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Q1.01: Are existing protection algorithms and devices with appropriate settings sufficient to protect the grid in most cases or are new algorithms or methods required?

In the case of synchronous generation, fault signatures can be predicted with some accuracy since they are largely a function of fixed equipment design parameter. This results in deterministic voltage and current signal traces for a given disturbance. Additionally, the relatively slow response of the generator excitation and turbine controls does not change these signals significantly for many cycles during the fault (what we refer to as high-inertia generation source), thus aiding the relay decision making process.

However, in the presence of the IBR, power electronics interfaces the renewable energy source and the grid. This power electronic interface is capable of fast fault current injection, which not only limits the fault current, but also impacts the fault current signatures (what we refer as low-inertia generation source)

The desired objective during the fault ride through condition can be achieved by choosing one of the operating modes. This brings in multiple options for the utility to choose the mode of operation thereby introducing the possibility of having different fault signature for a same fault type at the point of measurement.

This is not the case in conventional synchronous generator where for a particular fault type, fault scenario and system parameters, the fault signature is almost the same irrespective of any generator manufacturers and any firmware for field controls. Although, recent standards mandate the injection of negative sequence current, still the IBR's may not replicate the conventional synchronous generator behaviour as for Type III the angle of injection can vary during the initial few cycles after fault inception.

From experience different grid codes impose different performance requirements and operating priority. As a result, the fault current values depend on the control modes and the design parameters of the controller which can vary to meet different grid code requirements. This may impact the conventional relaying algorithms which were designed based on the deterministic voltage and current relationship and enhancements are required.

It is important to evaluate the risk before adopting any protection philosophy, particularly as currently there is a mix of not just existing protection and new algorithms, but varying degrees of REN penetration. It is clear that more research and testing are required to understand the limits of the existing protection and gain confidence in the new approaches.