Islanding detection and seamless transition through operation modes in microgrids: HIL experiences

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Islanding Phenomenon

Islanding: a section of the distribution system containing Distributed Generation (DGs) is disconnected from the main utility grid, while the DGs continue to supply fully or partially the load in the isolated section, termed as island.

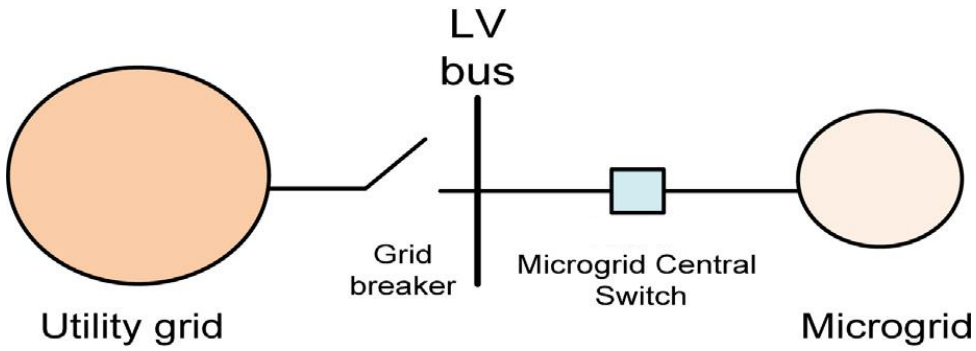
IEEE Std. 929-2000

IEEE Std. 1547-2003

IEEE 1547

UL1741

Disconnection required



Major Issues regarding Islanding

- ✓**Personnel safety**
- ✓**Overvoltages – Transients**
- ✓**Power Quality issues**
- ✓**Protection**
- ✓**Economic issues**

Islanding Detection Methods(IDM)

- **Active IDMs** →impose additional perturbation signals to cause power mismatches, so that a certain system parameter drifts, once islanding occurs.

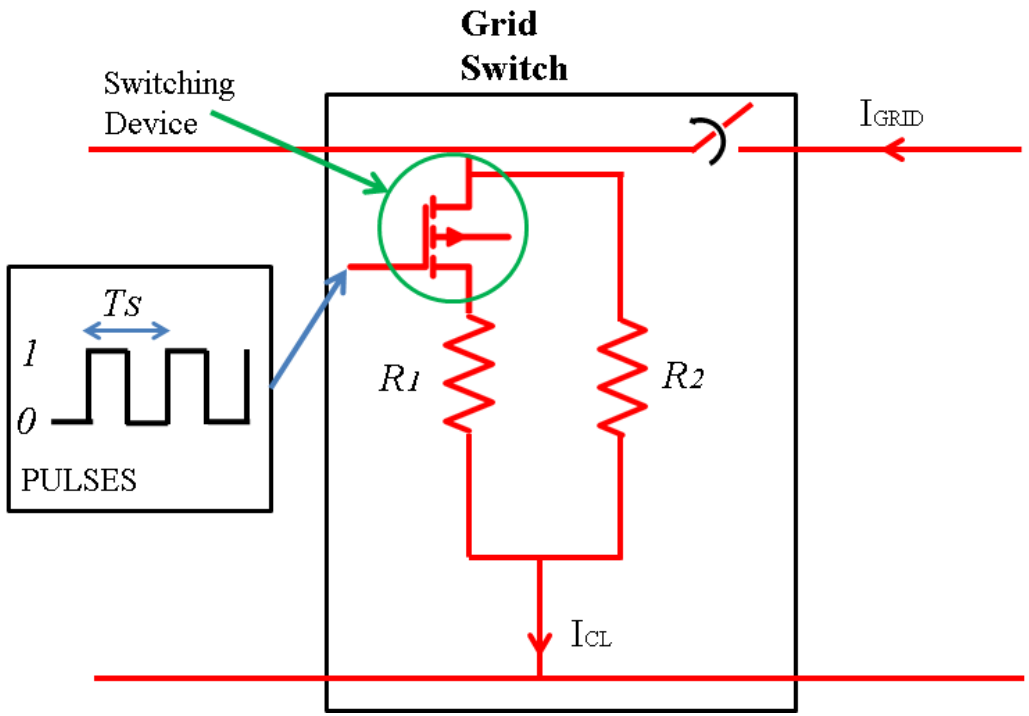
- **Passive IDMs** →are based on measuring a local parameter-index and comparing it with a preset value.

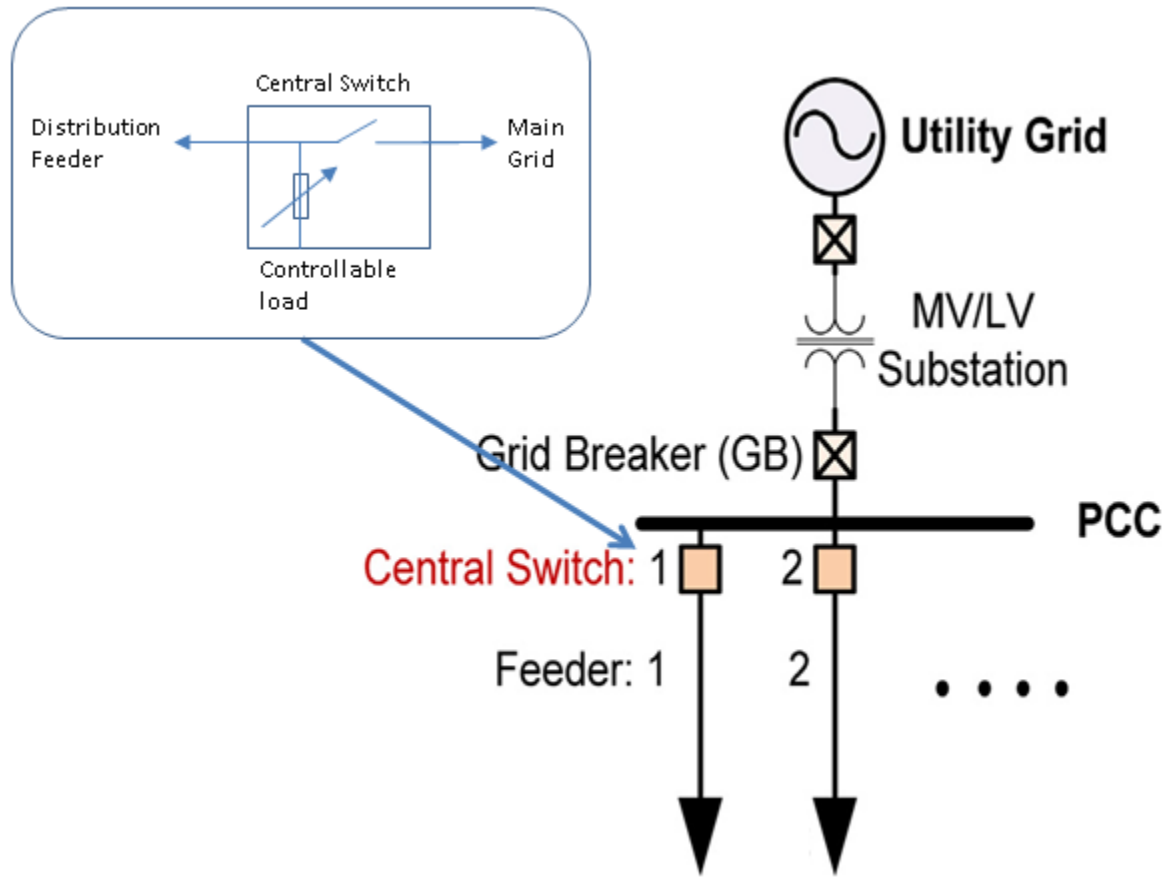
- **Hybrid IDMs** →combine the effects of both categories

Main challenges for the IDMs

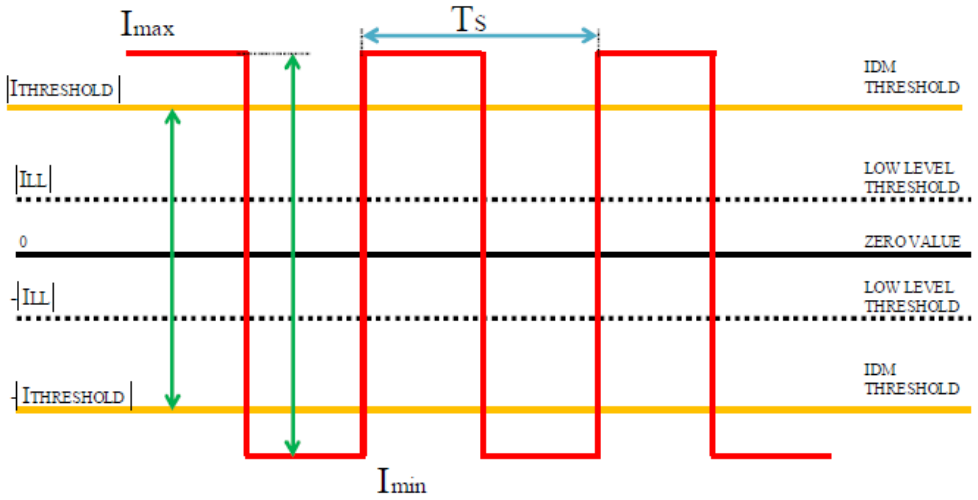
- ✓Fast detection under the international standard set-time<0.2 s.
- ✓Elimination or minimization of the non-detection zone (**NDZ**).
- ✓Seamless operation under multi-converters
- ✓Serve the plug and play scenario
- ✓Serve easy engineering.
- ✓No power quality deterioration.
- ✓Simple and cost effective.
- ✓Communications free.

Proposed IDM

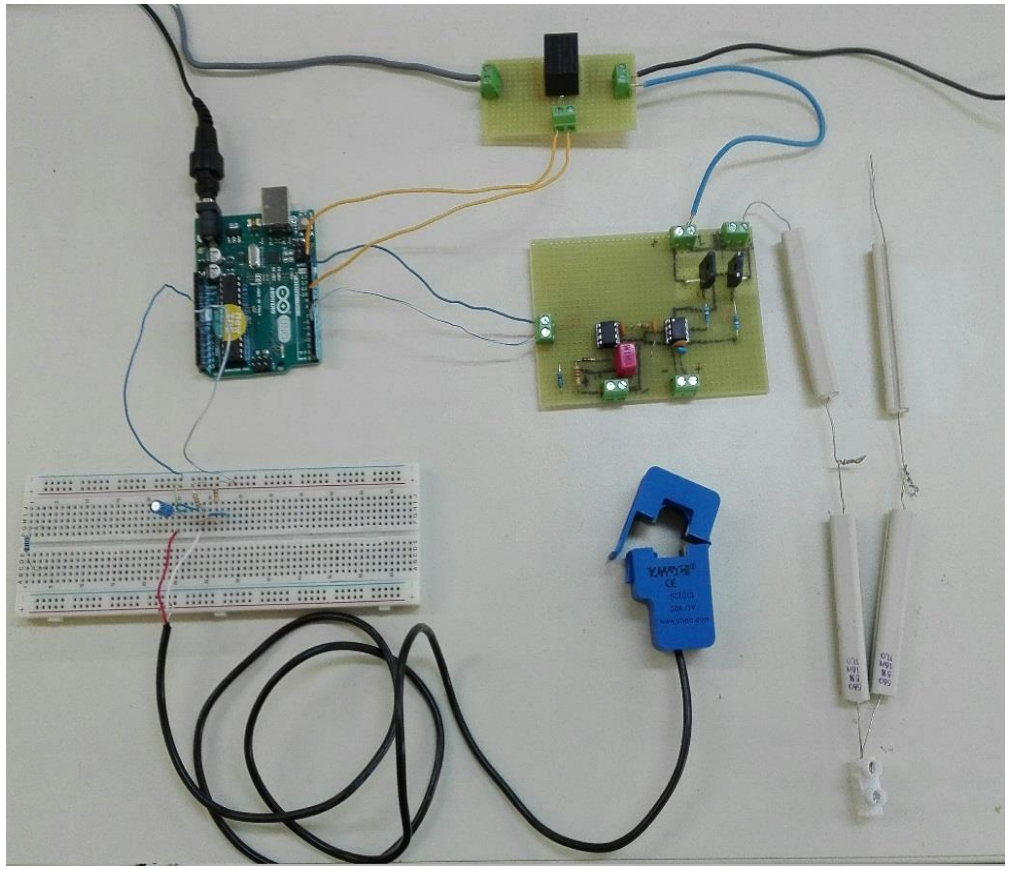




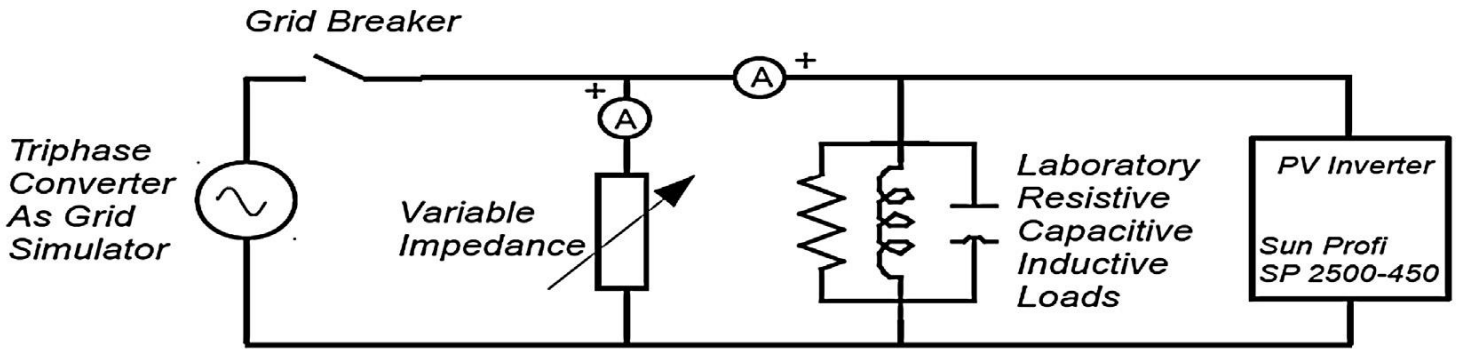
Lab prototype



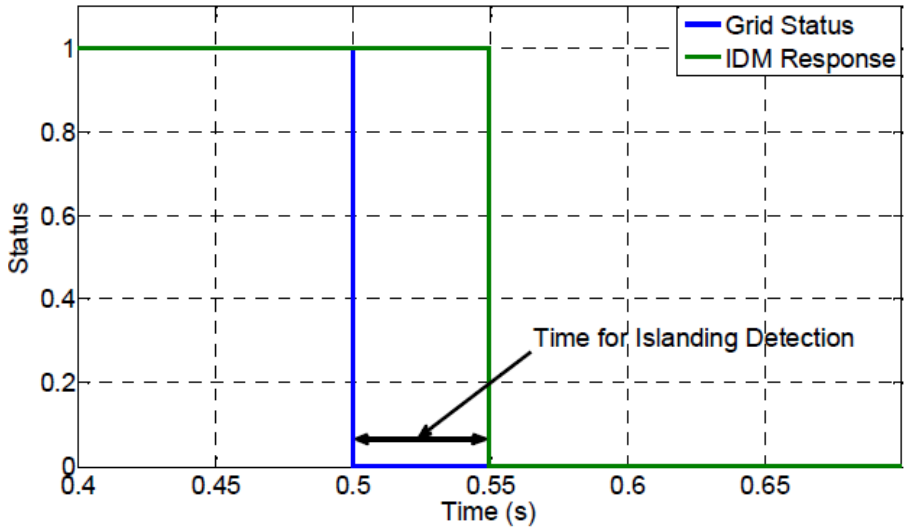
- I_{LL} is the lower value the measuring equipment can measure with sufficient accuracy.
- $I_{THRESHOLD}$ is the IDM threshold. It is always higher than I_{LL}. If I_{DC_GRID} is lower than this value for a specified time-period (e.g. 0.2s) the IDM detects islanding.
- I_{min} is the current drawn from R_2 when the switching device is OFF.
- I_{max} is the current drawn from the total resistance when the switching device is ON (R_1 // R_2).
- T_s is the time period of the resistance variations.

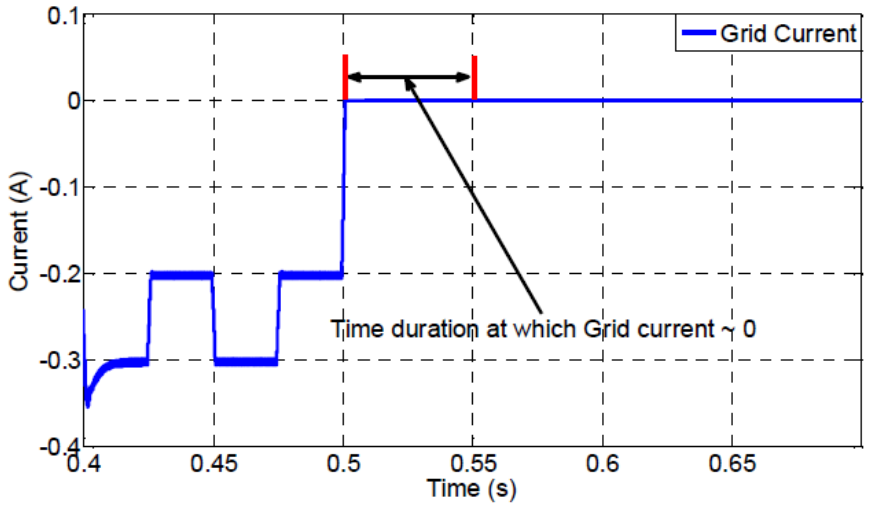


IDMs and HIL experiments[1]



IDMs and HIL experiments[2]





C.N Papadimitriou, V.A Kleftakis & N.D Hatziargyriou, ""A Novel Method for Islanding Detection in DC Networks", IEEE Transactions on Sustainable Energy, vol. 8, no. 1, pp. 441-448, ***(2017)***

C. N. Papadimitriou, V. Kleftakis and N. Hatziargyriou, "A novel islanding detection method for microgrids based on variable impedance insertion", Electric Power Systems Research, Volume 121, ***(2015)****,pp. 58-66.*

Two modes of operation for Microgrids

- Increase the quality of service.
- Offer ancillary services.
- Enhance the resiliency.

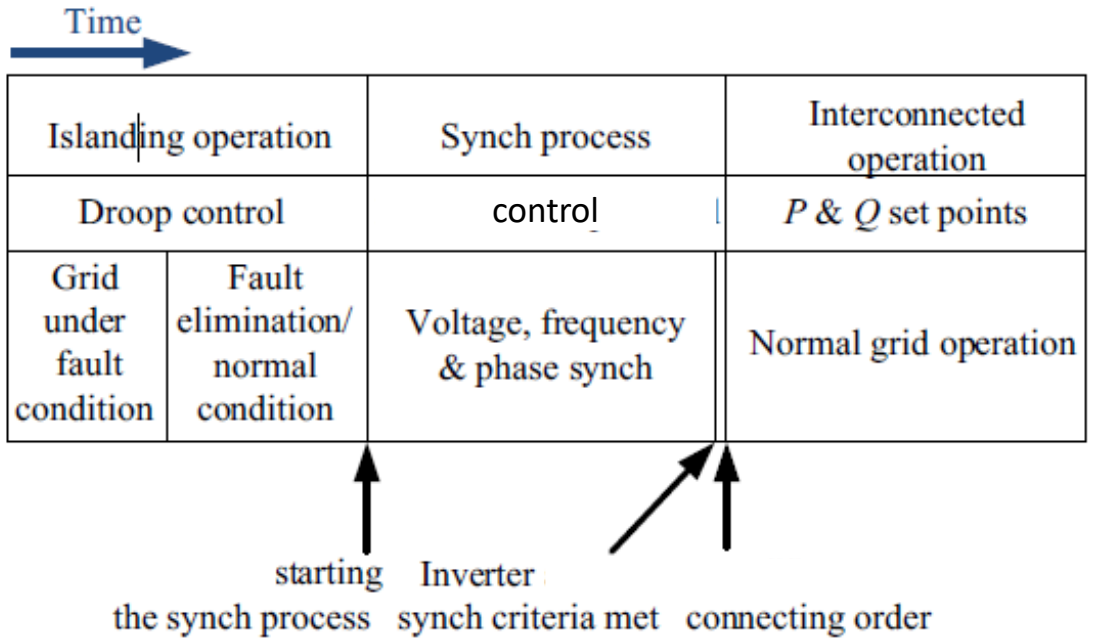
Disconnection might no longer be a practical or reliable solution

Intended islanding of DGs(IEEE Std. 1547-2003)

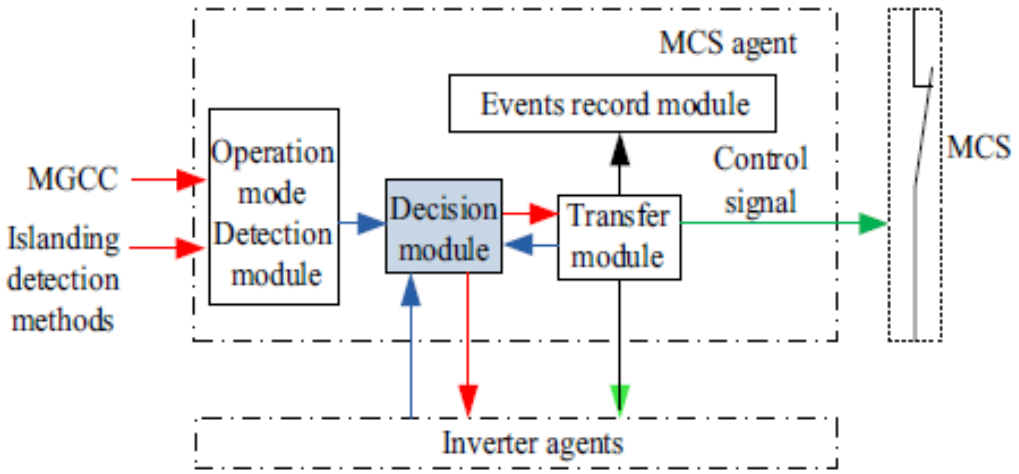
So we have microgrids support the operation in **two modes**

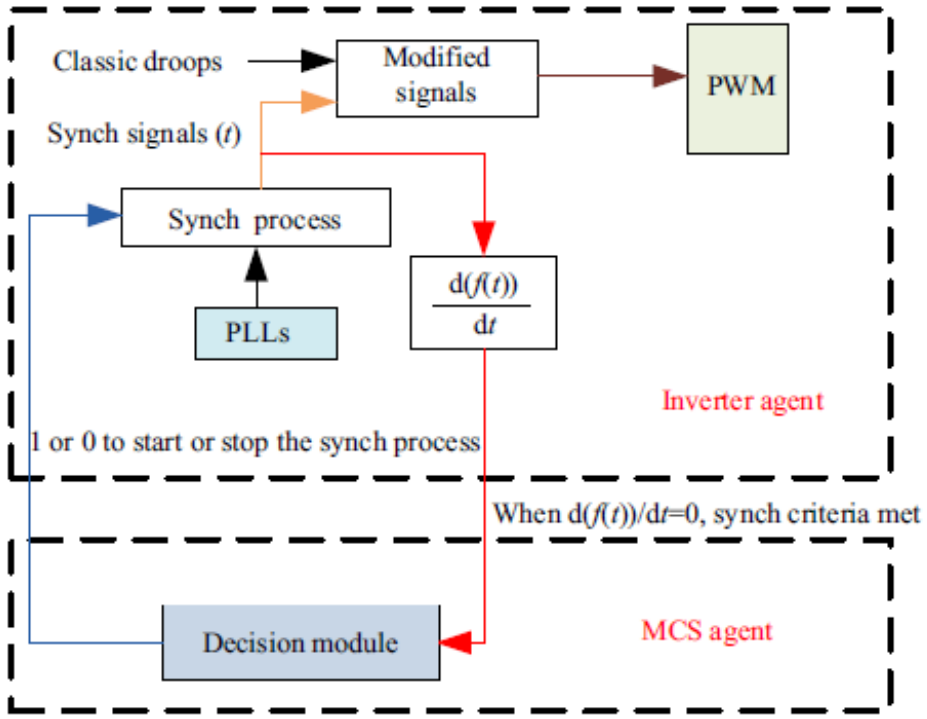
Seamless transition[1]

In general, a smooth connection is achieved when the voltages of the systems to be connected coincide in **magnitude**, **phase** and the **frequency.**

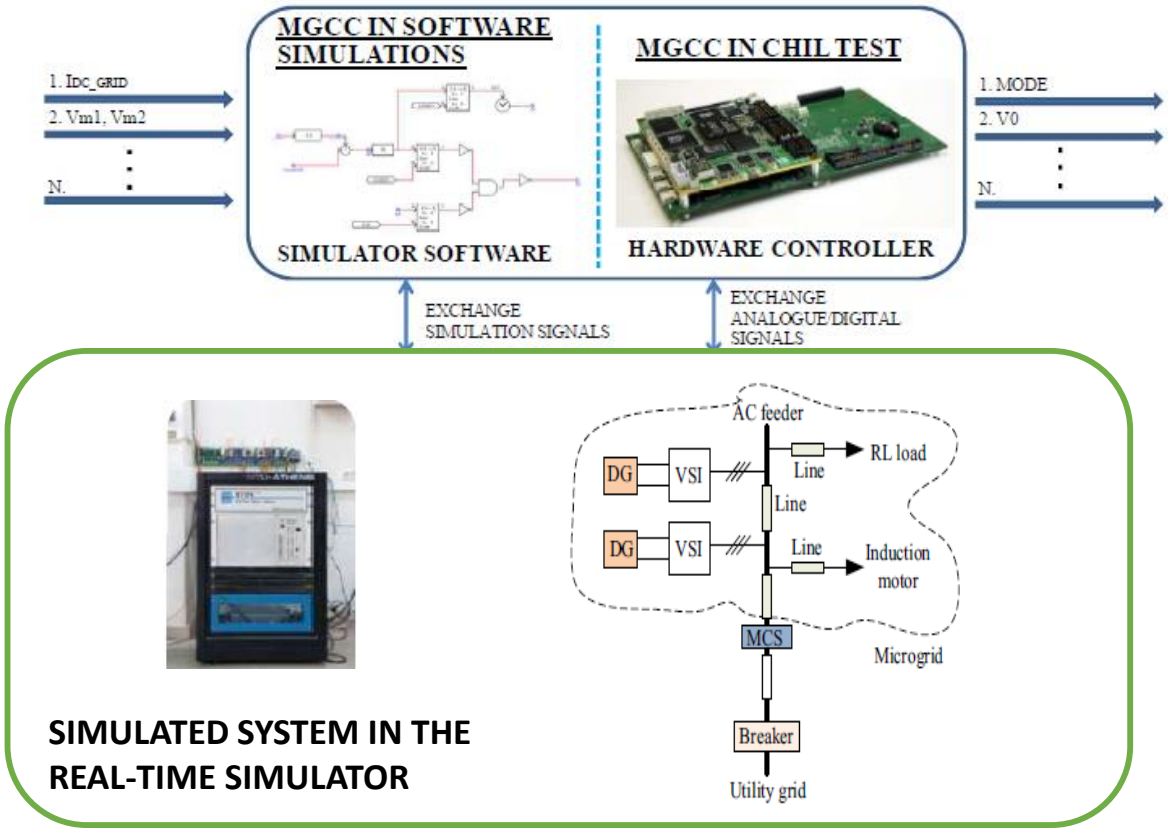


Seamless transition[2]

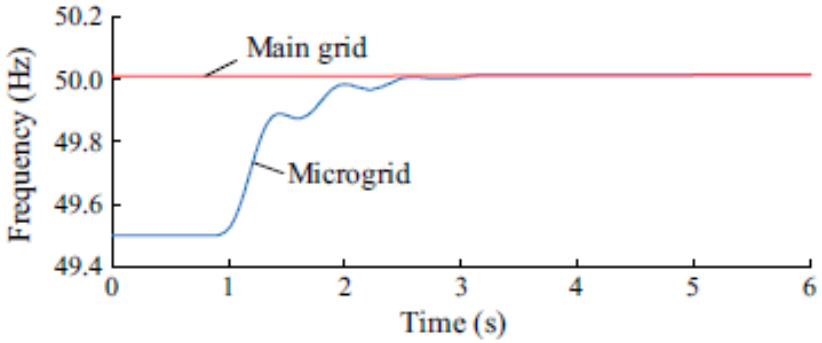


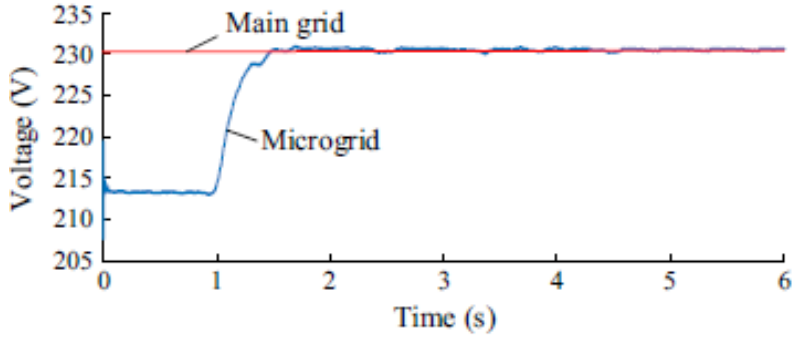


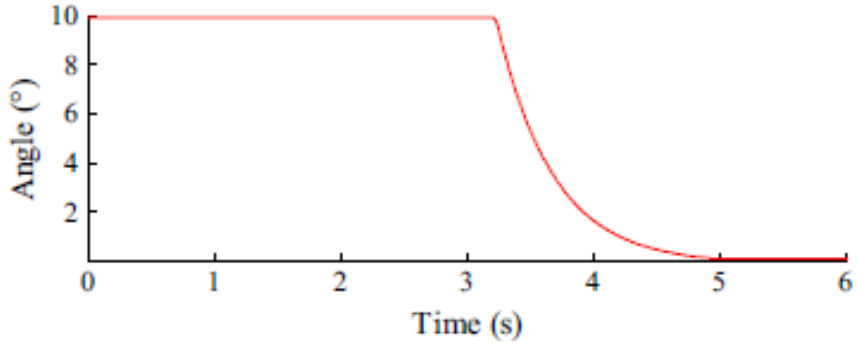
Transition and HIL experiments[1]



Transition and HIL experiments[2]







C.N Papadimitriou, V.A Kleftakis & N.D Hatziargyriou, "Control strategy for seamless transition from islanded to interconnected operation mode of microgrids", J. Mod. Power Syst. Clean Energy ***(2016).*** *doi:10.1007/s40565-016-0229-0.*

V. A. Kleftakis, D. T. Lagos, C. N. Papadimitriou and N. D. Hatziargyriou, "Seamless transition between interconnected and islanded operation of DC Microgrids," in IEEE Transactions on Smart Grid, vol. PP, no. 99, pp. 1-1. ***(2017)***

Conclusions

HIL setup can

✓serve in modeling complex energy systems.

✓serve in emulating control layers in the system.

✓support testing/optimization cycles for controls/devices.

Thank you