Renewable energy: From wind to watts

Absolute encoders and linear transducers in wind power plant testing and operation

The position of the rotor blades and the gondola of wind power plants has to be constantly adjusted to the direction and strength of the wind. Optoelectronic and electromagnetic absolute encoders have been in use for feeding back actual positions for a long time. The wind direction is converted to a proportional electrical signal by means of a contact-free sensor system. Before a wind power plant can be certified, a high number of behavioural characteristics have to be tested. These include e.g. the mechanical stress on the rotor blades, the drive train and the tower construction. Acoustic emissions, the electrical behaviour of the output power and dependencies on wind speed and wind direction distribution also have to be measured.

Wind park as viewed by the painter Ioan Iacob. ►

Measurement means knowledge

Various sensor technologies are used

Potentiometric or inductive linear transducers are used for the necessary measurements, insofar as these are concerned with linear movements. They are used to record the movement of transmission shafts and transmission supports and the shift in machine foundations. Tower movements are measured using strain gauges and acceleration sensors. When measuring load, the position of the gondola, etc. has to be measured in order to determine whether the system is „facing the wind“ or is positioned incorrectly. A multi-turn absolute encoder with analogue signal output is used to measure the position.

The measurement examples mentioned above, which are required for type certification, for example, necessitate measuring transducers which can be adapted to the type of system to be tested. This applies e.g. to fastenings and coupling mechanisms. The transducers must be resistant to moisture and extreme temperature conditions under all circumstances. The housings and adjustment shafts therefore have to be manufactured from seawater-resistant aluminium or stainless steel. Seals and electrical connections must correspond to protection types up to IP 68. Offshore use, which is increasingly the case, requires careful selection of the transducers to be used.

Absolute encoders of various designs for pitch and yaw control on wind power plant gondolas. ▼

Attention must also be paid to reliable electrical transmission technology. All of the above mentioned measuring transducers supply absolute measuring signals with a fixed reference point. The current status is also reported following a voltage interruption. New reference travel is not necessary.

Face to the wind

Constant power output is demanded

At wind speeds above the rated values, the strain on wind power plants exceeds the limits given by the rotor structure’s strength layout. In addition, the permissible, maximum generator output acts at the limit for the wind power plant’s power output at the output shaft. As the wind power increases three-fold along with the wind speed, the system’s power uptake has to be limited. In addition to these aspects of protection and operational safety, limiting the output may also be desired by the operator. In particular, this includes outputting a constant electrical power, insofar as the available wind allows this.

Both specifications can only be met by means of aerodynamic control methods. One method, which is particularly used in larger wind power plants, is output limitation via adjustment of the rotor blade angle (pitch). In this principle, aerodynamic forces are precisely influenced, by rotating the rotor blades around their longitudinal axis, so that the wind power plant’s power output remains constant as of rated output.

▲ Absolute encoders in combination with cam group for gradual and constant angle feedback for pitch control.

In pitch control, each rotor blade can be individually adjusted over a range from 0 to 90°. Optoelectronic absolute encoders with a resolution of 12 bits/360° and a serial SSI interface have been in use for over 10 years to feed back the positions. Besides the electrical data, the robust, mechanical design, particularly the adjustment shaft's reliable axial and radial load-bearing capability of up to 250 N, protection type IP 66 and the selection of high-quality components for maximum reliability and a long service life are also authoritative as regards use. Depending on the design of the electronic control system, various wind power plant manufacturers now also use absolute encoders with analogue interfaces from 0 to 20 mA, 0 to 10 VDC or with CANopen interfaces as standard. The application areas now extend to cover systems with outputs from 250 to 6000 KW.

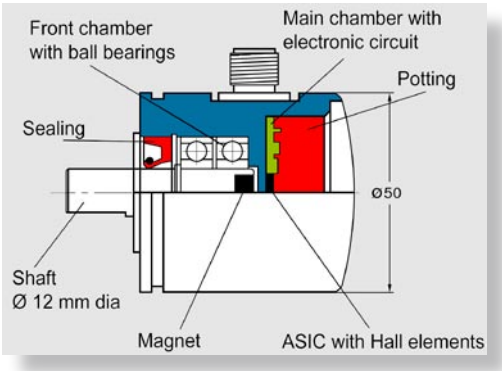
Multi-turn absolute encoders with Han-Brid connectors for ► interruption-free fibre optical data transmission over long distances.

Electromagnetic encoders are particularly robust

The new generation with Hall elements

New options in terms of harsh operating conditions, particularly such as those found in marine environments, are being accessed via the use of electromagnetic absolute encoders in dual-chamber design. In this construction, the adjustment shaft, which is equipped with a small, permanent magnet, is separated from the electronic system by a metal wall. The circuitry with Hall elements in an ASiC and the signal processing system are housed in the rear chamber and are completely cast-in. This guarantees protection type IP 68.

The housings are manufactured either from seawater-resistant aluminium or stainless steel. They have a maximum resolution of 13 bits/360°, resulting in a resolution of around 3 angular minutes for the 90° measuring range. Digital and analogue interfaces are also available. Special functions can be implemented according to the system manufacturer's specifications. Absolute encoders in dual-chamber design with CANopen interfaces are used in newer systems. Together with other subscribers, these are linked to the control system via the common network. This significantly reduces the level of wiring which is required.



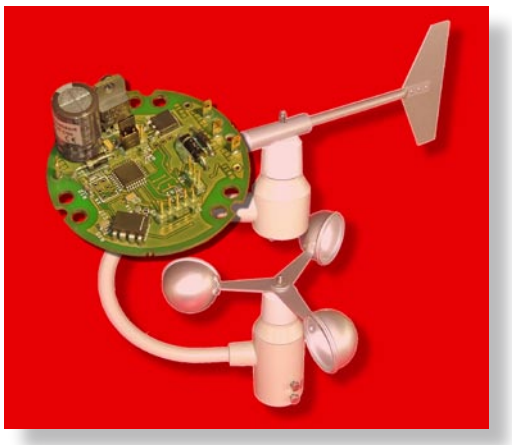
▲ Structure of an electromagnetic absolute encoder in dual-chamber design for particularly harsh operating conditions.

The wind direction is integrated into control

The measured value must not be falsified

To determine the wind direction, the movement of a wind vane is recorded by a contact-free, electromagnetic rotary encoder, which is integrated into the anemometer as a construction kit. The encoder supplies a signal from 0 to 10 VDC over 0° to 360°; this is made available to the control system. A preset input enables adjustment to the centre, with the result that a measured angle of ±180° corresponds to the output signal of ±5 VDC. The resolution is 6 angular minutes. To save space, the construction kit can be integrated into anemometers without separate bearings. Due to contact-free, magnetic activation, no friction occurs and the measured value is not therefore falsified. Wind vane vibrations do not lead to wear in the sensor system.

The position of the wind vane is recorded without contact by an electromagnetic sensor and is forwarded to the control system as a voltage signal. ►



Top priority is given to reliability and service life

Down time is expensive

Depending on the manufacturer, the systems are routinely serviced within 5 to 10 years of starting operation. Failures which occur in the meanwhile not only mean a lack of power, but also lead to considerable costs for repairs and the exchange of individual components. This particularly applies if such work has to be carried out in or on the gondola at hub heights of 50 m to 120 m. Absolute encoders, which are used on the rotors for position feedback, as described in this contribution, therefore have to be designed for maximum reliability and a long service life. All electronic components must be selected accordingly. As operation takes place under highly diverse climatic conditions, for example, extreme differences in operating temperature and moisture conditions have to be taken into consideration. Reliability and service lives of 10 years and over are therefore a significant factor in analysing the price/performance ratio.