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PROJECT TITLE: ASSESSMENT OF THE UNIVERSAL FEASIBILITY OF USING POWER SYSTEM HARMONICS AS LOSS OF MAINS DETECTION FOR DISTRIBUTED ENERGY RESOURCES

CONTRACT NUMBER: RD3-21 MILESTONE NUMBER: 10

REPORT DATE: NOVEMBER 30, 2011

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MILESTONE REPORT

EXECUTIVE SUMMARY

The purpose of this project is to assess the universal applicability of harmonic signatures and/or synchrophasors as a means for detecting unintentional islanding of distributed generation equipment such as photovoltaics. This report covers the time period November 01, 2010 to November 30, 2011, and describes our progress on Milestone 10. Milestone 10 has been completed. Accomplishments in this reporting period include:

- Complete detailed report on synchrophasor and harmonic signature methods for dissemination to the power community.

To meet this milestone, NPPT produced two publications, one on a synchrophasor-based method of loss of mains detection method and the other on a passive method derived from harmonic signature recognition. The key conclusions of these papers are listed under "Technical Progress" below, but can be summarized as follows: a) communications-based loss of mains detection is likely to be the first line of defense in high penetration scenarios, and the synchrophasor-based method is a strong contender in this category; and b) passive anti-islanding will regain importance because it will be needed as a backup method for communications-based methods when communications are unavailable. The papers also discuss some key points regarding adjustment of applicable standards to make them compatible with future loss of mains detection methods. The key standard in this case is the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547, "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems", July 2003 version, also known as IEEE-1547. IEEE 1547 is designed to streamline the process of interconnecting small (less than 10 MW) distributed energy resources to power systems by defining the required behavior that makes a distributed energy resource acceptable for reliable and safe connection to the system. One key aspect of IEEE 1547 is islanding detection, or loss of mains detection. The committees that write IEEE standards strive to keep them technology neutral, but it is still important to ensure that no conflicts or inadvertent constraints are written into IEEE 1547 that would hamper the use of the types of loss of mains detection techniques being explored in this RDF project.

Project funding is provided by customers of Xcel Energy through a grant from the Renewable Development Fund.

TECHNICAL PROGRESS

Milestone #10 consisted of:

- Complete detailed report on synchrophasor and harmonic signature methods for dissemination to the power community.

We have now completed papers on the Correlation Coefficient Based (CCB) method that uses synchrophasors, and on harmonic signature methods. The latter paper covers passive anti-islanding in general, needed modifications to the IEEE 1547 standard to enable advanced loss of mains detection (this will be clarified and expanded upon in a future Milestone report) and justification for those modifications, and a new passive loss of mains detection method. Those two papers were successfully submitted to the IEEE Power and Energy Society General Meeting (PES-GM) that will be held in July 2012, and will be available to the public in the Proceedings of the IEEE PES-GM by the end of August 2012 (assuming that they are accepted).

The key conclusions of these two papers are as follows.

- Communications-based loss of mains detection methods are likely to be the first line of defense against unintentional islands in the future. The CCB method falls into this category, along with other methods such as power line carrier permissive signaling.
- The CCB method has been shown to work very well in simulation, laboratory testing, and in preliminary field trials, and is thus emerging as a strong contender for future applications. The CCB method successfully detected all islands, including multiple-inverter ones, and successfully rode through all non-islanded cases. The primary weakness of the CCB method is that it is not always fast enough to catch islands within the 2-sec limit imposed by IEEE 1547, but this aspect of the method can likely be improved via already-identified paths.
- Communications-based methods will require a fallback method in the event that communications are unavailable for any reason. The active anti-islanding used in inverters today is unsuited to be that fallback method in high-penetration scenarios, meaning that passive anti-islanding must assume this backup role. There is thus a critical need for additional work in and improvement of passive loss of mains detection techniques.
- Some passive methods, particularly those derived from harmonic signature recognition techniques, have the capability to be highly effective in loss of mains detection, particularly if they are allowed more time to act than is currently allowed by IEEE-1547. Many of these methods require advanced signal processing techniques, which is a disadvantage.
- A new passive method, developed under the RDF program and derived from harmonic signature recognition, has been shown in initial testing to be highly promising. This method does not require advanced signal processing techniques and is thus easier to implement on lower-cost equipment. The primary weakness of this new method is that it, like the CCB, sometimes takes longer than 2 sec to detect a loss of mains.
- In standards like IEEE 1547, the power community should begin to separate loss of mains detection from fault detection and overvoltage detection. As presently written, the standards effectively require that loss-of-mains techniques also act as fault detection, but this causes unnecessary requirements to be imposed. It is logical that faults should be detected in considerably less than 2 sec, but for a balanced island there is no need to detect a loss of mains so quickly. Also, the conditions for fault detection are entirely different than those for loss of mains detection. Thus, it is logical that separate time-to-trip categories be established for loss of mains detection, fault detection, and overvoltage detection, and considerably longer than 2 sec (perhaps as long as 10 sec) is acceptable for loss of mains detection.

NEXT STEPS

We now turn our attention to Milestone #11. As noted above, this work is already substantially completed; further details will be included in our Milestone #11 report, which we intend to submit on or about December 31, 2011.

PROJECT STATUS

We are on track to submit Milestone Report #11 in December 2011, and Milestone Report #12 by the end of February 2012.

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