



# ACHIEVING THE PERFECT PITCH

Wind Energy Solutions

YOUR PARTNER IN PITCH CONTROL

**MOOG**

# LEADING-EDGE PITCH SOLUTIONS FOR RELIABILITY AND HIGH PERFORMANCE

As countries and energy companies around the globe turn to ever larger, more powerful wind turbines in hostile on- and offshore locations, OEMs are faced with new and increasingly complex performance challenges.

OEMs must accommodate park locations with lower or unsteady winds, ensure reliability and operator safety in all installations, as well as continue to keep pace with changing design parameters and emerging technologies. Fortunately, you're not alone in managing these challenges.

Moog has been a leader in motion control for the power generation industry for more than 20 years. With proven expertise in both electric and hydraulic technologies and the vast global resources of a two-billion dollar corporation, Moog's depth of expertise and collaborative approach make us the ideal partner for pitch control solutions.

Here are just a few reasons to consider Moog:

- ✓ Trusted provider of pitch systems, slip ring solutions, blade sensing and rotor monitoring systems
- ✓ Proven supplier to the world's top ten wind turbine manufacturers—more than 27,000 units in operation worldwide
- ✓ Global supply chain for production, sales and on-site technical service anywhere in the world
- ✓ Solutions that help you reduce the cost of ownership, extend product and system lifetime and minimize maintenance requirements
- ✓ Unsurpassed technical expertise to simplify installation and troubleshoot potential problems

We invite you to see for yourself what Moog technologies, resources and innovation can bring to your onshore and offshore wind energy applications, wherever they may be.

# MEETING TODAY'S ENERGY CHALLENGES ON A GLOBAL LEVEL

In more than 26 countries worldwide, Moog teams work proactively with customers to take ideas further, incorporate higher performance, reduce operating costs and facilitate the development of next generation machine design. The pitch control challenges for wind turbines are particularly complex, ranging from assuring efficiency to increasing reliability and safety.

Moog offers high performance solutions across four key application areas: pitch systems, slip ring solutions, rotor monitoring and blade sensing systems. Here is a brief look at how we work collaboratively to meet the needs of the world's most respected energy providers.

## Higher reliability

High investment costs and operational inefficiencies have been associated with wind turbines for years due to continuous 24/7 operation in harsh, onshore and offshore environments and irregular wind conditions. By focusing on the requirements of hydraulic and electric systems, Moog is setting a new standard for smooth, reliable performance. And that translates into more uptime and significantly reduced maintenance costs.

## Safe operation

The sheer size, height and high investment costs of wind turbines mean that safety is a key factor. Moog solutions offer remote operation and diagnostics and greater fail-safe functionality for a higher degree of safety in any environment including offshore.

## Enhanced efficiency

Today's fastest growing applications for wind turbines involve offshore locations that provide access to stronger winds. Moog's innovative pitch control technology delivers the maximum efficiency and ensures greater productivity through less maintenance-related downtime. Our flexible solutions also enhance the energy efficiency of blades in wind park locations with lower or unsteady wind speed.

## Remote diagnostics

The location and height of wind turbines mean that all aspects of commissioning, set-up, troubleshooting and maintenance are costly and challenging. Innovations such as remote diagnostics in our systems are critical to reliable 24/7 operation.

## Application know-how

Another trend is toward larger, more powerful turbines and more offshore locations. The pitch technologies of even a few years ago are being pushed to their limits by these new designs, which is why Moog experts are focused on facilitating new solutions that let you keep pace with the emerging changes in turbine design.

## Worldwide service

Around the world, Moog Global Support™ ensures that our trained service technicians are on call for timely and precise repair and maintenance of Moog systems and products.

From installation and troubleshooting to product upgrades, we partner with you to ensure your critical wind turbine installations are well managed and expertly maintained.

## PROVIDING THE TOTAL SOLUTION

### The request

Provide a total offshore pitch control solution up to 5 MW or higher—including pitch servo drive, pitch motor, slip ring and blade sensing system—that is rated for extreme climate conditions and will ensure cost-effective operation. In addition, the customer wanted a global partner who spoke their language and could respond quickly to their needs.

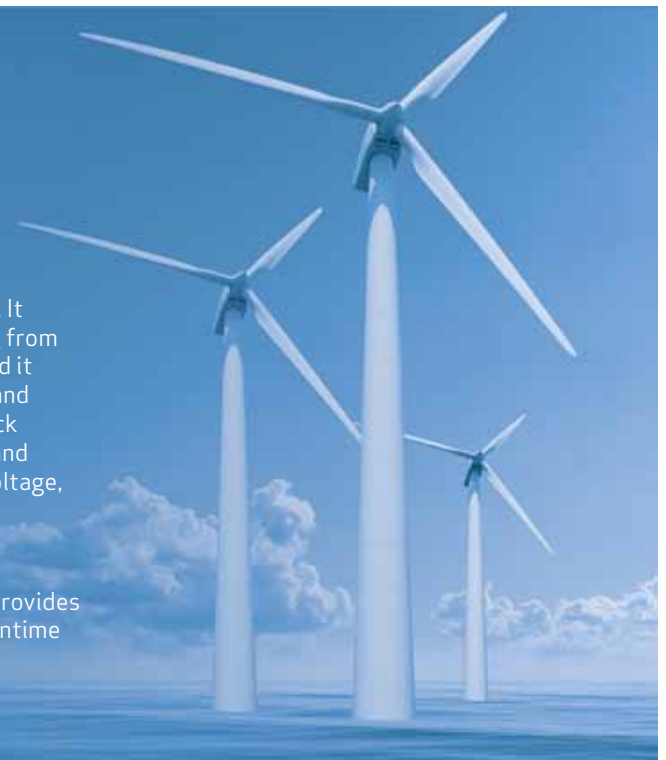
### The solution

Moog's team of experts designed and delivered a total pitch control solution to meet their specific request. The solution

is fully customized to suit wind conditions at the installation site. It operates in temperatures ranging from -30 to +50° C (-22 to +122° F). And it is designed for low maintenance and proven reliability with safety check functionality, fail-safe software and monitoring functions for force, voltage, current and temperature.

### The result

The Moog pitch control solution provides reduced operating costs, low downtime and long service life.

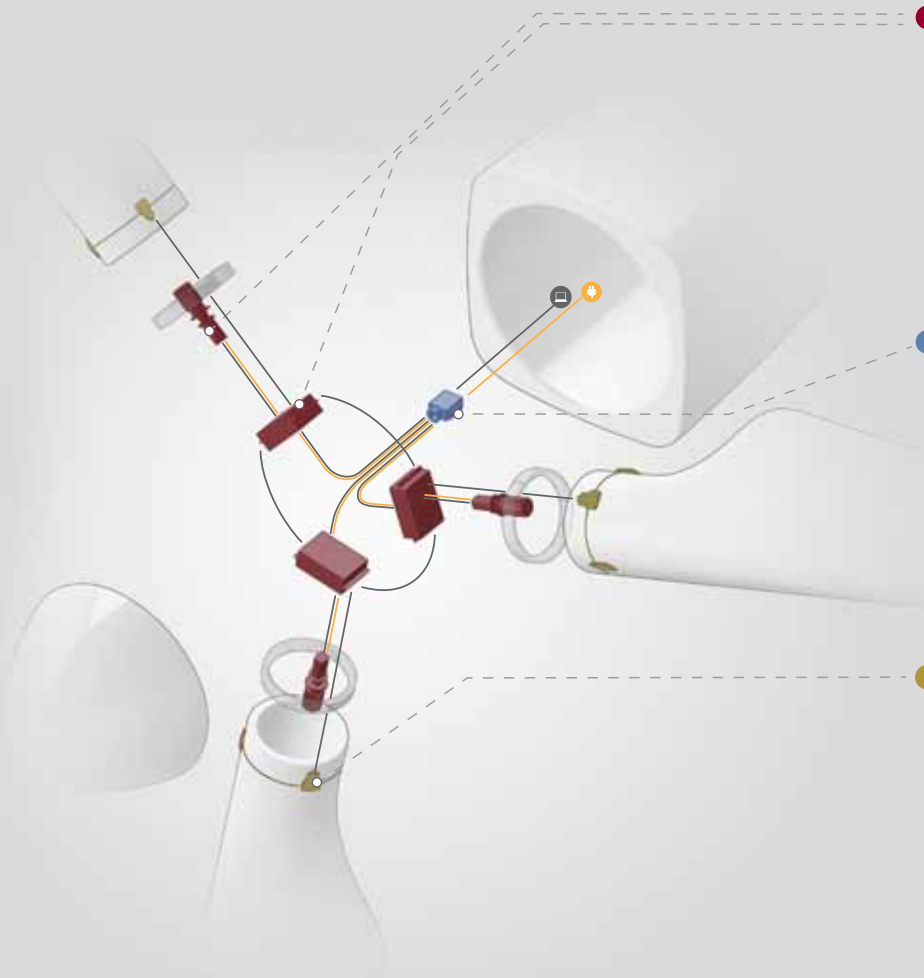


# AN INNOVATIVE, SOLUTIONS-BASED APPROACH TO PITCH CONTROL

Accurately controlling the pitch of a turbine's blades is essential to the overall performance and safety of a wind turbine. During operation each blade is subjected

to instantaneously changing loads and forces. Based on the rotor position and wind conditions, a pitch system actively works to manage these changes.

## MOOG WIND TURBINE PITCH SOLUTIONS



### ● Pitch System

- Customized solution saves space in the hub, while ensuring safe and reliable performance
- Moog Wind Turbine Pitch Servo Drive has a flexible design that allows selectable installation positions
- Resistant to vibration and shock

### ● Slip Ring Solutions

- Ideal for highly reliable power and data transmission in electric and hydraulic systems
- Built for high performance in harsh conditions on- or offshore
- Fiber brush design for maintenance-free operation of over 100 million revolutions

### ● Blade Sensing & Rotor Monitoring Systems

- Supplies accurate, real-time information to the pitch system or main controller of the turbine
- Enables dynamic response and intelligent management of loads during operation

## MOOG WIND TURBINE PITCH SYSTEM

The Moog Wind Turbine Pitch System is designed for reliability, reduced downtime and simple integration. Each high performance solution can be tailored to match your specific requirements for maximum safety, reliability and efficiency. In addition, every installed Moog system is backed by our global support network.

Our systems include a high performance Pitch Servo Drive, Pitch Motor and Backup System designed to meet the unique needs of each customer. The system cabinets are designed to meet your specifications and accommodate the available hub space. Our backup systems feature acid lead batteries, lithium ion batteries, or capacitors, and are independent and not interconnected to ensure redundancy.



Axis Box with Integrated Backup



Backup System

## ELECTRIC PITCH PRODUCTS

Moog offers flexible solutions that save space in the hub, while ensuring safe and reliable performance.



### Pitch Servo Drive

The Moog Servo Drive was developed for the harsh conditions in the rotating hub and operates reliably under internal switchgear cabinet temperatures from -30 to +70° C (-22 to 158° F). Its flexible design provides selectable installation positions and is resistant to vibration, shock and permanent shock.



### Pitch Motor

Moog's new AC Pitch Motor has sensorless technology that is capable of driving the required torques and speeds needed for safe feathering even during the grid loss condition in pitch control applications. It has higher safety and higher servo motion performance

in a smaller package with an integrated blade brake unit. DC motors are also available for pitch systems requiring this safety concept.

## HYDRAULIC PITCH PRODUCTS

In cooperation with system integrators, we offer unique hydraulic blade pitch control systems with integrated fail-safe functionality.



### Pitch Valve

Our valve features microprocessor-based electronics and CANopen, Profibus DP or Real-Time Ethernet fieldbus interfaces. This enables fully digital communication for improved performance, enhanced remote diagnostics and greater process control.



### Pitch Pump

Moog delivers the Hydraulic Pitch Pump (Radial Piston Pump or RKP-II) as part of the Hydraulic Power Unit. The pump features low noise and provides longer service life. It is available with digital onboard electronics for remote maintenance and condition monitoring.

## BLADE SENSING SYSTEMS



Moog's Blade Sensing System dynamically adjusts the pitch of each blade in real time to optimize the loading of the rotor. It supplies accurate, real-time information to the turbine's pitch control system or main controller, enabling the turbine to dynamically respond and intelligently manage loads during operation through control algorithms.



By managing loads, the system reduces wear on components, minimizes downtime and maintenance costs. It also increases efficiency through improved turbine operation, reduced friction and better wind utilization.

## SLIP RING SOLUTIONS



Moog Slip Rings, Fluid Rotary Unions and Fiber Optic Rotary Joints set the standard for reliable power and data transmission in electric and hydraulic systems, even in harsh conditions and offshore environments.

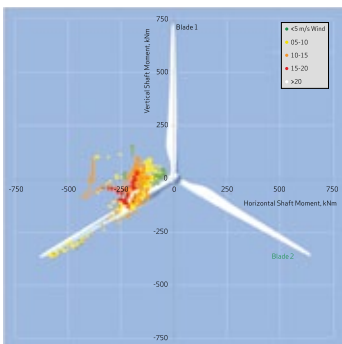


Our Slip Ring Products utilize fiber brush technology to offer extremely long brush and ring life, minimal wear debris generation, lower lifecycle costs and no lubrication for low maintenance.

Each product features a rugged enclosure, connection options on both rotor and stator, and a wide operating temperature and speed range. The modular design configurations adapt to unique mounting configurations quickly and effectively.



Moog Fiber Optic Rotary Joints and Multiplexers are ideal for transferring high data rates over longer distances. Our innovative contactless technologies are also included in our family of slip rings.



## ROTOR MONITORING SYSTEMS

The Rotor Monitoring System (RMS) is a proven, robust, load measuring system specifically for installation in the turbine hub. The system can be designed-in during manufacture or retrofitted to existing operational turbines. The RMS allows cost-effective remote monitoring of turbines for the early detection of operational and maintenance issues such as:

**Rotor imbalance**—provides information on aerodynamic imbalances, enabling early remedial action to maximize generation capacity and avoiding costly damage. Moog offers a full data analysis service, configured to customer needs and requirements to provide optimum benefits.

**Blade damage**—provides real-time notification of damage impacting the structural or aerodynamic performance of the blade, enabling early remedial action and avoiding costly damage.

# MOOG GLOBAL SUPPORT™



Wherever you are in the world, you can rest assured that Moog's team of experienced, trained technicians are there for you with the service, training and parts you need to keep your wind turbines performing at peak condition. Moog Global Support™ is your direct link to optimal turbine reliability and performance.

## SERVICE

Moog has a presence in 26 countries worldwide, so our technicians understand what you're up against and speak your language, too.

- ✓ On-site services bring the expertise to you
- ✓ Planned preventative maintenance programs decrease downtime
- ✓ Total support for setting up or commissioning new installations
- ✓ Diagnostics and fault-finding
- ✓ System optimization
- ✓ Preparation of customer-specific documentation

## TRAINING

Whether you attend classes at the Moog Wind Training Center or have our experts provide on-site training, you can expect a wealth of knowledge and smart solutions to your toughest challenges.

- ✓ Training on a wide range of technical topics
- ✓ Educational programs tailored to your specific needs
- ✓ Insights and recommendations for adapting product parameters
- ✓ Access to the latest technical documentation to eliminate problems and minimize downtime

## PARTS

Reduce downtime with a spare parts program designed specifically around your wind turbines.

- ✓ Upgrade with the latest technologies
- ✓ Get high-quality spare parts virtually anywhere in the world
- ✓ On-site exchanges, conversions and repairs

Find out more about Moog's worldwide support at [www.moog.com/wind](http://www.moog.com/wind).



# TAKE A CLOSER LOOK.

Moog solutions for wind energy are only a click away. Visit our worldwide Web site for more information and the Moog facility nearest you.

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