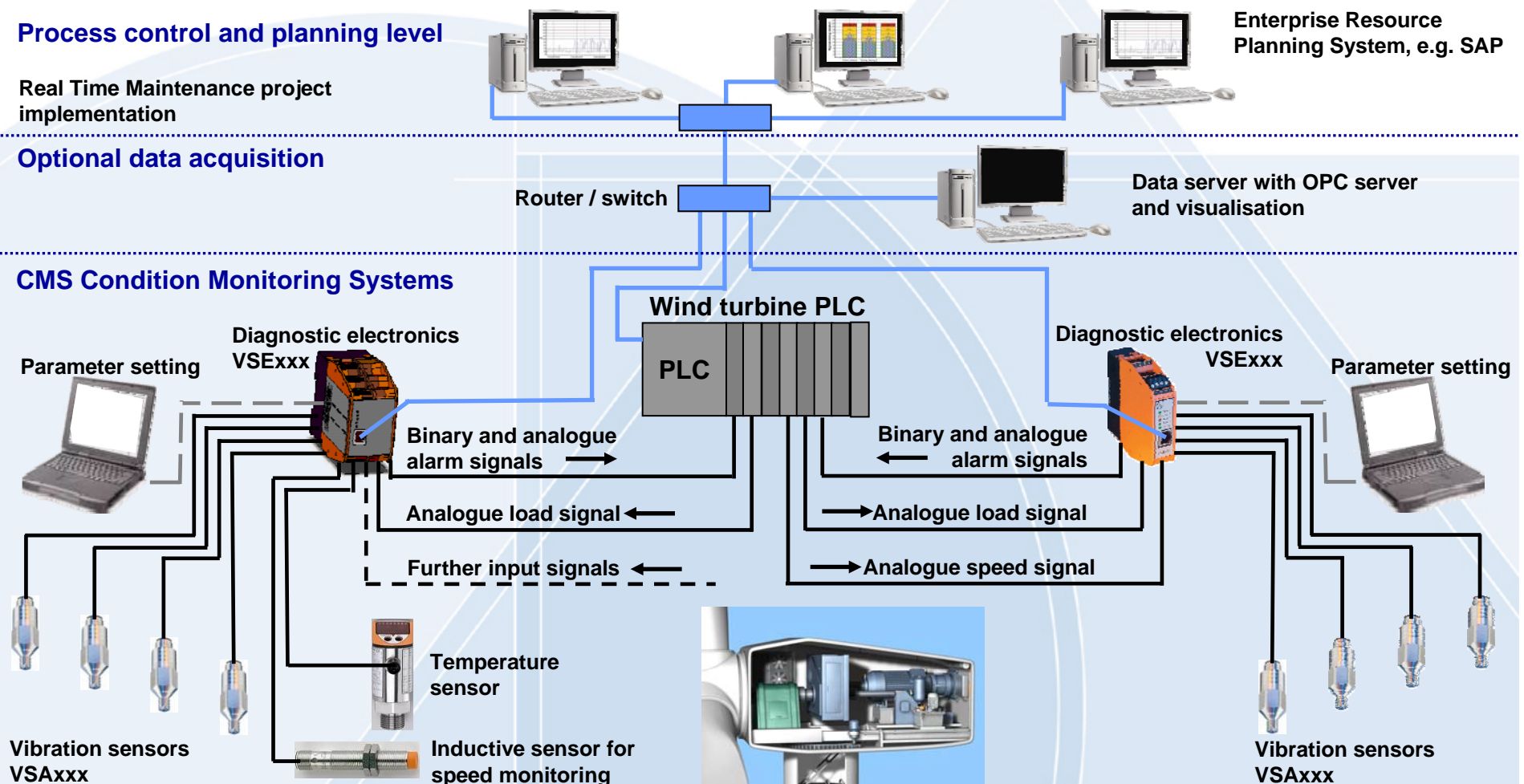
Data transfer of online vibration diagnosis type VSE

Process control and planning level

Real Time Maintenance project implementation

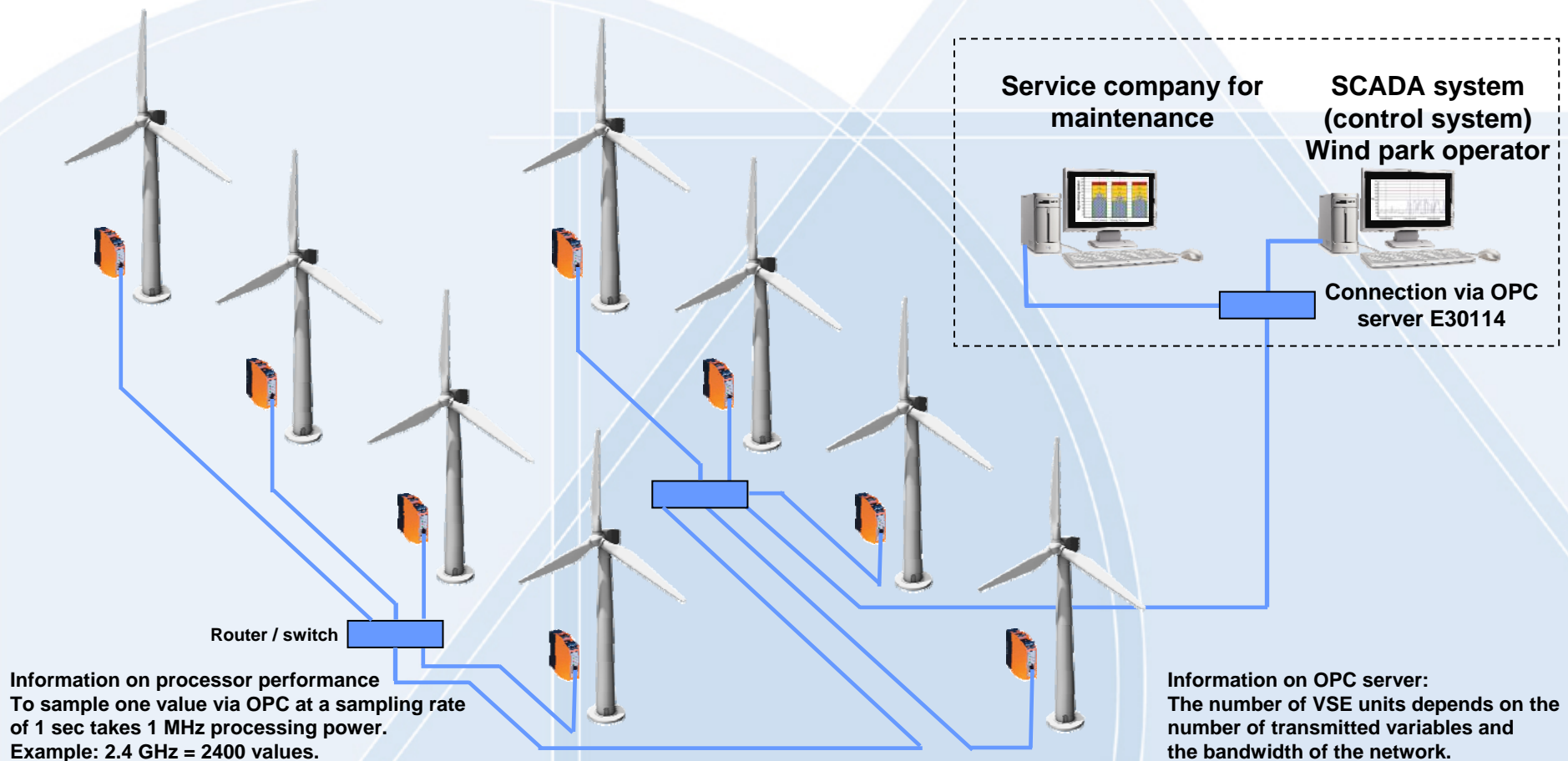
Optional data acquisition

CMS Condition Monitoring Systems



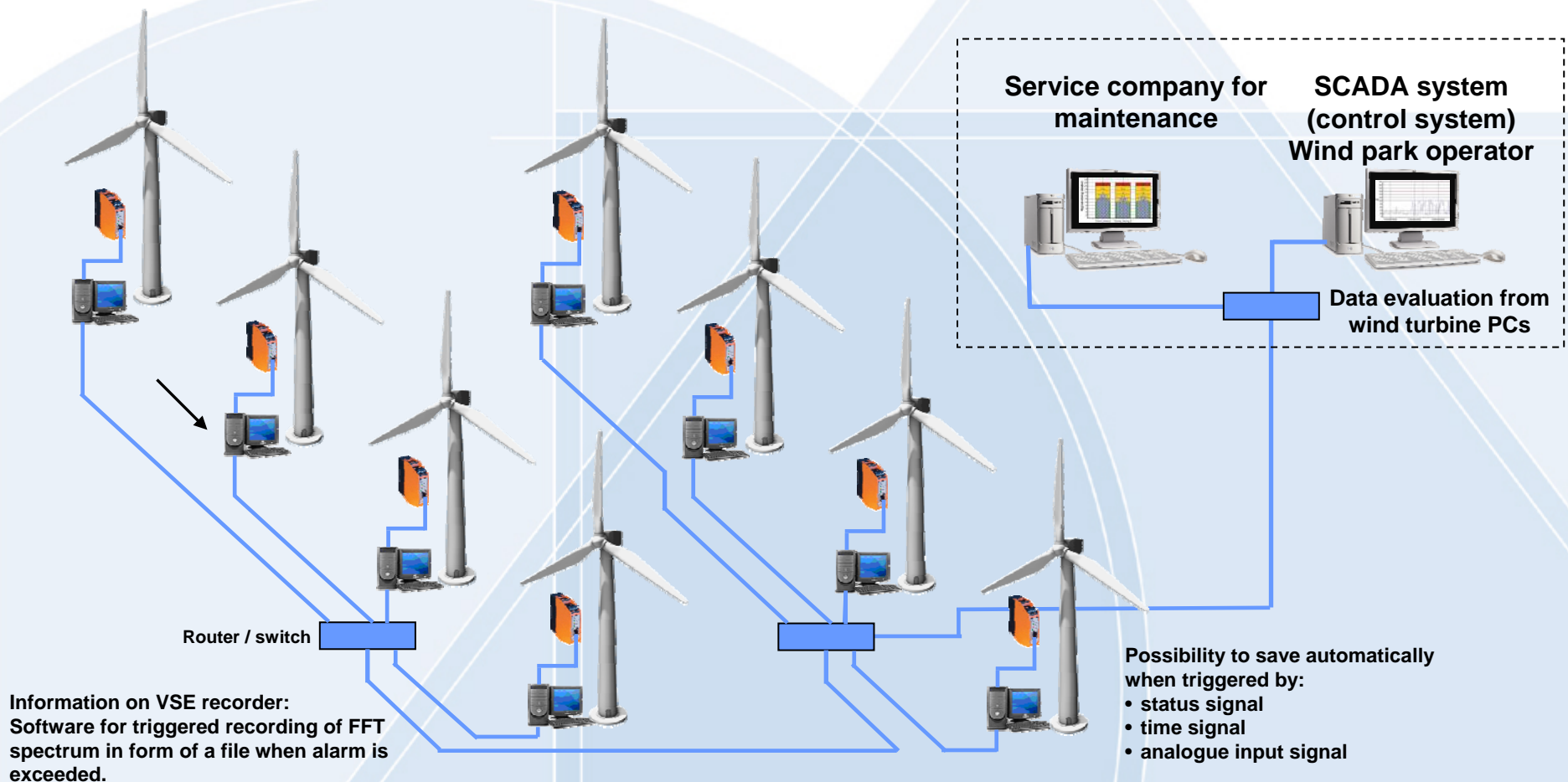


Condition monitoring in wind parks via Ethernet / OPC interface





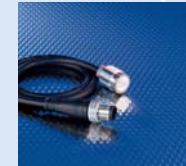
Condition monitoring in wind parks via VSE recorder software. Detailed in-depth analysis as FFT or envelope curve FFT spectrum.





Technical overview

- ▶ Signal evaluation already in the system
- ▶ Online vibration diagnostics at an excellent price / performance ratio
- ▶ Decentralised monitoring of plant and equipment integrated into the machine.
- ▶ Different designs:
Compact field devices (type VK / VE) or control cabinet modules (type VSE)
- ▶ Internal trend recording of all monitored diagnosis values (type VE / VSE)
- ▶ Both process quantities (e.g. load and rotational speed, temperature and pressure, etc.) can be monitored with regard to whether the actual value is above or below the limit value and can be saved in the history memory.
- ▶ Digital and analogue alarm outputs
- ▶ Gateway function for additional process signals
- ▶ Standard data interface (OPC)
for integration into higher-level systems (type VSE)



The right product for each application

Design parameters	Target	Product series		
		VK	VE	VSE
Machine vibrations in general	PROTECTION	√	√	√
Internal trending	DOCUMENTATION	x	√	√
Diagnosis	EARLY DAMAGE DETECTION	x	x	√
Network compatible	SYSTEM	x	x	√





Example applications in wind power stations

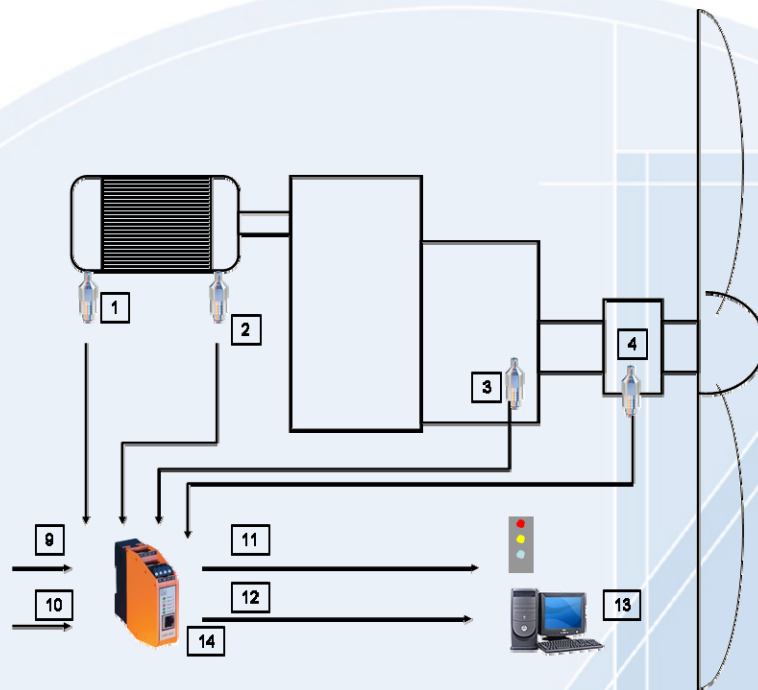


- ▶ **"Economy" CMS:**
Condition Monitoring System
for generator + gearbox + rotor
bearing
- ▶ **"Premium" CMS:**
Condition Monitoring System
for generator + gearbox + rotor
bearing
- ▶ Rotor blade monitoring via
vibration diagnosis
- ▶ Diagnosis of pumps and motors
in the periphery





"Economy" Condition Monitoring System for generator + gearbox + rotor bearing under 1000 €*



Diagnostic data:

ISO RMS, bearing state (BPFO, BPFI, BSF),
cage frequency (FTF), a_peak, a_rms

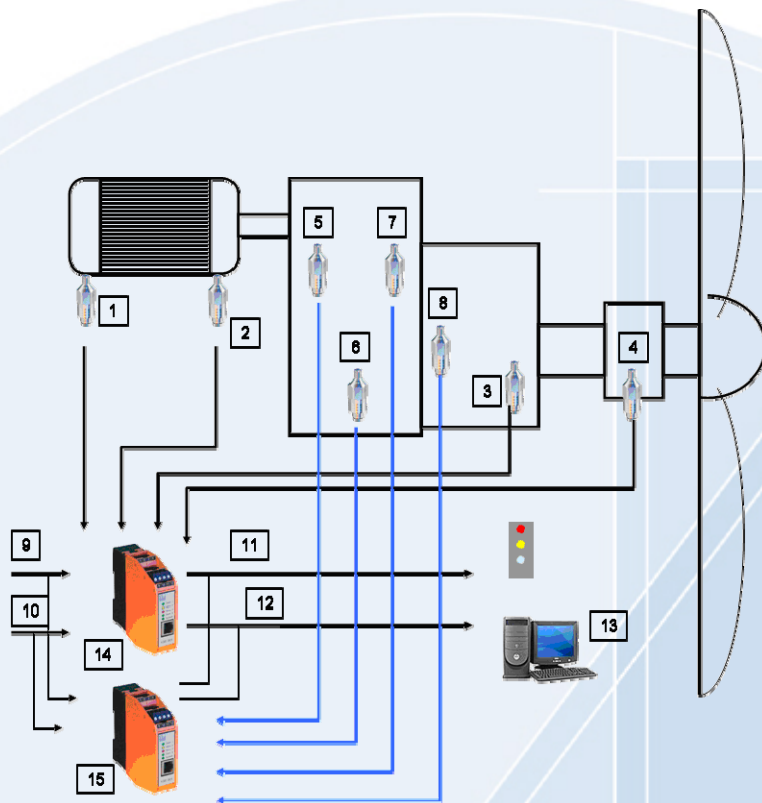
Characteristic data:

- ▶ online diagnosis + alarm message + trend recording under 1000 €*
- ▶ consisting of 4 vibration sensors VSA001 and 1 diagnostic electronics VSE002
- ▶ 1) monitoring bearing, converter
- ▶ 2) monitoring bearing, rotor
- ▶ 3) monitoring bearing, rotor shaft (end of gearbox)
- ▶ 4) monitoring rotor bearing
- ▶ 9) speed input (pulse, 4-20 mA)
- ▶ 10) load input (pulse, 4-20 mA)
- ▶ 11) alarm output (2 to 10 alarm outputs)
- ▶ 12) data interface TCP/IP
- ▶ 13) PC for configuration or data storage
- ▶ 14) diagnostic electronics VSE

* referred to price list Germany 2009



"Premium" Condition Monitoring System for generator + gearbox + rotor bearing



Diagnostic data:

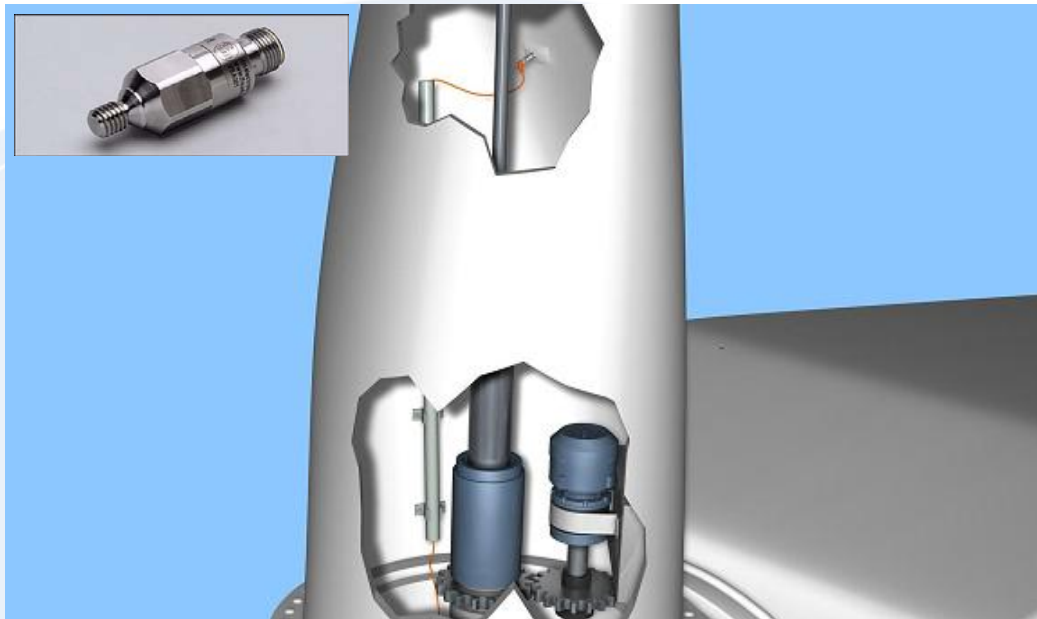
ISO RMS, bearing state (BPFO, BPFI, BSF),
cage frequency (FTF), meshing,
side-band analysis, a_peak, a_rms

Characteristic data:

- ▶ online diagnosis + alarm message + trend recording
- ▶ consisting of 8 vibration sensors VSA001 and 2 diagnostic electronics VSE
- ▶ 1) monitoring bearing, converter
- ▶ 2) monitoring bearing, rotor
- ▶ 3) monitoring bearing, rotor shaft (end of gearbox)
- ▶ 4) monitoring rotor bearing
- ▶ 5)-8) vibration monitoring gearbox
- ▶ 9) speed input (pulse, 4-20 mA)
- ▶ 10) load input (pulse, 4-20 mA)
- ▶ 11) alarm output (2 to 10 alarm outputs)
- ▶ 12) data interface TCP/IP
- ▶ 13) PC for configuration or data storage
- ▶ 14) diagnostic electronics VSE



Condition monitoring of the rotor blades



Changes in the condition of the rotor blades caused by cracks and ice formation are detected via the changes in vibration and can be directly evaluated by the diagnostic electronics.



VSE002 efector octavis diagnostic electronics & VSA001 vibration sensor:

- ▶ One vibration sensor per rotor blade
- ▶ Central evaluation via diagnostic electronics with Ethernet interface in the rotor control cabinet
- ▶ Additional evaluation of external sensors (VSE100, binary and analogue)





Diagnosis of pumps and motors in the periphery (offshore)



efector octavis VE1xxx:

- ▶ e.g. VE1001 or VE1002
- ▶ Detection of damage to rolling element bearings by frequency analysis
- ▶ up to 20 frequencies in the spectrum, freely selectable, diagnostic level adjustable
- ▶ Compact design: Sensor, evaluation and diagnosis in one unit



In a wind turbine there are often motors and pumps in the periphery which have to be monitored regarding damage to rolling element bearings, unbalance and cavitation. efector octavis provides the user with an optimum plant availability by permanently monitoring these aggregates. Furthermore alignment errors can be detected and meshing can be monitored.



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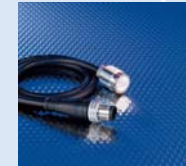
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Customer benefits by choosing ifm electronic as the supplier

- ▶ Leading supplier of integrated online vibration monitoring systems
- ▶ Supplier renowned world-wide for his quality
- ▶ Own production with high quality standards, QS certification
- ▶ Development and production in Germany
- ▶ Notable references in the field of wind power (approx. 1000 systems worldwide, as per 2008)
- ▶ Parameter setting software free of charge
- ▶ Supplier-independent data evaluation
- ▶ Competent local contacts worldwide
- ▶ Worldwide consultation, training, and support



ifm electronic – close to you!

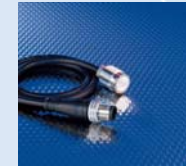




- ▶ Increasing the availability of machines and plants
- ▶ Reducing maintenance costs
- ▶ Quality assurance



**ifm electronic –
close to you!**





Product overview of ifm electronic

▶ Position sensors and object recognition

- ▶ Inductive sensors, capacitive sensors, magnetic sensors, cylinder sensors, valve sensors, safety technology, photoelectric sensors, object recognition, encoders

▶ Fluid sensors and diagnostic systems

- ▶ Level sensors, flow sensors, pressure sensors, temperature sensors, diagnostic systems

▶ Evaluation systems, power supplies and switching amplifiers

▶ Bus system AS-Interface

▶ Identification systems

- ▶ RF-identification systems, optical identification systems

▶ Control systems

▶ Connection technology

