Islanding Detection in Microgrids Using Harmonic Signatures

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Objectives

- Develop an Islanding Detection Method (IDM) that improves on the critical cases: non-detection zones (NDZ)
- Fulfill the requirements of IEEE Std. 1547 at the Point of Common Coupling (PCC)

Islanding Detection Methods

- Passive methods: monitor changes on a significant magnitude
  - Pros: No control action over the system; inexpensive
  - Cons: They have NDZs
  - Examples: under/over frequency, unusual changes in active power, reactive power or voltage
- Active methods: induce a change in the system, measures system's response
  - Pros: Absence of NDZs
  - Cons: Detection speed tied to system's reaction time; high implementation cost
  - Examples: Injection of high-frequency signal, introduction of phase and voltage changes, perturbation on inverter's PLL
- IDMs on microgrids: not a multi-inverter case!
  - Bidirectional power
  - PCC is on the microgrid interconnection point, not each individual inverter
  - Intentional and unintentional islanding occur on a microgrid
  - An extension of IDMs to microgrids is needed

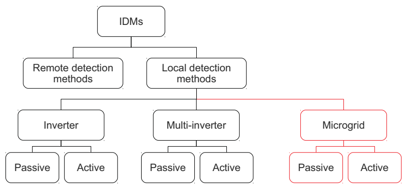


Figure 1: Extension of IDMs to Microgrids

Harmonic signatures

- Distribution systems are generally rich in harmonics
- Sources: non-linear loads, rectifiers, CFLs, SMPS, saturated transformers, among others
- Harmonic signatures will be different between grid-tied and islanded modes, due to the different structures of the two networks

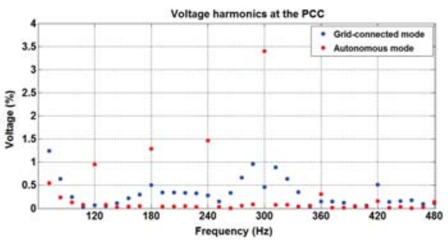


Figure 2: Typical harmonic voltages under grid-connected and autonomous modes

Proposed IDM

- Utilize harmonic signatures to recognize the microgrid islanding situation
- Delegate the islanding detection responsibility to the smart disconnection switch ("microswitch")
- As observed in experiments, **5th harmonic voltage** is readily present in the microgrid, and its change after an islanding event is easily identified

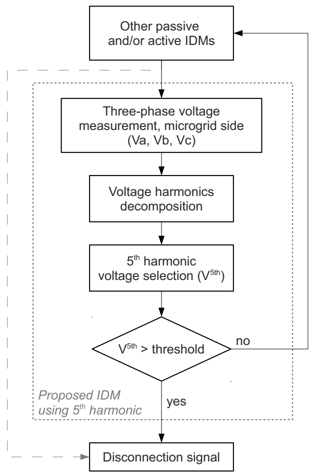
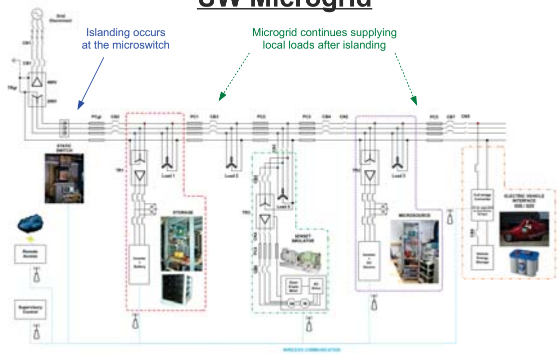


Figure 3: Flow diagram of the proposed IDM using 5th harmonic signature

UW Microgrid



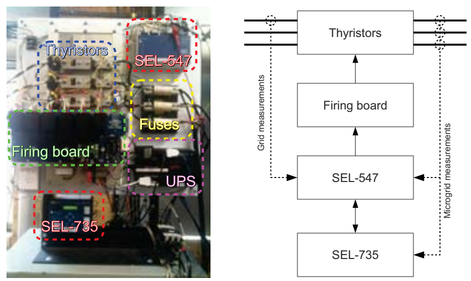


Figure 4: Static switch hardware details (left) and logic flow diagram (right)

Experimental Results

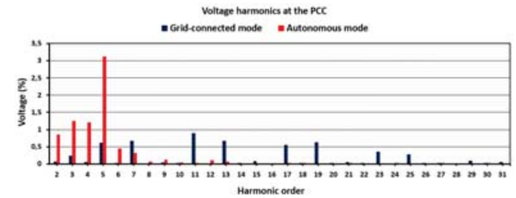


Figure 5: Voltage harmonics at the PCC under no power flow condition (NDZ)

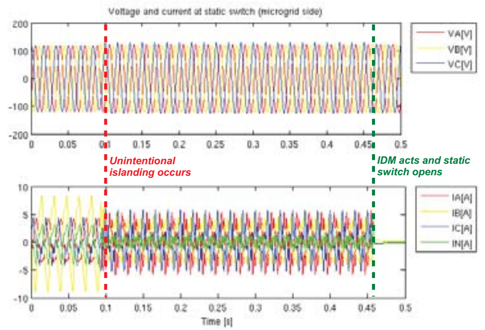


Figure 6: Voltage waveforms at the PCC in grid and microgrid sides, and currents through the microswitch, during the islanding detection

Unintentional islanding time	5th harmonic trip time	Detection time (s)
21:14:05.281	21:14:05.605	0.324
21:16:39.527	21:16:39.777	0.250
21:19:20.932	21:19:21.140	0.208
21:21:04.446	21:21:04.812	0.366
21:22:06.386	21:22:06.736	0.350
21:26:28.160	21:26:28.510	0.350
	Average	**0.308**

Table 1: Sample detection times for proposed IDM algorithm

Conclusions

- An effective IDM for a microgrid is proposed and successfully tested in a laboratory hardware setup
- The proposed IDM has no NDZ
- The method allows the microgrid to fulfill IEEE Std 1547, with unintentional islanding detection under 2 seconds

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