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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: 8** **REPORT DATE: DECEMBER 21, 2010**

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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 September 21, 2010 to December 21, 2010, and describes our progress on Milestone 8. Milestone 8 has been completed. Accomplishments in this reporting period include:

- Continued testing of synchrophasor models. Significant results obtained.
- Held fourth face-to-face coordination meeting with the project team.
- Finalized the results dissemination plan.
- Finalized the plan for working with standards committees.

This version of Milestone Report 8 is for public dissemination.

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

TECHNICAL PROGRESS

Milestone #8 consisted of:

- Continue testing and evaluation of synchrophasor and harmonic models.
- Hold fourth face-to-face coordination meeting with the project team.
- Report on results to date.
- Finalize results dissemination plan.
- Finalize plans for interactions with standards-making bodies.

Testing results: synchrophasor-based methods

Tables 1 and 2 show the results to date for the synchrophasor (communications) based islanding detection techniques. Two techniques are under investigation, the WAN method and the CCB method (both described in Milestone Report #7). Testing has been completed using the "average" Xcel feeder, and those results are reported in the Tables. Thus far, results for both methods remain highly promising. The WAN method has performed very well on the real-world feeders, albeit with a change in detect/nondetect criteria in each case. The reader may note that in both tables, the results under the strong feeder have been changed to "retesting". This is because we detected a possible problem with the model we have been using for that feeder. This problem is one that could artificially impact the results of the tests, so

we are working to correct it. For the CCB method, in addition to the new results in Table 2, successful laboratory tests have been conducted, and the method is now being applied to field data to determine how well it might work in the "real world".

Table 1. Initial results for the WAN method. Results shown in green indicate success; results shown in red indicate that an undesirable result was obtained.

Feeder→ / Test case ↓	IEEE 34-bus standard feeder	Xcel "weak" feeder	Xcel "average" feeder	Xcel "strong" feeder
a	Detect	Detect	Detect	Retesting
b	Detection failure	Detect	Detect	Retesting
c	Ride-through	Ride through	Ride through	Retesting
d	Ride-through	Ride through	Ride through	Retesting

Table 2. Initial results for the CCB method. Results shown in green indicate success; results shown in red indicate that an undesirable result was obtained.

Feeder→ / Test case ↓	IEEE 34-bus standard feeder	Xcel "weak" feeder	Xcel "average" feeder	Xcel "strong" feeder
a	Detect	Not yet tested	Detect	Retesting
b	Detect	Not yet tested	Detect	Retesting
c	Ride-through	Not yet tested	Ride through	Retesting
d	Ride-through	Not yet tested	Ride through	Retesting

Testing results: harmonics-based method

We have begun testing of a harmonics-based method developed by NPPT during this project. Details of the method remain proprietary, but it can be disclosed that the method does not rely on communications, but instead looks only at the steady-state and transient harmonic content of the inverter terminal voltage and performs a unique signal processing algorithm on that quantity. Thus far, only the "average feeder" case has been tested, but the results have been encouraging. The method detects islanding well, but still needs work in differentiating between the large local load switching event and the engine-genset island case. Results have also been obtained using experimental data post-processed using the new algorithm, and those results also indicate good performance; islanding cases are reliably detected, and at least most classes of non-islanding transient event are correctly differentiated.

Table 3. Initial results for the new harmonic-based method. Results shown in green indicate success; results shown in red indicate that an undesirable result was obtained.

Feeder→ / Test case ↓	IEEE 34-bus standard feeder	Xcel "weak" feeder	Xcel "average" feeder	Xcel "strong" feeder
a	Not yet tested	Not yet tested	Detect	Not yet tested
b	Not yet tested	Not yet tested	Detect	Not yet tested
c	Not yet tested	Not yet tested	Ride through	Not yet tested
d	Not yet tested	Not yet tested	Questionable	Not yet tested

Fourth coordination meeting

The team held its fourth face-to-face coordination meeting in Knoxville, TN, on November 15 2010. Team members discussed results to date and next steps, and divided up duties on the harmonics-based techniques being studied.

Enernex has assumed primary responsibility for modeling with wind turbines; NPPT is working on PV and engine-gensets. It was briefly discussed that the next face-to-face meeting may be held in Brookings.

Results dissemination plan

Results dissemination has been complicated somewhat by IP concerns. However, the intent at this time is that we will produce three publications during CY 2011. One of these will be a paper and presentation at the Minnesota Power Systems Conference in November 2011. Another will be a paper and presentation at the Western Protective Relaying Conference in October 2011. The third will be a presentation to the IEEE Power and Energy Society General Meeting. That paper will, unfortunately, be presented in July of 2012, after the project end date; but the submission deadline will be in November 2011, and the PES requires that the full paper be presented at that date (not simply an abstract). Thus, the *production* date of the paper is still within CY 2011, and we will know well before the project end date whether we have been successful in that submission.

Plan for interactions with standards-making bodies

It is fortuitous that the governing standard for islanding prevention, IEEE 1547, is currently undergoing a very significant revision. The relevant sub-part of the standard is 1547.8, which deals with an expanded interpretation of the existing 1547 standard and aims to make that standard more broadly applicable. NPPT's President and Principal Engineer has joined the IEEE 1547.8 committee, and this will be our primary mode of interaction with the standards-writing community. There appears to be a solid and growing consensus that methods of the type being studied here are the future of islanding prevention, so it appears likely that the standard will not include any barriers to such methods. (The reader is encouraged to bear in mind that the standard is deliberately technology-agnostic, so inclusion of no barriers is as favorable a response as could be expected.)

PROJECT STATUS

We remain a couple of weeks behind in our reporting, but by and large the project is on schedule and producing extremely promising results.

LEGAL NOTICE