Developing Protection Settings for Large DERs to Mitigate System-wide Impacts across Transmission and Distribution Systems

Project Status Summary:

In this project, the team is investigating the ability to develop a strategy for evaluating protection device operations, recloser settings, and mitigation strategies for ride-through operation of Distributed Energy Resources (DERs) at the distribution level in response to faults at the transmission level using an integrated T&D simulation model. The tool being used to develop the integrated T&D setup is called PSS®SINCAL, which is a power system planning and analysis software tool developed by SIEMENS. The first part of this project included tasks such as collection of transmission, distribution, and key substation network data, integration of these models into PSS®SINCAL, and evaluation of developed T&D setups under multiple fault scenarios to understand system wide impacts on the DERs.

The team has accomplished the task of identifying, modeling, and integrating the necessary power system networks in PSS®SINCAL. The team then worked on evaluating the system wide effects on the DERs due to multiple fault scenarios. The goal of this analysis was to develop protection guidelines and settings for the DERs to minimize the impact of system-wide events. The case-study that was used to evaluate the aforementioned effects includes application of multiple faults on the transmission network. The voltage profile at the distribution-connected DER (PV farm) locations was monitored to observe variations in the voltage sag for different transmission level event locations. In total, there were five fault locations and each of these fault locations were chosen in such a way that it resembled a transmission level event located farthest, closer, and closest to the substation/distribution network where the monitored DERs are located. Although the initial results of this analysis were promising, the team experienced certain limitations mostly due to the shortcomings of the software tool (PSS®SINCAL).

Generator model import was one of the major limitations that the team had to overcome. Unlike PSS®E, PSS®SINCAL has one standard generator model that is used to map the generator dynamics, because of which, the team experienced data import non-convergence for some of the units (while importing data from PSS®E). To overcome this issue, some simplifications (reduction techniques) were applied to the imported (transmission) network. As a consequence of these simplifications, some discrepancies in the simulated results vs the observed (PMU data) results were observed.

The team is currently working with SIEMENS to get these data import issues sorted out. Meanwhile, the team is also working on a parallel approach which aims at extending the PSS®E by developing a reduced balanced system model for a given distribution system. This balanced equivalent circuit will then be integrated into PSS®E to get an integrated T&D model. Hence, the proposed approach has two steps. In the first step we are developing a program that will obtain a reduced balanced model for a distribution feeder. The program keeps only the main primary feeder of a given distribution feeder, as the primary part is usually three phase. Also, large scale PV farms are connected to the primary feeder. Then the program obtains a balanced equivalent model for a given feeder by reducing all the lateral branches and replacing them with equivalent three phase balanced loads. Test results on a four-feeder system shows that this approach provides voltage estimates at the PV locations that are quite close to that of the full feeder model. In the second step, we convert the reduced feeder model to the PSS®E model so that the feeder models can be added to the transmission system model. We use the PSS®E API (Application Program Interface) and develop a Python script for this model integration step.