Analysis and Mitigation of Zero-Missing Phenomenon Following the Energizing of High Voltage AC Cables with Shunt Compensation

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Ac transmission cables are a common option in connecting offshore wind generation plants to the corresponding onshore grid substation. Presence of such long AC cables causes numerous technical challenges. Therefore, the utilities have to assess the appropriate solutions and determine if the risks associated with implementing selected solution are acceptable.

As the Ac cable systems consume large amounts of capacitive reactive power, they are generally compensated through shunt reactive power devices. This is essential to meet the transmission grid code requirements as well as to limit the temporary over voltage or system events such as load rejection. When energizing such cable systems with shunt compensation, they are susceptible to "zero-missing phenomenon" which is defined as the absence of current zero-crossing for many cycles. Within the zero-missing period it is may not be possible to open the circuit breaker and interrupt the current successfully. This phenomenon is further investigated through the studies on a proposed wind power plant.

The wind power plant under study is named Triton Knoll and is a 1.2 GW project to be installed off the North Norfolk coast on the North Sea, East UK by RWE Innogy. Electromagnetic transient simulation studies on Triton Knoll offshore wind power plant were performed and "zero-missing phenomenon" [1] was identified as the main concern to be addressed. While "zero-missing phenomenon" is well understood, only a handful of past publications address the issue. In this study, the relationship between the cable charging, the reactor size and the zero miss duration is analyzed in order to determine the acceptable risk.

Another observation not previously reported is the current distortion following the closing of the breaker to energize the cable and the reactor. The observed current harmonics can be a power quality concern. EMT simulations and analysis are carried out to further investigate this observation [1]. Impact of the substation transformer is discussed along with the appropriate equations developed to represent the phenomenon using a circuit representation. In addition, mitigation methods such as distributing the reactors across different locations of the cable and the implementation of pre insertion breaker resistors are studied. Using a breaker pre-insertion resistance was identified as the preferred mitigation option.

REFERENCES


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