Innovative sensors for wind turbines

By Christian Fell, FRABA Inc.

Introduction

Wind turbines have become an increasingly familiar part of the landscape, especially in coastal or mountainous regions where winds are strong and steady. And these three-armed giants are destined to become even more common. According to the US Energy Information Administration's 2010 report on the international energy outlook, the installed base of wind generation capacity in the US is projected to rise from 16 Gigawatts (GW) in 2007 to 69 GW in 2035. The report further predicts that worldwide capacity of wind-powered generation will grow from 93 GW to 486 GW over the same period.

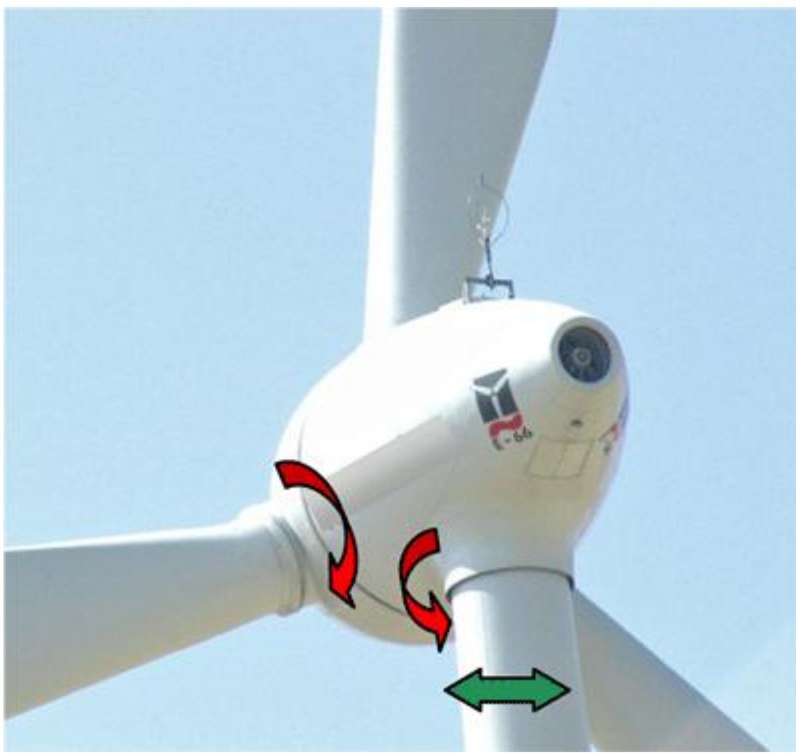
Wind Turbine Controls

While wind turbines have relatively low operating costs (the "fuel", after all, comes for free), the capital cost is high and the key to profitability is to maximize the output from each unit. Manufacturers have responded to this need by designing equipment that is highly efficient (in terms of extracting as much energy as possible from the wind), while at the same time maintaining reliability and durability.

A key element in achieving these goals is the control system, which maximizes electrical outlet by optimizing the aerodynamics of the turbine in response to changing wind conditions. The control system has two main components:

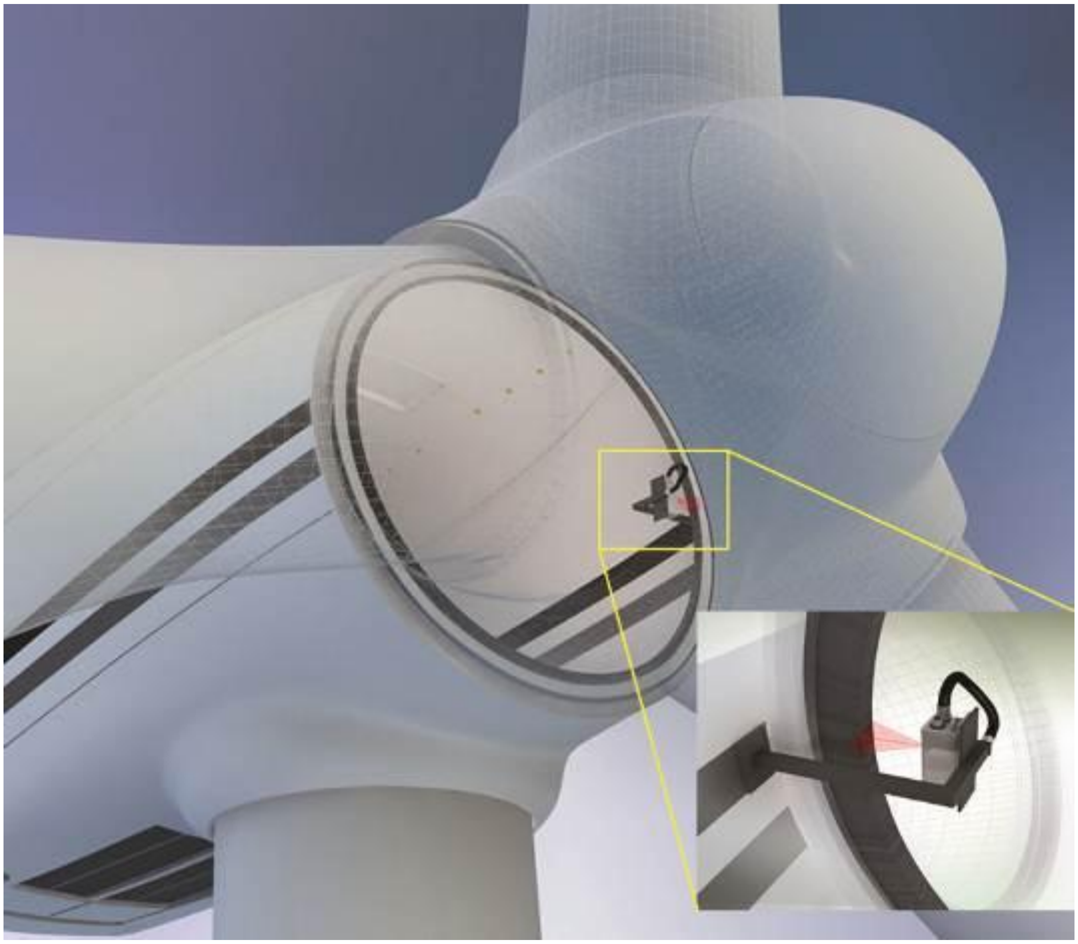
The **yaw control** is designed to keep the turbine pointed directly into the wind, based on feedback from an anemometer or wind sensor mounted on the turbine body. The task of changing the orientation of the turbine is generally handled by one or more electric motors, each fitted with a pinion that engages a large ring gear mounted at the connection between the turbine's nacelle and the supporting mast. These motors are typically equipped with a rotary encoder that records rotations of the drive motor, and hence the turbine nacelle. Absolute, multi-turn encoders, such as POSITAL's OPTOCODE or MAGNETOCODE encoders are very useful here since they always report the complete rotary position (number of turns plus angular displacement) of the motor shaft(s).

The **pitch control** system trims the angle of the turbine blades to extract as much energy from the wind as possible, while typically maintaining a constant rotational speed. Here again, small electric motors are used to change the angle of attack of the blades. Rotary encoders are an essential component of the system, providing feedback on the pitch angle of each blade. A secondary – but critical – function of the control system is to protect the turbine from very high winds by changing the angle of the blades to a neutral position so that they slow or even stop rotating when the wind speed exceeds a safe level.



Yaw and pitch control

Motion Sensors Improve Speed Monitoring



OPTIPACT sensor measures velocity at nose-cone skirt

Accurate measurement of rotor speed is clearly important for the efficient and safe operation of wind turbines and manufacturers often build several speed monitoring sensors into their control systems. These might include an incremental rotary encoder connected directly to the rotor shaft and a proximity sensor mounted to detect the passage of special features built into the rotating components. One European wind turbine maker decided to test OPTIPACT optical motion sensors, built by from FRABA, in this application. These sensors are designed to measure the rate of motion of an object moving through their field of vision (see sidebar). For the wind turbine application, the OPTIPACT sensors were mounted inside the turbine nacelle in a position where they could monitor the speed at which the inner surface of the rotor's nose cone passed the sensor location. Since the diameter of the nose cone is known, the rotational speed of the rotor assembly could be easily determined (Figure 1). These sensors were originally introduced on an experimental basis to replace proximity sensors as a backup system for speed monitoring. (Non-contacting OPTIPACT sensors eliminate the need for special surface preparation in the area where the velocity is measured, while proximity sensors usually require that a number or ‘features’ be machined around the circumference of the rotor shaft that will trigger the sensor.)

OPTIPACT contactless motion sensor

The optical motion sensors were found to be very accurate and, even more importantly, to have excellent dynamic response to sudden changes of rotor speed due to wind gusts or other disturbances. (Wind turbine blades are long, heavy and lightly damped. Vibrations caused by sudden variations in wind direction or speed can be powerful and long-lived.) In fact, the new sensors proved to have better dynamic response than shaft-mounted rotary encoders. This led the turbine manufacturer to 'promote' the OPTIPACT sensors to the role of primary rotational speed sensor, with the shaft-mounted rotary encoders serving as back-ups.

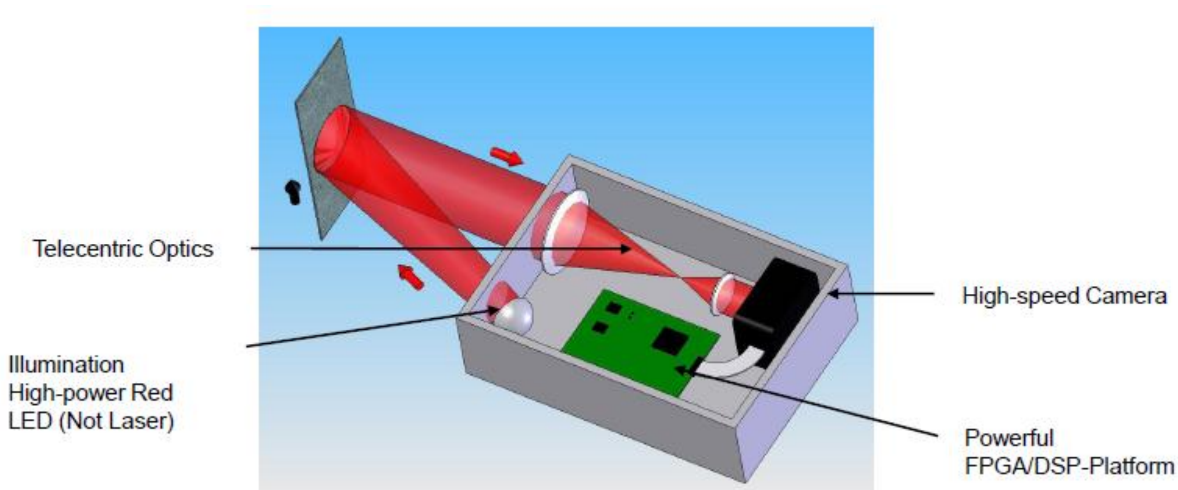
The excellent accuracy and dynamic response of the OPTIPACT motion sensors would enable turbine manufacturers to implement advanced features, such as individual pitch control for each blade. This would mean that the pitch of individual blades could be instantly adjusted to compensate for local variations in wind speed (e.g. as the blade passes in front of the supporting tower). Individual blade control would provide a useful incremental improvement in overall turbine performance.

Of course, there are factors beyond accuracy that determine the suitability of a device for a particular application. Wind turbines operate in a harsh environment with extreme temperatures, rain, fog, ice, snow, dust and constant vibration. Here again, the OPTIPACT sensors have proven to be up to the task, thanks to their lack of moving parts, their sturdy construction and well-sealed packaging. Compatibility with controller systems is another important factor. These sensors feature quadrature outputs that can be interfaced to many popular PLC’s.

Because OPTIPACT motion sensors are so easy to install, they are an excellent retrofit option for wind turbine operators who need to replace or upgrade the control systems in older machines.

More about OPTIPACT optical motion sensors

FRABA's innovative OPTIPACT motion sensor measures velocity by a no-contact optical method. The device incorporates a tiny digital camera and measures the velocity of a moving object by monitoring the rate at which an image of the object travels across the surface of the optical sensor. With no physical contact between the sensor and the moving object, the presence of dirt or other surface contaminates will not degrade the accuracy of velocity measurements.



About FRABA, INTACTON and POSITAL

FRABA Inc. is the North American sister company of Germany-based FRABA AG, a group of enterprises focused on providing advanced products for position sensing and motion control in many sectors and applications. Business units within the FRABA group include POSITAL (rotary encoders and inclinometers), VITECTOR (safety assurance equipment), and INTACTON (optical motion sensors).