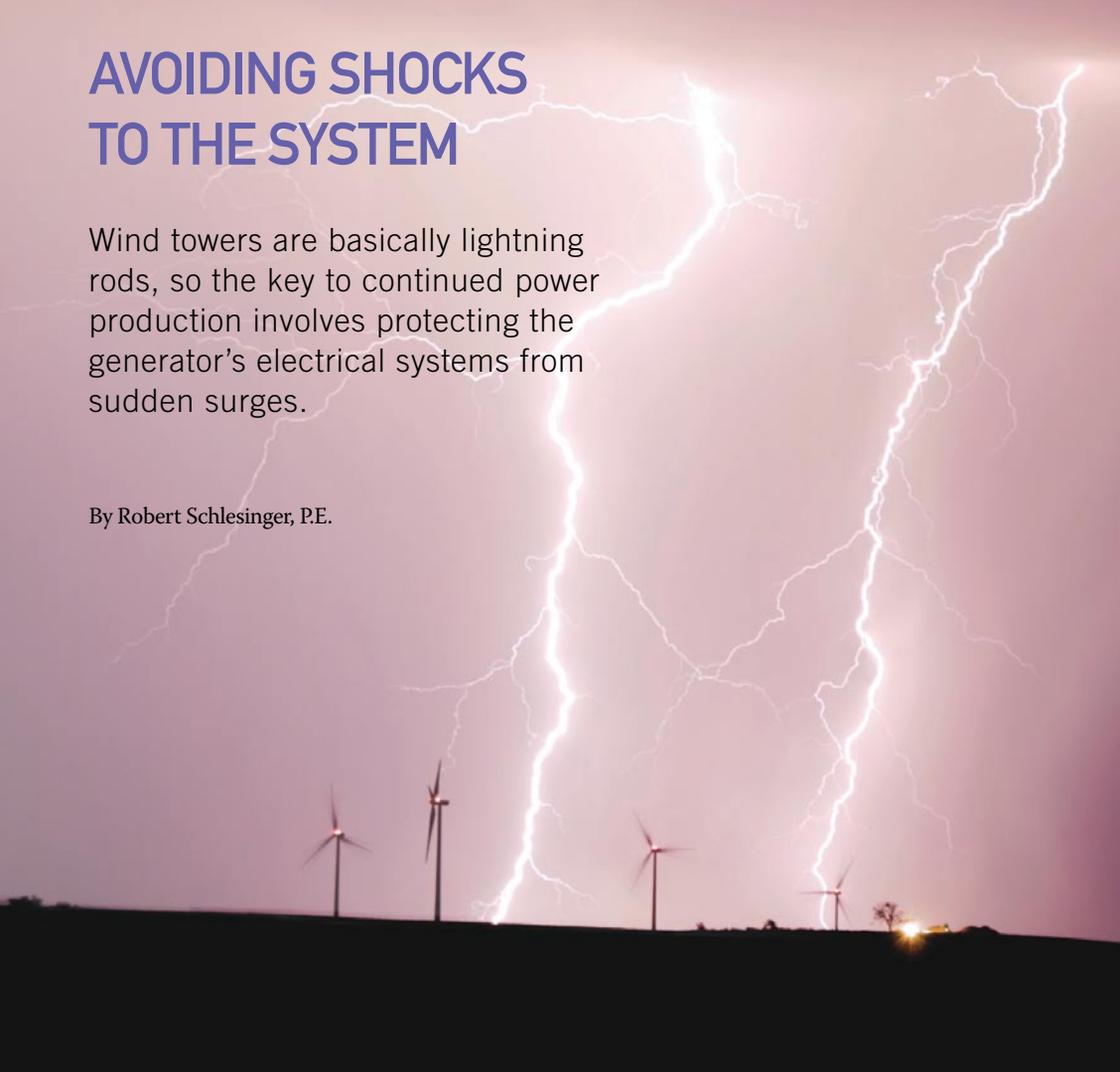


AVOIDING SHOCKS TO THE SYSTEM



Wind towers are basically lightning rods, so the key to continued power production involves protecting the generator's electrical systems from sudden surges.

By Robert Schlesinger, P.E.

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TO A THUNDERSTORM A WIND TOWER appears as a lightning rod, meaning that generators are highly susceptible to the effects of lightning. They are by design the tallest structure in the area, frequently found where lightning occurs regularly, and they have many conductors for power and communications running from uptower to ground level, therefore susceptible to induced electromagnetic effects from lightning discharges. They also have sensitive electronic measurement and control systems that can easily be damaged or upset and are connected to the utility grid, exposing the system to yet additional issues for damage or disruption of service.

While a direct strike by lightning to a blade or the nacelle may be thought to be the greatest

cause of concern, and certainly would have the most dramatic effect, it is not the most common occurrence to have an effect on the operation of a wind generator. A recent study reports the following interesting statistics:

- 7-10 percent of all lightning faults involved blade damage
- 43-51 percent involved control system damage
- 20-32 percent involved damage to the power system

While the most noticeable and catastrophic events involve the very expensive blades, this represents a relatively small percentage of all events compared to the more frequent and less-cata-



strophic faults affecting the electrical system (63-83 percent of the lightning faults involved damage to electrical/electronic systems). This includes components of the power system, instrumentation, and measurement and control systems, yet these seemingly less-dramatic failures still render the generator inoperable. Furthermore, the repeated exposure of sensitive electronics to these transients will shorten their otherwise long life expectancy.

There is technology available that attempts to divert a lightning stroke from a blade tip to earth, thus saving mechanical parts of the wind generator the damage they would otherwise experience. This, however, does not mitigate the effect that the electrical system will experience. A direct

strike to the wind generator or nearby structures will cause a local ground potential rise that, when referenced to distant points that are connected by power or measurement, control or instrumentation circuits may show many tens of thousand of volts between them. Strikes to power lines, nearby strikes, or even cloud-to-cloud discharges will induce transients onto circuits of sufficient magnitudes to cause insulation or dielectric breakdown of critical components, deterioration of those components, or even what may appear as erroneous signals on control circuits, causing PLC and controller to mis-operate.

The issues of these transients or surges affecting power and control systems are manageable by the use surge protective devices that are strategically located, properly rated for the necessary voltage protection level, and rated sufficiently to discharge the magnitude of current associated with the lightning affect. This last parameter is key, because if the SPD is not able to discharge the associated lightning current, it too will be destroyed. Figure 1 is a representation of two wave forms of equal magnitude, with the longer one (10/350 μ sec) having about 25 times the energy of the shorter one (8/20 μ sec). Lightning current discharges associated with direct strikes are more closely represented by the longer duration wave, while induced caused transients are of the shorter duration.

Depending upon the application, the proper SPD must be selected to be capable of discharging current associated with the event. That must take into expected magnitude of the current, as well as the duration.

The basic concept of protection is “equal potential bonding,” where all conductors can be bonded during the occurrence of a transient so as to have all equipment terminals at an equal potential. This is accomplished by directing lightning flashes to ground through air terminals and a well-bonded conductor system and using properly placed, rated, and coordinated surge protective devices, or SPDs. These devices use technology based on spark gaps, metal oxide varistors (MOVs), silicon avalanche diodes (SADs), and gas discharge tubes, with each having their own characteristics.

Transients appearing on energized conductors are managed by use of lightning and surge protection devices, which discharges these transient voltages and associated currents. Lightning current arresters are designed, rated, and tested for discharge impulse currents with a 10/350 μ s wave shape characteristic. Electromagnetic fields caused by direct and indirect flashes—as well as by internally switched or utility switched components—will introduce lower energy transients on conductors, and they too must be managed by the use of SPDs, which are designed to handle lower energy transients defined by 8/20 μ s wave shapes.

The distinction between lightning current ar-

Test current impulse (10/350 μ s) for lightning currents
 Test current impulse (8/20 μ s) for surge currents

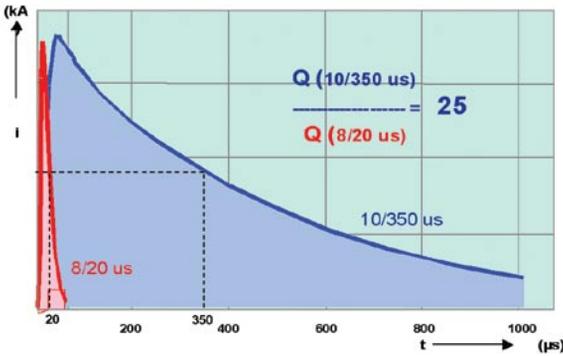


Fig. 1: Comparison lightning/surge discharge current wave shapes.

resters and surge protective devices, and the determination of where to place each, is covered by the Lightning Protection Zone (LPZ) concept referenced in standard IEC/EN 62305. This concept defines boundaries between high-risk exposed lightning strike areas and other areas that are differently affected by lightning currents and their induced counterparts.

These devices must be selected and placed properly within the system. The selection is based upon their ability to adequately discharge the transient currents, to continue to be available for future occurrences, to limit the voltage drop across them to protect the components and systems for which they are intended, and not to disrupt the function or performance of the system while installed or during their operation. Because of the number of parameters that must be met, different technologies are used, with each having their virtues and weaknesses. The key to properly protecting a system is selecting the correct technology or combination of coordinated technologies to meet all requirements and placing them in the correct critical locations.

In summary, the key of lightning and surge protection is to:

- Direct lightning currents to ground by use of air terminals and properly rated conductors.
- Properly bond all non energized conductors to prevent any potential differences on them.
- Use SPDs between conductors, and between conductors and ground where over voltage transients may appear.
- Apply SPDs as close to, and before equipment to be protected and use Lightning Protection Zone concept as a guide for determining placement and ratings.

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Fig. 2: Example of a combination of Class I and Class II SPD, using coordinated spark gaps and metal oxide varistors.

- Select SPD based upon correct discharge current (Class I, II, or III) ratings and the correct signal application.
- Use correct sized and properly routed conductors to minimize voltage drop.

As to what is accomplished by using surge suppressors, they can protect equipment and components against catastrophic failures caused by



Fig. 3: Example of coordinated SPD for control circuits using coordinated gas discharge tubes and silicon avalanche diodes.

transients; against the constant deterioration of dielectric/insulation materials when exposed to transients over long periods of time, which leads to premature failures, and; protect systems from mis-operation due to erroneous signals, which are actually unwanted transients. The result is improved system efficiency, reliability, increased system integrity, less downtime, less maintenance costs, and improved service. ⚡

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