

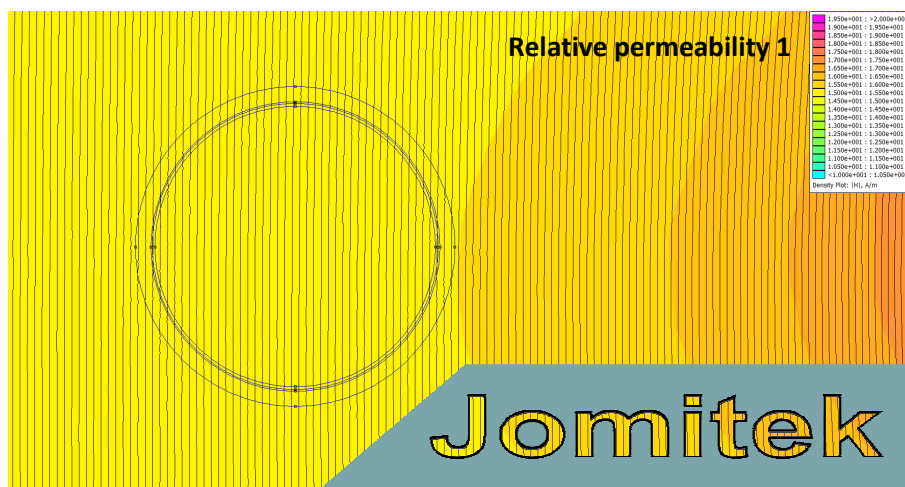
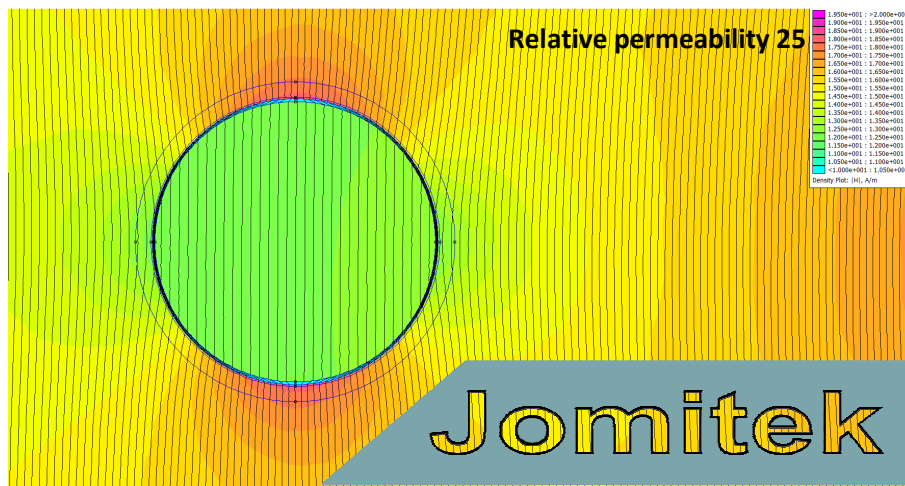
Immunity against nearby lightning

In EN61400-24:2010 the Rolling Sphere method is used to establish a protection level classification for wind turbines. The precursor for parts of the standard can be found in Recommendation 25, Lightning protection of wind turbines, defu, 1999. Using these protection levels, a reference is created in this document to exemplify the level of immunity against nearby lightning of the Lightning Sensor Advanced system.

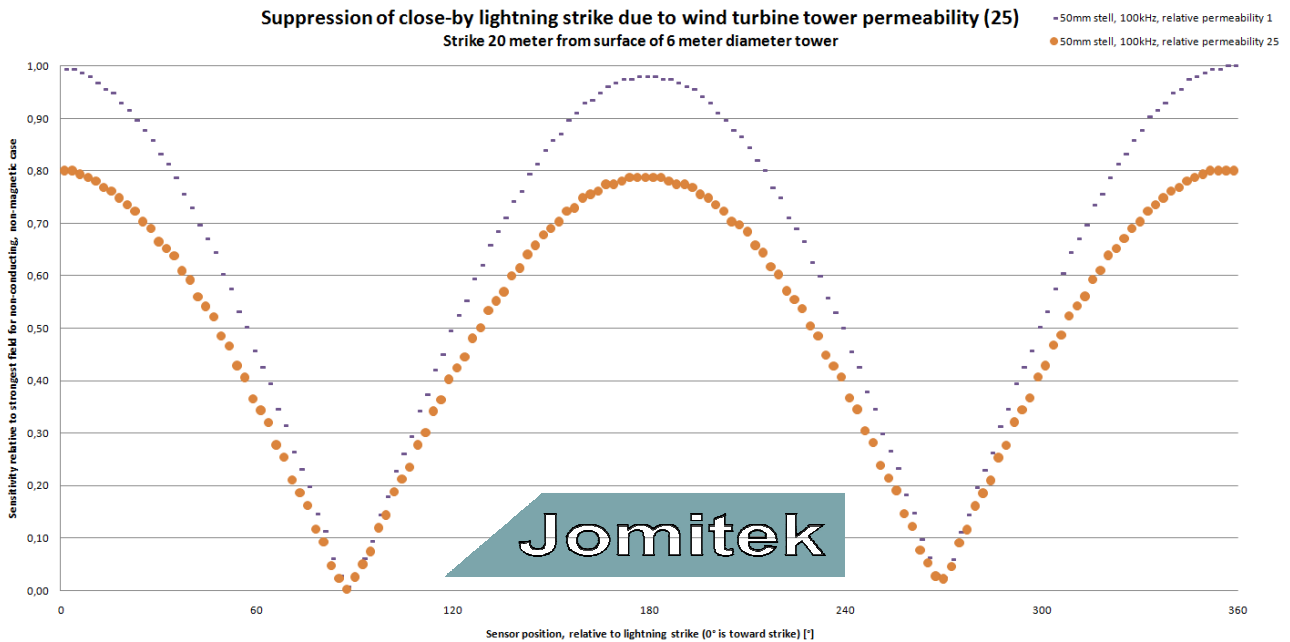
Protection level	Strike distance from tower surface [meter]	Efficiency [%]
I	20	98
II	30	95
III	45	90
IV	60	80

The simulations presented in the following assumes a 100kHz discharge characteristic and a wind turbine tower 6 meter in diameter, with 50mm thick walls. At the frequency assumed, the relative permeability of a steel wind turbine tower is around 25. Finite Element Modeling in varying distances, and assuming relative permeability 1 and 25 has been created.

A discharge 20 meters from a the tower surface is seen in below illustrations:



The lightning sensor measures the magnetic field created by the lightning current tangentially and horizontally to the surface of a wind turbine tower at a distance of 3cm. The following graph presents the magnitude of the tangential field relative to the maximum tangential magnitude in the simulation with permeability 1:



As would be expected, it is apparent that the case where the sensor is directly facing the nearby strike is where the strongest tangential magnetic field is seen. The main reference points to note are the following:

- A steel tower will reduce the field strength of a nearby lightning with $\sim 20\%$, due to the 'field sucking' properties of a material with >1 relative permeability.
- Within the spans 80° - 100° and 260° - 280° the total field strength is reduced to less than 10% compared to the 0° worst case scenario.

The worst case relative immunity towards nearby lightning can be summarized as follows based on a wind turbine tower with minimum 50mm tower thickness, relative permeability 25:

Protection level	Strike distance from tower surface [meter]	Detected strike magnitude relative to direct strike (6 meter tower diameter)
I	20	12%
II	30	8%
III	45	5%
IV	60	4%

An example based on above table, is that with a 2kA detection limit a strike in a distance of 30 meter will trigger a detection if the discharge exceeds at least 25kA. If there is a nearby structure to the wind turbine, with a particular risk of being struck by lightning, and the preference is to avoid this type of detection, placing the sensor in the least sensitive orientation on the turbine tower will further reduce the sensitivity by a factor of 10.

In summary, the sensor will very rarely risk detection of nearby lightning strikes, and in the event that it does trigger on a nearby strike, the magnitude is significantly reduced compared to the actual magnitude of the strike.