Introduction

Next generation power distribution networking will be 100% Power-Electronic Based. This is already evident in electric shipboard systems and some microgrid applications. There are several converging forces that are leading to eventual:

1. The increase in renewable energy sources, such as solar PV and wind, and energy storage systems (ESS) in the distribution system requires power electronic interfaces to network to match voltage (for dc systems) and frequency (for ac systems). This factor is multiplied by the simultaneous decrease in cost of PV, wind, and ESS, and the push by both government regulation and citizen desire for increase in renewable energy generation.

2. Continual improvements in wide-bandgap (WBG) semiconductor devices and packaging which increases the power throughput and power density of power electronic converters. High power-density, megawatt-scale power converter will proliferate within the next 5-10 years.

3. Interfacing native ac generation source and loads such as synchronous generators and permanent magnet synchronous motors with power electronics allow both generators and motors to run at optimal efficiency and decouple transient effects from the distribution network.

With power electronics and distributed energy resources (DERs) such as PV, wind, ESS, and generators now distributed throughout the network, decentralized, meshed networks are now possible. Such networks allows for multiple redundant power flow paths and multiple energy generation sources. This promises to increase resiliency of the overall network when recovering from an electrical fault, enabling the network to deliver the right amount of power to the right location at the right time, even in a highly degraded state.

Furthermore, how does one quantity resiliency, and compare different power electronic-based distribution systems, which can vary in DER location, distribution paths, protection schemes, and power conversion topology, in a fair apple-to-apple comparison? Like the RISC vs CISC reduced instruction set computers vs complex instruction set computers debate in the mid 1980’s, it wasn’t unless an agreed upon standard of performance metrics was determined that a fair assessment be made between the computer architectural approaches. A similar approach of industry agreed upon set of performance metrics is needed to assess resiliency of power electronic based distribution systems.

Microgrid Design Process

However, before being able to assess various network configurations and DER locations, the meshed networks had to perform fault detection, isolation, and recovery (FDIR). Designing a meshed network to successfully perform FDIR is a challenge in of itself, as protective functionality must be correctly distributed between power conversion and power distribution equipment. This task is more complex than conventional power distribution protection design as it combines domain knowledge between power distribution and power electronic engineers in new form.

Towards Quantification and Assessment of Resiliency for Power Electronic-Based Distribution Systems

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Conclusion and Future Work

In order to assess resiliency of power electronic based distribution network for FDIR, first it must be designed. To do so, protection features must be allocated between distribution equipment and power conversion equipment, something new due to the convergence of power distribution and power electronic fields. To design such an encompassing protection network, and iterative design process is proposed. This design process will use real-time to accelerator through the hundreds simulations required to design and validation protection and ride-through settings. Candidate architectures will be validated in CHIL simulation.

From here, the UWM team will work the system engineering team at Naval Postgraduate School to develop quantifiable metrics for resiliency, and work to bridge the gaps of resiliency between a power electronics-level and system engineering level. This work will enable fair comparison of power electronic-based distribution system candidate architecture. Although a case study is presented here for an islanded ac microgrid, this can and will be applied to dc and hybrid ac/dc microgrids, electrically shipboarded systems of the first examples of high power, power electronic distribution system in production, and even moon-based microgrids. With the new push of development of a sustainable base on the moon, a resiliency distribution system is need to ensure continuity of power in a such harsh unforgiving environment, while assess trade-offs between environmental and size/weight to physical get the equipment on site.

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