Handout lightning and surge protection of BLADEcontrol® system

BLADEcontrol® is a blade based condition monitoring and ice detection system designed for reliable functionality during and after lighting events. Its surge and lighting protection concept is based on the international standards IEC 61400-24 and IEC 62305-3. Of course, a functioning lighting protection system of the wind turbine is required for reliable surge protection.

For those reasons, the following design and installation measurements are implemented:

1. Surge protection devices (SPD) are installed at transition between different lighting protection zones (LPZ) and at the power input of the BLADEcontrol® system.

2. Equipotential bonding is realized by electrically connecting BLADEcontrol® components to wind turbine grounding system.

3. Prevention of flashover voltage of up to 225kV between lightning conductor and sensor cable in rotor blades by additional high insulation of sensor and cable. Experimental test of the dielectric strength was conducted by a certified laboratory. Test specifications were chosen acc. to IEC 60060-1:2010-09 with impulse voltages of waveshape 0,4/45µs and 1,2/50µs in.

4. Individual consultation on cable routing and sensor placement for each new wind turbine or new rotor blade equipped with BLADEcontrol®. Weidmüller has over a decade of experience in the planning of the sensor cable routing inside rotor blades.

Fig. 1 shows typical LPZ in HUB and Nacelle of a wind turbine with installed BLADEcontrol® system. The blade sensor is installed in LPZ 0B and cable routing planned to maximize the possible distance to any lightning conductor. This is an additional measurement to prevent flashover voltage.
Sensor cable transits from the stiffener plate into the Hub and is connected to HMU in LPZ 1. Thus, SPD are installed inside HMU at the sensor inputs.
To reduce risk of possible surge damage to the sensor in case of feedback surge, SPD are also integrated into the sensor head.
Equipotential bonding is achieved by electrically connecting HMU to wind turbine grounding system. Weidmüller can also offer customer specific solutions for grounding of the sensor cable at the stiffener plate if required.

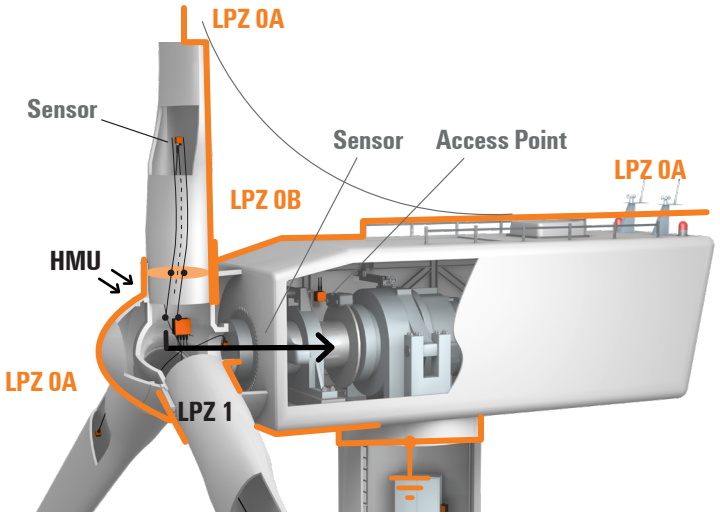

Fig. 1 Lightning protection zones inside wind turbine with installed BLADEcontrol®

To support the decision making of cable routing in the blade and reduce any residual possible flashover voltage, a specialized external laboratory analyzed BLADEcontrols® surge and lighting protection concept.
The analysis considered international standards and empirical data in order to provide a basis for decision making of sensor cable routing. Due to the individuality of each wind turbine, discussion between Weidmüller and customer is required before defining cable routing. Especially the possibility of using carbon fibers as lighting conductors and the length of parallel routing between the cable and lighting conductors must be considered in planning.
For practical determination of minimum safety distance s between sensor cable and lighting conductor, an empirical equation was derived in IEC 62305-3. As approved by external laboratory analysis, the empirical equation might be used for BLADEcontrol® with the factor values listed in Tab. 1.

Safety distance: $s = k_a * k_c * \frac{l}{k_m}$

Variable	Description
k_a	LPZ factor, k_a = 0.073, for realistic sensor cable routing in rotor blades from LPZ 0 to LPZ 1
k_c	Factor for electrical current division, k_c = 1, for single lighting conductor k_c = 0.44, for carbon fiber reinforced blades
k_m	Electrical isolation factor k_m = 1, isolation by air k_m = 1.08, for high insulated sensor BCA523 k_m = 1.21, for high insulated sensor BCA523 and glass fiber web inside blade
l	Parallel length between sensor cable and lighting conductor

Tab. 1 Variables for empirical equation to determine safety distance

Fig. 2 shows exemplary cases of the safety distance s between sensor cable and lightning conductor for parallel cable routing of length l based on the empirical equation. These provide a first approximation of the safety distance for BLADEcontrol® in your wind turbine. For BLADEcontrol®, the sensor normally is installed at 1/3 of the rotor blade length. Thereby, the position of the stiffener plate is defined at length l = 0m.

- Non insulated BCA503-sensor in blade without carbon fibers
- High insulated BCA523-sensor and a GRB web between sensor cable and lightning conductor
- Non insulated BCA503-sensor in blade with carbon fibers that are part of lightning conduction system
- High insulated BCA523-sensor and a glass fiber web between sensor cable and lightning conductor in blade with carbon fibers that are part of the lightning conduction system

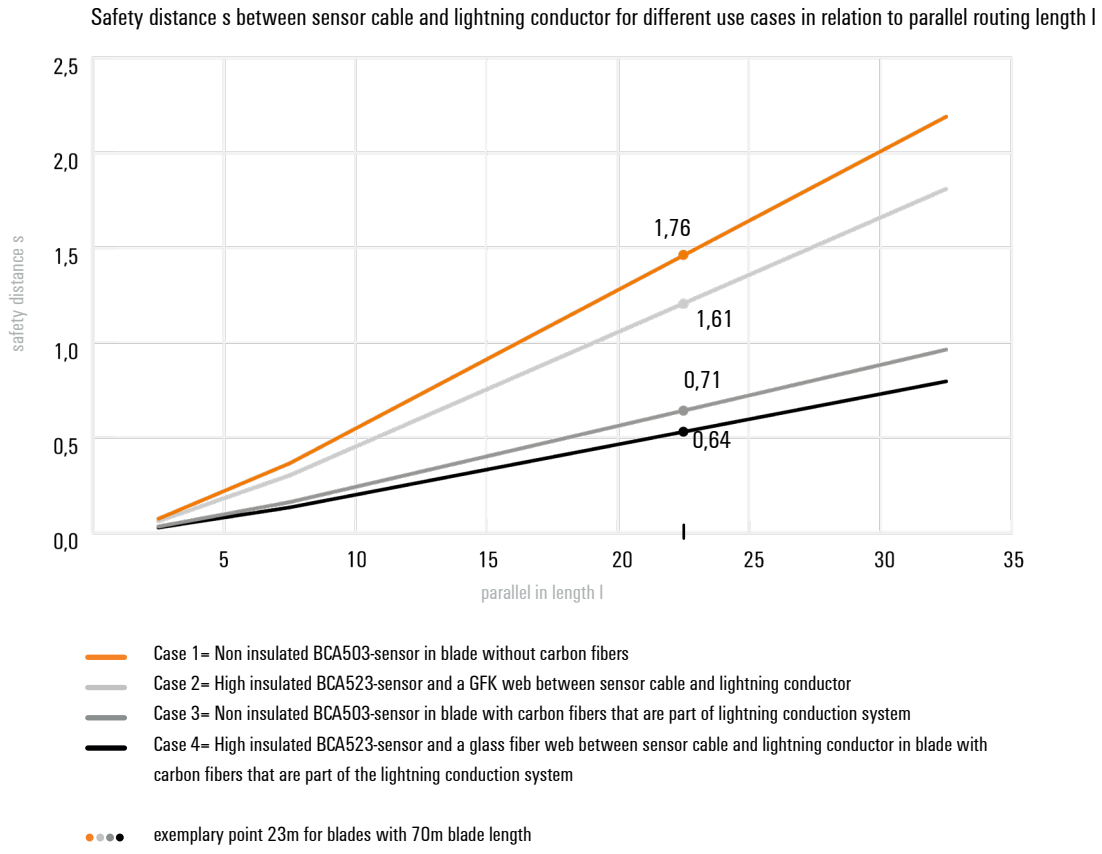

Fig. 2 Safety distance s between sensor cable and lightning conductor for different use cases in relation to parallel routing length l

Conclusion:

- BLADEcontrol® design includes effective surge and lightning protection measurements for reliable long-term application in wind turbines.
- A functioning and maintained lighting protection system of the wind turbine is required, e.g. functioning grounding via lighting conductor and slip ring.
- Validation of design and installation measurements by certified laboratories.
- Continuous tracking of installed BLADEcontrol® systems shows no failure due to surge or lightning events if current measurements are applied:

1. high insulated sensors,
2. SPD use and equipotential bonding
3. individual consulting on installation