



RELIABLE PITCH SYSTEMS FOR A LOWER LCoE

Wind Energy Pitch Solutions, Products and Services

YOUR PARTNER IN PITCH CONTROL

MOOG

RELIABLE PITCH SYSTEMS THAT REDUCE THE LEVELIZED COST OF ENERGY

Reducing wind turbines' Levelized Cost of Energy (LCoE) has become critical to success in today's increasingly competitive power generation market. By improving turbine reliability and minimizing downtime, Moog pitch systems can help you achieve that.

Although pitch systems represent less than 3% of wind turbine CapEX, they have a significant impact on overall turbine reliability. In fact, pitch system failures account for nearly a quarter of all downtime in wind turbines – more than any other component or system. In addition, because they are often exposed to harsh ambient conditions inside the rotating hub, including extreme temperature, humidity and vibration, pitch systems typically exhibit a higher failure rate than other components.

By decreasing pitch system part count and design complexity, failure rate can be reduced, operating costs can be decreased, and the overall viability of wind power generation can be improved.

Moog's pitch control solutions and related products are designed to do exactly that. Our Pitch System 3 features fewer components and a highly integrated architecture that leads to greater reliability, minimal downtime and reduced maintenance. This ultimately improves turbine availability and lowers LCoE, enabling you to remain competitive in today's increasingly complex global energy market.

MEETING YOUR PRODUCTIVITY CHALLENGES WITH A PITCH SYSTEM THAT OFFERS HIGH RELIABILITY AND UP TO 50% LESS DOWNTIME

Moog is a global leader in the design of motion control solutions for power generating applications. Leveraging over two decades of experience in the energy sector, along with our in-depth expertise across the entire spectrum of pitch control technologies, we'll work collaboratively to take your wind operations to the next level of productivity.

Our Pitch System 3 represents a breakthrough in pitch control that can help you get the most out of your turbines by:

Decreasing Levelized Cost of Energy – Moog's Pitch System 3 features a highly reliable design that reduces maintenance requirements, improves turbine availability and maximizes power generating capabilities—all of which are critical to decreasing your wind turbine's LCoE.

Increasing Reliability – Fewer components to malfunction means trouble-free performance over the lifetime of your turbine. This results in increased productivity and enables you to generate more power from your wind farms.

Minimizing Downtime – The optimized system architecture of the Moog Pitch System 3 consists of 66% fewer parts than that of a conventional electric pitch system. This, coupled with the system's highly ruggedized design, significantly increases the mean time between failures (MTBF) and reduces downtime by up to 50%.

Reducing Unscheduled Service Requirements – With increased reliability, the Moog Pitch System 3 drastically reduces maintenance requirements. Its compact, lightweight and modular design also allows for easier handling of components, which improves the safety and efficiency of O&M activities.

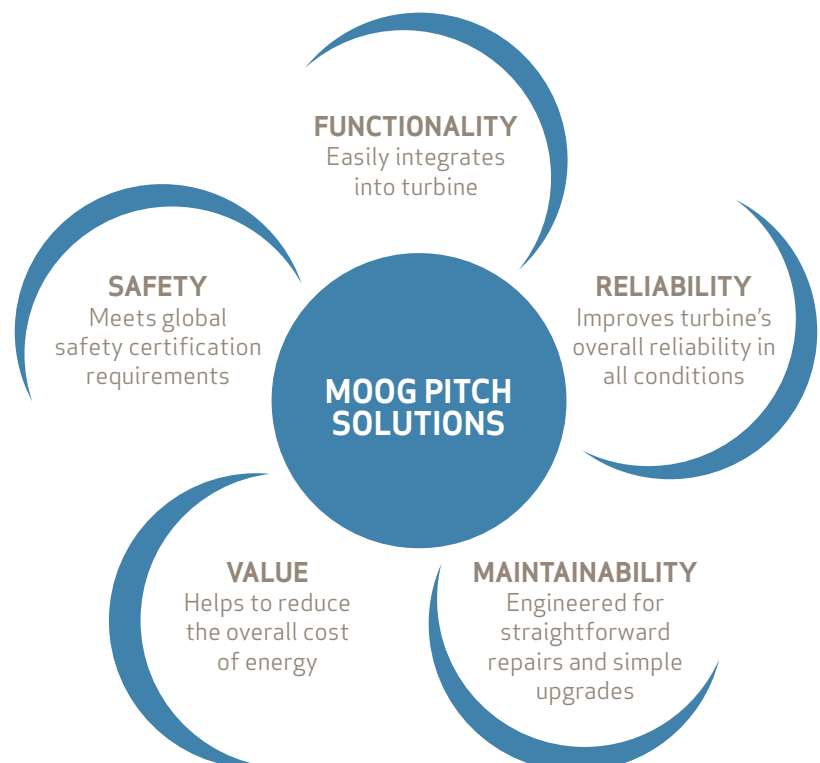
Optimizing Backup Management – In addition to reducing the charging time of ultracapacitors by up to 90%, our backup energy systems are independent of primary systems to ensure safety and redundancy.

Extending Pitch System Life – Low motor inertia results in less loading on the drive train (pitch gearbox, bearing teeth, etc.) and extends the overall life of your pitch system. Convection cooling also eliminates the need for fans and minimizes mechanical wear.

Taking Advantage of Moog Global Support – Moog's wind energy service experts offer training, retrofits, flexible service agreements, replacement parts and technical support to maximize the value of your pitch control investment. Our global supply chain for production and a worldwide sales presence ensure total support when and where you need it.

OFFERING THE BEST OF MOOG'S WIND ENERGY EXPERIENCE

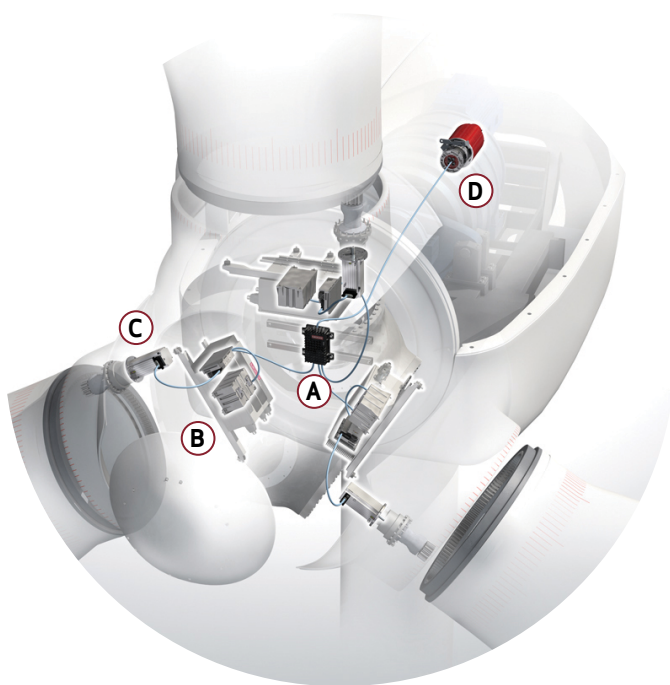
Currently, more than 40,000 of Moog's pitch systems and related products are in operation in over 22,000 wind turbines worldwide. Our Pitch System 3 represents the best of Moog's many years providing pitch control solutions to wind farms around the world – offering high performance and increased reliability for a lower LCoE.



AN INNOVATIVE, SOLUTIONS-BASED APPROACH TO PITCH CONTROL

Moog developed a new design that is highly reliable, compact and lightweight. The new Moog Pitch System 3 design is based on a very high level of integration of functional elements, made possible by pluggable

PCB modules instead of wiring off-the-shelf DIN-rail components. Using fewer components results in a decreased probability of failure/wiring errors and better control of manufacturing quality.



INSIDE THE MOOG PITCH CONTROL SOLUTION

PITCH SYSTEM 3

Space-saving solution ensures safe, reliable performance

- A** Pitch Interface Module
- B** Pitch Axis Box (Pitch Servo Drive 3/Pitch Capacitor Module)
- C** Pitch Motor

SLIP RING SOLUTIONS

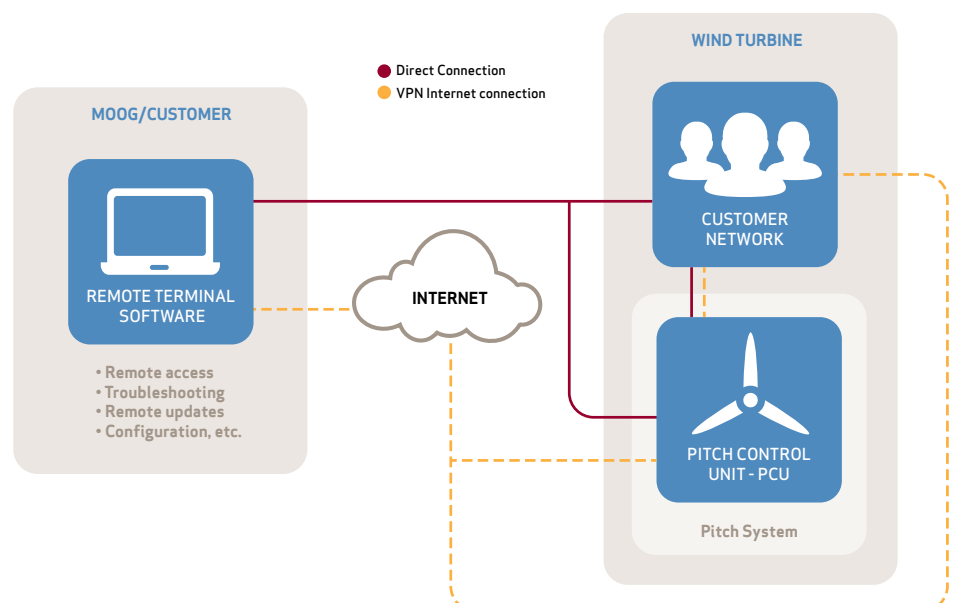
Highly reliable power/data transmission

- D** Slip Ring

REMOTE TERMINAL SOFTWARE (RTS) FOR WINDOWS XP AND WINDOWS 7 DEVELOPED IN .NET FRAMEWORK 4.0

Moog's software offers real-time operational monitoring and troubleshooting for wind turbine pitch systems. Its simple graphical user interface gives you greater control and a more in-depth understanding of pitch system operation.

- Available for Moog Pitch Systems worldwide
- Specially designed for remote access



INSIDE THE MOOG WIND TURBINE PITCH SYSTEM 3

Pitch Axis Box

- Based on proven system design
- Incorporates key components like Pitch Servo Drive 3 and Pitch Capacitor Module
- Features architecture enhancements like DC power supply to the drives, direct coupling of ultracap backup and integrated intelligence
- Significant reduction in system component count for less maintenance
- Meets functional safety requirements with enhanced protection against Common Cause Line Failures (CCF)
- Results in improved reliability & reduced lifecycle costs
- Limiting peak current from grid line supply extends lifetime of slip ring



Pitch Interface Module

- Compact and ruggedized design with IP55 housing
- Firewall to protect drives against common cause supply failures from outside (unstable grid, overvoltage caused by lightning strike)
- Fully integrated capacitor fast-charging unit with three separated outputs
- Integrated control logic with various customer communication interfaces (CANopen, Profibus, EtherCAT)
- Optional module for additional IOs and sensors
- Diagnosis and configuration tool with user-adaptable functionality (Remote Terminal Software)

Pitch Capacitor Module

- Based on proven UCAP cells
- Optimized design with highest quality and reliability; designed to withstand the shock and vibration requirements in wind turbine pitch applications
- Easy to handle in service (handle bars and plug & play connector)
- Passed extensive lab testing (e.g. successful FEA, thermal, shock and vibration, and HALT tests)
- Robust aluminum housing



PITCH PRODUCTS

Moog offers a complete range of electric and hydraulic components that save space in the hub while ensuring safety, reliable performance and fail-safe functionality.

ELECTRIC PITCH PRODUCTS



Pitch Servo Drive

- Ensures functional safety by complying with performance level d according to EN ISO 13849 in a 2oo3 configuration
- Enhanced peak power capacity during S2 safety run
- Operates reliably under internal cabinet temperatures from -30°C to +70°C. Startup at -40°C.
- Improved efficiency due to direct coupling of ultracaps and re-use of regenerated energy



Pitch Motor

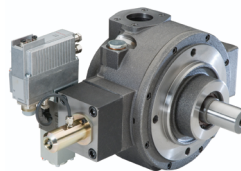
- AC servo motor features low maintenance with brushless, natural cooled design
- Incorporates integrated blade brake unit in compact, lightweight design
- Supports sensorless control to drive required torque and speed needed for safe feathering, even during resolver failure
- Delivers higher safety and servo motion performance

HYDRAULIC PITCH PRODUCTS



Pitch Valve

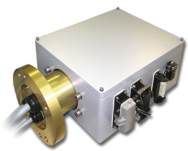
- Features proven technology that can be easily integrated into your machine automation system, allowing for easy commissioning and tuning
- Provides access to real-time data to improve maintenance decisions and offers easier troubleshooting, reducing downtime



Pitch Pump

- Incorporates the Moog Radial Piston Pump as part of hydraulic pump unit
- Features low noise
- Provides longer service life
- Available with digital onboard electronics for remote maintenance and condition monitoring

ELECTRIC AND HYDRAULIC SYSTEMS



Slip Rings

- Utilize fiber brush technology to offer extremely long brush and ring life, minimal debris generation, lower lifecycle costs
- No lubrication required over lifetime
- Modular configurations adapt to unique mounting configurations quickly and effectively
- Feature rugged enclosures, connection options on both rotor and stator, wide operating temperatures and speed ranges



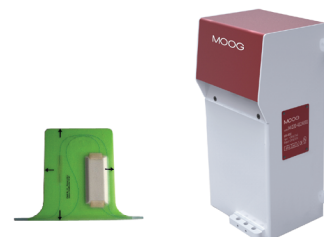
Fiber Optic Rotary Joints & Multiplexers

- Ideal for transferring high data rates over longer distances
- Feature innovative contactless technologies
- Moog Fluid Rotary Unions are also optimized for wind turbine applications and can be combined with slip rings as required



BLADE SENSING SYSTEMS

- Supply accurate, real-time blade load information to turbine's main controller
- This enables the turbine to dynamically respond and intelligently manage loads during operation through the use of Individual Pitch Control (IPC) algorithms
- Use of IPC algorithms reduce and balance loads on turbines for reduced energy costs, minimized wear and increased turbine life



COMMITTED TO RESPONSIVE SERVICE FOR WIND FARMS WORLDWIDE

Moog Global Support is our promise to help wind farm maintenance professionals worldwide to maximize availability, ensure pitch system reliability and lower the cost of energy.

Our service offering includes hands-on training, expert technical support, flexible options for OEM parts and reliable retrofits/ upgrades of pitch products and systems.



TRAINING

Gain additional expertise and improve skill gaps your maintenance team may have in pitch control technology

- Get hands-on experience with trainers using Moog equipment; Online courses provide flexibility and interactivity
- Learn how to effectively manage installation and troubleshooting
- Speed up repair and maintenance work to ensure turbine availability
- Ensure your team is prepared to safely operate and maintain turbines



TECHNICAL SUPPORT

Rely on professional field service support including installation, commissioning and troubleshooting

- Get turbines up and running faster with expert support
- Supplement your staff with expert motion control professionals
- Reduce the risk of unnecessary downtime



RETROFITS/UPGRADES

Access better reliability for pitch control with drop-in replacements and the support of a technical team to meet your specific needs

- Improve quality and performance of underperforming turbines
- Incorporate the latest technology upgrades in Moog retrofits



OEM PARTS

Insist on Moog OEM parts, delivered anywhere in the world and supported by Moog repair services

- Ensure less unplanned downtime and more availability
- Incorporate industry-leading, "as-new" pitch control performance for the life of your turbine
- Benefit from greater reliability through our continuous improvements in design
- Rely on Moog factory repair services to minimize risk



FLEXIBLE SERVICE AGREEMENTS

Choose a flexible, bundled service program that focuses on your operating challenges

- Minimize risk of failure
- Gain total confidence that maintenance is always available
- Integrate any or all Moog Global Support offerings based on your unique operating challenges



MORE PRODUCTS. MORE SUPPORT.

Moog designs a range of motion control products to complement those featured in this document. Moog also provides service and support for all of our products. For more information, contact the Moog facility closest to you.

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