

Drive & Control Technology for Wind Turbines



Always Running Smoothly: Drive & Control Technology

Wind energy has developed into a global industry. Modern wind turbines are now producing electricity efficiently and reliably, due to innovative drive and control systems. In the area of gearboxes and hydraulics, Rexroth, a world leader for drive, control and motion solutions, is a strong partner for wind turbine manufacturers.

The drive system determines efficiency and reliability of a wind turbine. Rexroth offers a wide range of drive solutions – applicable to all types of wind turbines. MOBILEX GFB precision yaw drives ensure accurate orientation with the wind and turn the nacelle slowly to face the wind once the cut-in wind speed is reached. For rotor blade adjustment, Rexroth provides complete electromechanical or hydraulic pitch drives. As the core component of a wind turbine drive train, REDULUS GPV gearboxes step up the slow speed of the rotor shaft into the high speed of the generator shaft.

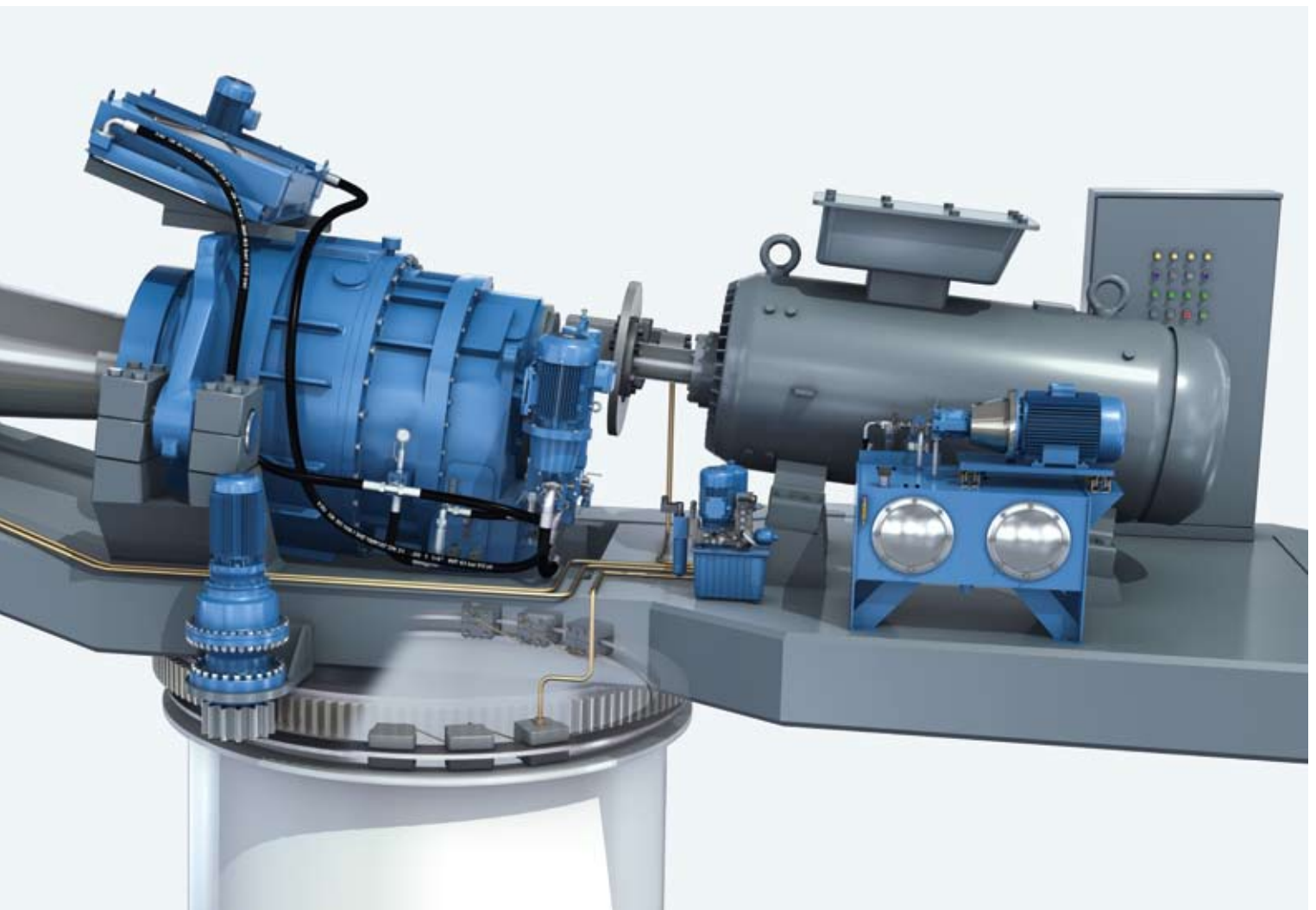
As a world leader in industrial hydraulics, Rexroth offers a multitude of hydraulic solutions for wind turbines: Our standard program range includes modular power units and controls for main drive train and yaw drive braking systems.

Reliable wind turbine operation requires condition monitoring systems. The BLADEcontrol rotor blade monitoring system and a gearbox oil monitoring system complete the Rexroth product offering for wind turbines.





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The Rexroth Advantage

Drive system components for wind turbines must meet exacting requirements: variable wind loads, increasing power capacities and limited installation space are just a few of the technical requirements that engineers and designers must overcome apart from climatically induced strains.

Wind Energy Competence and Experience

For almost a century, Rexroth has been developing and producing innovative drive system components, and was involved in the development of early wind turbine drive systems. The gearboxes for the 3.2 MW AEOLUS II wind turbines were developed in the early 90's – a true pioneering achievement in the wind energy industry.



The focus on innovation continues today, with the smart pitch system that increases turbine efficiency or the compact differential-type gearboxes that contribute significantly to reducing the tower head weight of multi-megawatt wind turbines. Cooperative projects with universities and research institutes as well as contributions by the central R&D Department of Robert Bosch GmbH, improve and optimize all turbine drive system components.

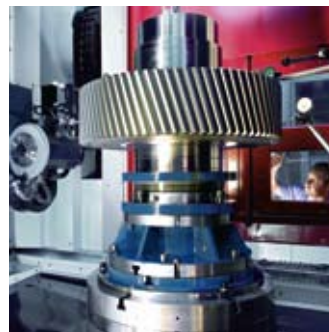
We see our strength in customer-specific engineering, combined with decades of experience in planetary gearboxes and hydraulic components. As a member of the Bosch Group we offer our customers the innovative power that is required for high-capacity multi-megawatt designs. Leveraging engineering, manufacturing and testing know-how as well as extensive FEM analysis before production release safeguards the customer over the life of the turbine.

Rexroth gearboxes are designed to meet the maximum requirements of safety and reliability. In designing and developing new components, our experienced engineers use modern calculation methods for gearing design and component optimization. They are thus able to perform even the most complex drive train simulations.

Top Performance from Start to Finish

To us, quality means doing it right the first time – from supplier qualification to Rexroth in-house machining, heat treatment and assembly including inspection, painting and shipment. In this context, our quality management system according to DIN EN ISO 9001:2008 forms the basis and is guarantor of consistent high quality. Environmental protection is another major concern of Rexroth. For many years now, we have had an environmental management system according to DIN EN ISO 14001 in place at our locations.

On modern test benches our components are tested to the most stringent quality criteria prior to shipment. During the manufacturing process we subject our gearboxes to full-load tests or to specific tests according to customers' requirements. Advanced inspection and monitoring programs are used to record temperatures and noise characteristics.

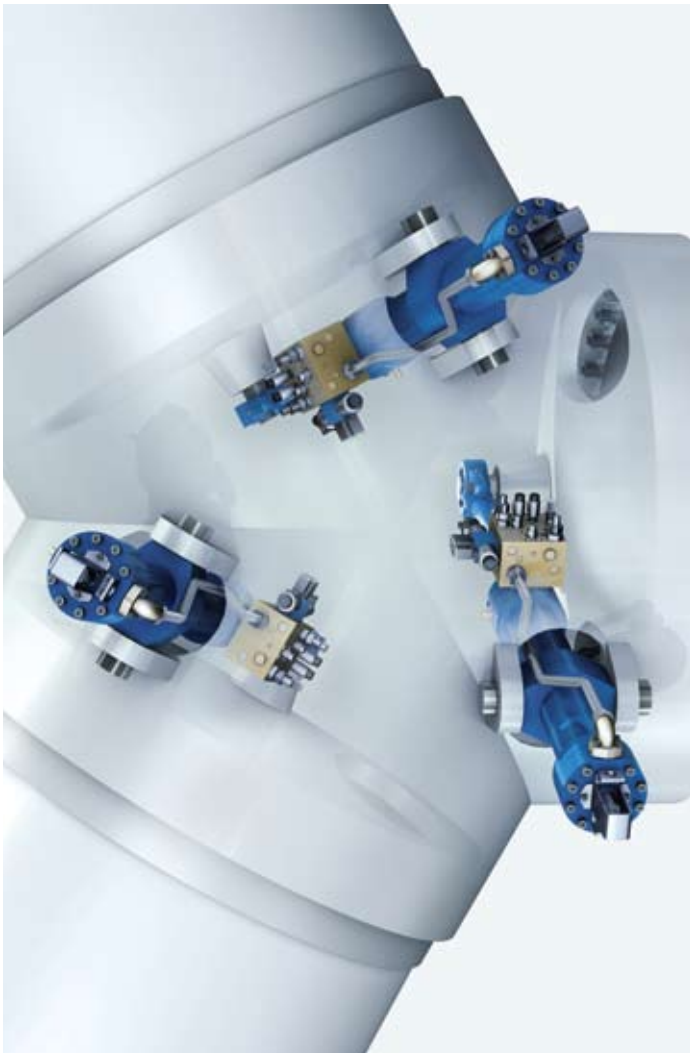


◀ **Rexroth manufactures wind turbine gearboxes at the primary facility in Witten, Germany. A new facility dedicated to wind turbine gearboxes is located in Nuremberg, Germany. An additional dedicated facility in Beijing serves the Chinese and Asian markets. Rexroth service is available in more than 80 countries, covering everything from on-site support to repair and in-depth damage analysis.**

- Main Offices
- Manufacturing
- Sales

Capturing the Wind: Rexroth Solutions for Rotor Blade Adjustment

100 meters above ground: There is a gusty wind blowing up here. The compact pitch drives of the wind turbine, which are located in the hub, constantly rotate with the motor and ensure correct blade adjustment. Besides reliability, accurate blade positioning is of the utmost importance. Rexroth meets these requirements with both hydraulic and electromechanical pitch adjustment systems.



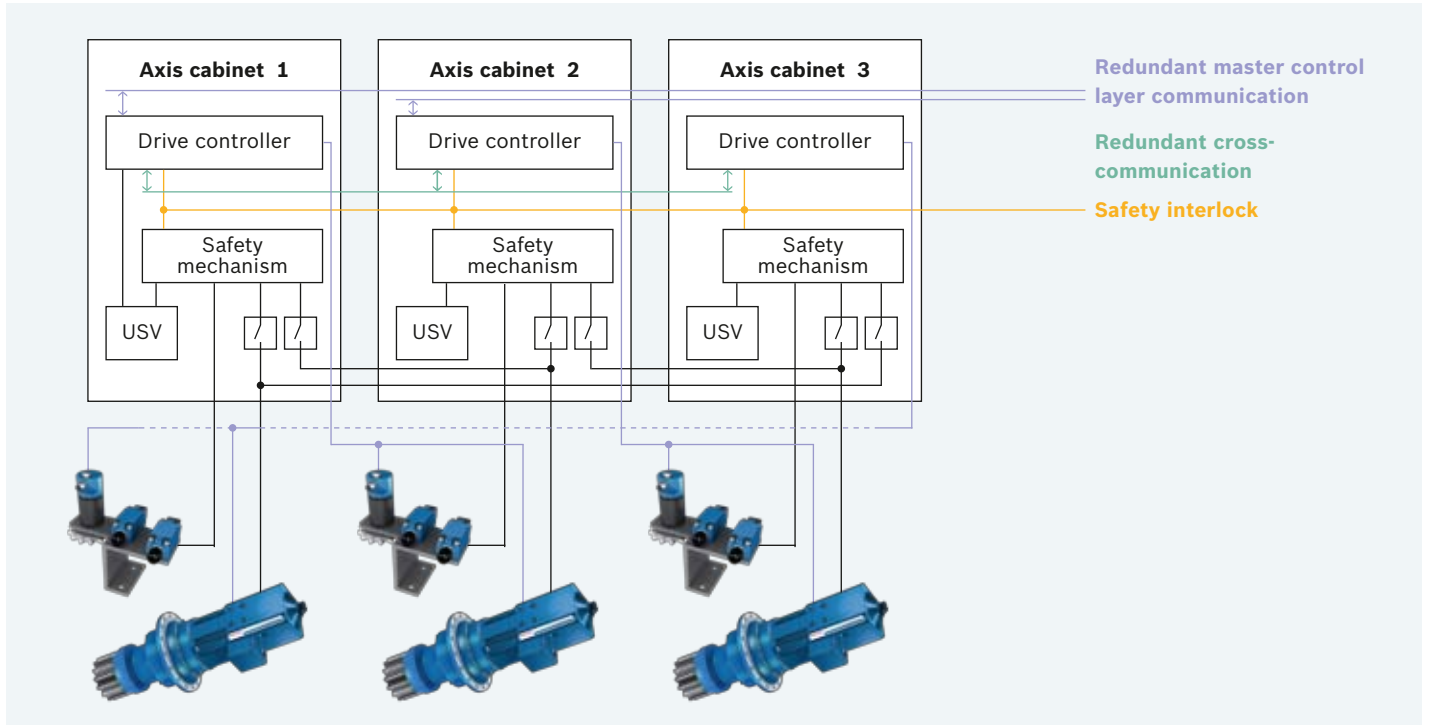
Hydraulic Rotor Blade Adjustment

The hydraulic pitch adjustment systems are characterized by high actuating forces, space constraints and high reliability. Proportional directional valves provide complex control functionality, while maintaining high dynamic regulation. Combining proportional control with mechanical default logic valves provides reliable turbine protection for all emergency shutdown situations. Available communication bus interfaces and on-board intelligence options can significantly reduce wiring and improve performance.

Electromechanical Rotor Blade Adjustment

The electrical pitch adjustment system features compact planetary gearboxes MOBILEX GFB type as well as maintenance-free asynchronous motors, intelligent control equipment and an uninterruptible power system with double-layer capacitors. The control and regulating electronics and the uninterruptible power system for each blade are accommodated in a hermetically sealed control cabinet.

- ◀ Hydraulic pitch adjustment
- ▶ Electromechanical pitch adjustment



Electrical System Architecture

Redundant monitoring and data exchange between and among the master control communication layer and the axis drives, coupled with the Rexroth “Step-In” functionality, ensures continuous operation in the event of a drive fault. The wind turbine must not shut down, but can continue to produce electricity, thus maintaining energy yield until a timely scheduled facility servicing and maintenance can occur.

- ▲ E-Pitch system architecture
- ▼ Electromechanical pitch adjustment



Compact, Quiet and Reliable: Main Gearbox REDULUS GPV

A wind farm near the Baltic Sea. The wind here is strong – force 8 on the Beaufort scale. Force 8 wind strains all components, but especially the main gearbox, the core component of the turbine drive train. Reliable operation for 20 years or about 175,000 operating hours is what’s expected, and this is exactly what the REDULUS GPV main gearbox delivers – day in and day out.



The REDULUS GPV gearbox steps up the rotational speed of the slow-speed rotor shaft to the required high speed of the generator shaft. For wind turbines of a capacity of up to 2 megawatts, Rexroth supplies compact gearboxes featuring a combination of a planetary gear stage and two helical gear stages.

Differential Gearboxes for Multi-Megawatt Turbines

The REDULUS GPV differential gearbox for multi-megawatt wind turbines is a slender and compact unit, that differs from conventional gearboxes in the following ways: Rather than having four or more planetary gears revolving around the input stage sun gear, the REDULUS GPV-D features two drive stages with three planetary gears each. This offers advantages of static determination coupled with freely adjustable sun pinions.

This design offers significant benefits: The diameter is smaller than conventional designs, but the overall length is almost unchanged. For high-capacity wind turbines, this differential concept offers a weight advantage of up to 15% over current gearbox designs. A factor that contributes to this advantage is the size of the REDULUS GPV-D components, which are smaller than in conventional gearboxes for multi-megawatt wind turbines. Benefits for our customers: Even today we are producing these components in large quantities and consistently high quality thanks to reliable manufacturing processes.



Differential Design: Functional Description

Power splitting takes place in the first planetary gear stage. Via the rotor speed, part of the power is directly transferred from the planet carrier into the first planetary stage, while the other part is transmitted, as lossless coupling power, to the revolving ring gear of the second planetary stage. The power distribution percentage is subject to the stationary gear ratio of the three planetary stages.

The speed of the first planetary stage sun gear is the same as that of the planet carrier of the differential stage. The speed of the sun gear of the second planetary stage is the same as that of the differential stage ring gear. The speed rates of the differential stage ring gear and planet carrier are cumulative with respect to the speed of the sun gear, thereby rejoining the previously split power together. The final helical gear stage steps up the speed again and transmits the increased speed through an offset shaft to the generator. This final stage ratio determines the turbine-specific overall speed multiplication gear ratio.

- ▲ Backlash measurement
- ◀ Wind turbine drive train
- ▼ Differential gearbox cutaway



Keeping on Track: Yaw Drives MOBILEX GFB

Wind direction varies. The wind turbine sensors detect the change and command a correction of 8° towards NNW. The control system activates four yaw drives which position the nacelle precisely as required. Precision and accurately coordinated operation of the drive systems are vital requirements and easily accomplished by the robust and powerful MOBILEX GFB yaw drives.

Rexroth offers a complete range of MOBILEX GFB gearboxes for any wind turbine – big or small. The drive itself consists of a planetary gearbox equipped with an output pinion and an electric motor. The planetary gearbox features four planetary stages, providing large gear ratios and allowing for very sensitive rotational adjustments.

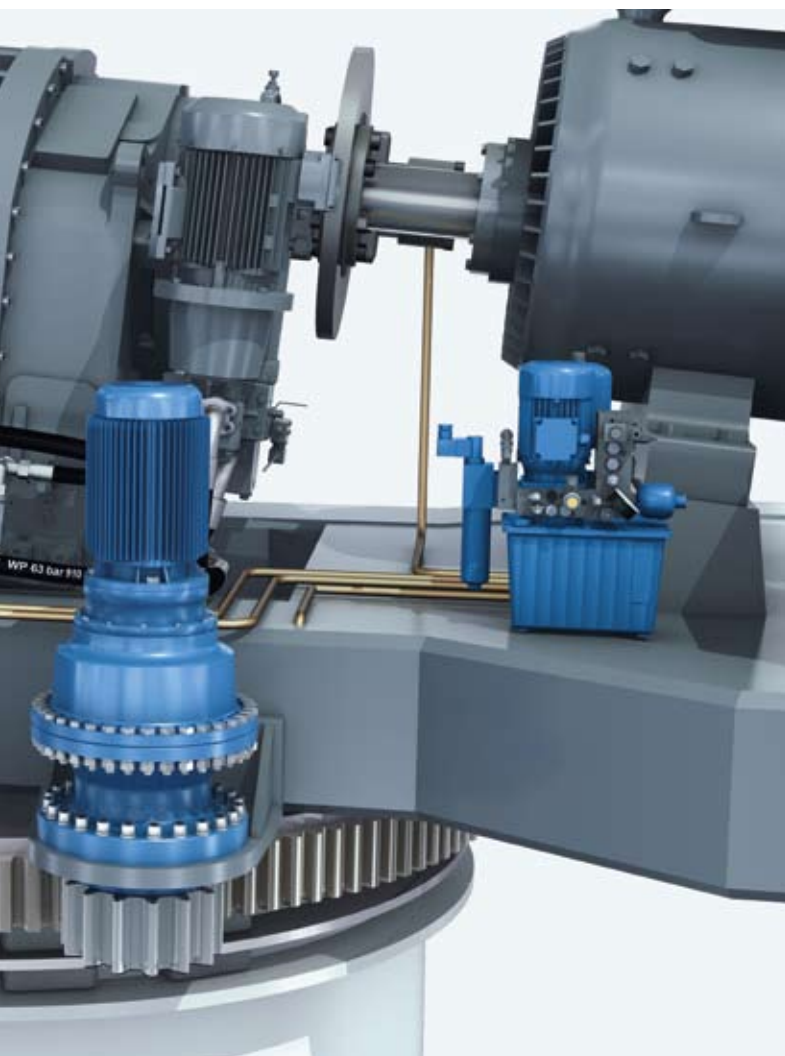
The ever-increasing size of nacelles calls for higher torque rates. These can be achieved by arranging several drives around the yaw bearing. For very large turbines, it is not uncommon to have 10 or more gearboxes being utilized for yaw control.



◀ Yaw drive
MOBILEX GFB

Strong – Yet Gentle: Drive Train and Yaw Drive Braking Systems

Years of experience with industrial hydraulic applications have made Rexroth very familiar with specific design requirements needed for wind turbine braking systems. These requirements include: high reliability, minimum size, good corrosion resistance, long service life, a wide ambient temperature range and high vibration resistance.



Rexroth has developed a modular braking system approach that meets all these specific requirements. All components for this extremely demanding application were specifically chosen to form a unique product portfolio. The modular design allows Rexroth to easily adapt to different combinations of rotor lock, drive train, and yaw drive braking needs. Rexroth is also able to manufacture custom components to customer specifications.

► **Complete control unit
for all braking functions**



Gearbox Lubrication System and Oil Condition Monitoring System

Wind turbine gearboxes have to transmit ever increasing power ratings – ideally in a lossless manner – and they need to do it day in day out. This not only puts even greater demands upon the lubricating fluid, but also upon the lubrication system itself. These systems must reliably protect all gears and antifriction bearings from wear. Rexroth designs, develops and manufactures all the components needed for cooling / lubrication systems.

Circulation Pump

The pump draws lubricating oil from the tank or sump and delivers it to the lubrication points via the filter and cooler elements. The gear ring pump used has the following features: few moving parts, high operational reliability, good priming characteristics at low temperatures, wide speed range and very low operating noise.

Oil Cooler

The oil cooler removes the friction heat and keeps the oil temperature within the optimum operating range at all times. In developing this new cooling system, Rexroth focused on excellent cooling performance, efficient airflow designs and low operating noise. Specially formed cooling fins prevent dirt deposits and cooling performance degradation. A corrosion resistant casing ensures that the cooling is also suitable for offshore installations.

Oil filter

Mechanical abrasion produces fine metallic particles, temperature-differentials induce air exchange and generate dust and moisture deposits, and aging leads to the formation of chemical residues. The filter removes all these contaminants from the oil. A high dirt removal capacity ensures extended filter replacement intervals.

Particle Monitor and Water Content Sensor

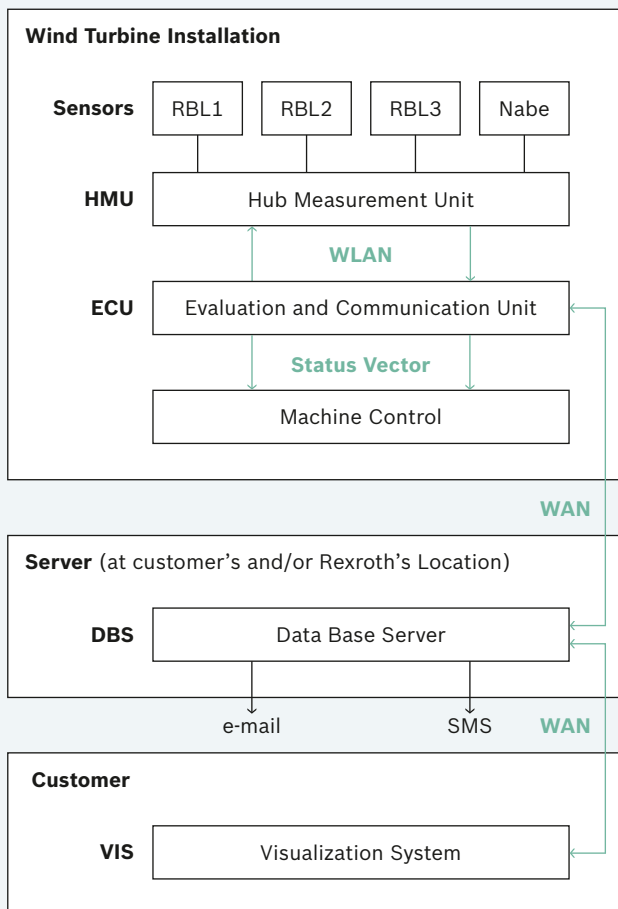
The online particle monitor measures the degree of oil contamination in the system. The particle count facilitates predictive maintenance and thus contributes to extending the useful life of the gearbox. Excessive water levels in the oil affect the lubricating characteristics and lead to increased corrosion. The Rexroth water content sensor measures the water content, thus providing important data for maintenance scheduling.



Minimizing Failure Risks – with Rexroth Condition Monitoring Systems

A wind farm in the Black Forest. Service engineers are inspecting the rotor blades. Made of glass-fiber-reinforced plastic, they are among those components that undergo the most strain on a wind turbine. Initiated by a damage warning signal from the BLADEcontrol® system, a visual inspection reveals a 17 cm long rear edge crack in one of the 3 rotor blades. Protected by BLADEcontrol®, the wind farm operator can take action before this type of damage propagates and causes long wind turbine downtimes.

BLADEcontrol® System Architecture



Rexroth's BLADEcontrol® system provides a solution for continuous remote rotor status monitoring. The system reliably detects even small rotor blade damage and tracks damage propagation. This permits wind farm operators to schedule repairs on a long-term basis. In the event of a safety hazard due to major damage, the turbine can be shut down immediately – and even automatically.

A further function of BLADEcontrol® is ice detection. The turbine does not need to be active for this system to detect ice formation. Advantage: Automatic restart without the need for a local visual inspection or turbine operational testing for the presence or absence of ice.

BLADEcontrol® is based on the natural frequency excitation analysis principle. Vibration sensors installed in the rotor blades detect rotor blade natural oscillation frequencies. A computer installed in the rotor hub transmits the measured data via WLAN to the evaluation unit in the nacelle which evaluates the data received and organizes communication with the operator. BLADEcontrol® serves, in particular, to detect significant deviations from normal conditions: It transmits data directly to the control system and also informs the operators, by e-mail and text messaging, of all rotor blade deviations from normal conditions.

No Matter, Where, When or Why. Our Service – at Your Disposal.

One thing's for sure. Should problems arise at a wind turbine installation, a Rexroth service team can quickly be on site to assist. Every wind farm operator's wish is to "get it up and running and harvest power!" Rexroth service not only appreciates this wish, but will help to fulfill it as quickly as possible.



In more than 80 countries our service division is ready to provide assistance. Rely on our unsurpassed service competence and efficiency, from on-site support to maintenance and repair. It does not matter which Rexroth component is involved, our qualified specialists and our reliable service personnel will be pleased to help you.

To find a Rexroth contact near your location, visit:

www.boschrexroth.com

Gearbox Inspection and Proactive Failure Detection

Preventive gearbox maintenance improves the availability of any wind turbine installation. Rexroth service engineers have comprehensive experience in early fault detection, and have proven inspection software at their disposal, as well as the ability to perform measurements and tests with any and all equipment and systems.



- ▲ Endoscopic gearbox inspection
- ◀ Planetary gear – an original spare part of Rexroth quality

Repairs

Our comprehensive knowledge of gearbox design makes sure that any required repair will be carried out professionally and at optimum cost. Repair activities, such as overhauling and remanufacturing as well as regrinding of gear teeth, will comply with original factory specifications. Repaired gearboxes are tested to the most stringent quality criteria and fully documented test reports are issued before they are returned to the customer.

Spares

This Rexroth service segment is characterized by speed, competence and efficient worldwide logistics. We furnish original OEM quality spares as well as spare part and upgrade kits for existing equipment – even after serial production has been discontinued.

Innovative Drive and Control Solutions for Harnessing Renewable Energies

The continuously growing demand for clean energy production is a central challenge of our time. By supplying reliable, safe quality products, Rexroth contributes to solutions for harnessing energy from the wind and the sea.

Rexroth products are found in more than 40 sectors of the industrial value-added chain. Our unique offering of mechanical, hydraulic and electronic components and systems for mobile equipment makes Rexroth the world leader in mobile hydraulics. For factory automation, Rexroth supplies, from a single source, electric drive and control systems, hydraulic equipment, linear and assembly technologies as well as pneumatic equipment. In the area of industrial applications, Rexroth has established itself as a worldwide leading supplier of hydraulic equipment.

Components and systems from Bosch Rexroth help increase the efficiency of facilities used for renewable energy production. Rexroth's success is based upon many years of experience as a development partner and on the excellence of our products.



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