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Autonomous Microgrid Enabled by Grid-forming Power Electronic Converters

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The DISCO Group
Dynamic Intelligent Systems, Control and Optimization

Motivation

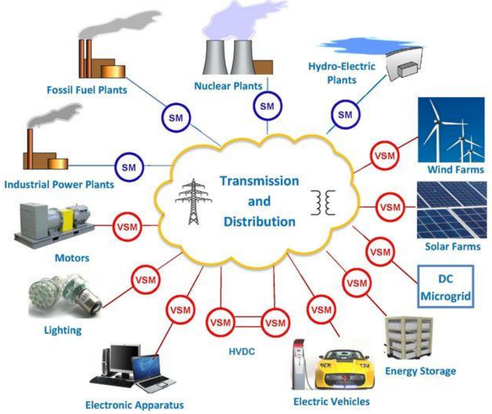
- Fast growth of renewable energy
- Power system going through a paradigm shift from electric machines-based to power electronics-based
- Grid-forming inverters to provide a unified interface for smart grid integration

Challenge

How to make sure that all players (including suppliers and loads) could work together to maintain system stability and reliability.

State of the Art: SYNDEM (Synchronized and Democratized) Grid Architecture

To embed the dynamics and behaviors of synchronous machines into the *power electronic converters* and regulate them as *virtual synchronous machines* [1].



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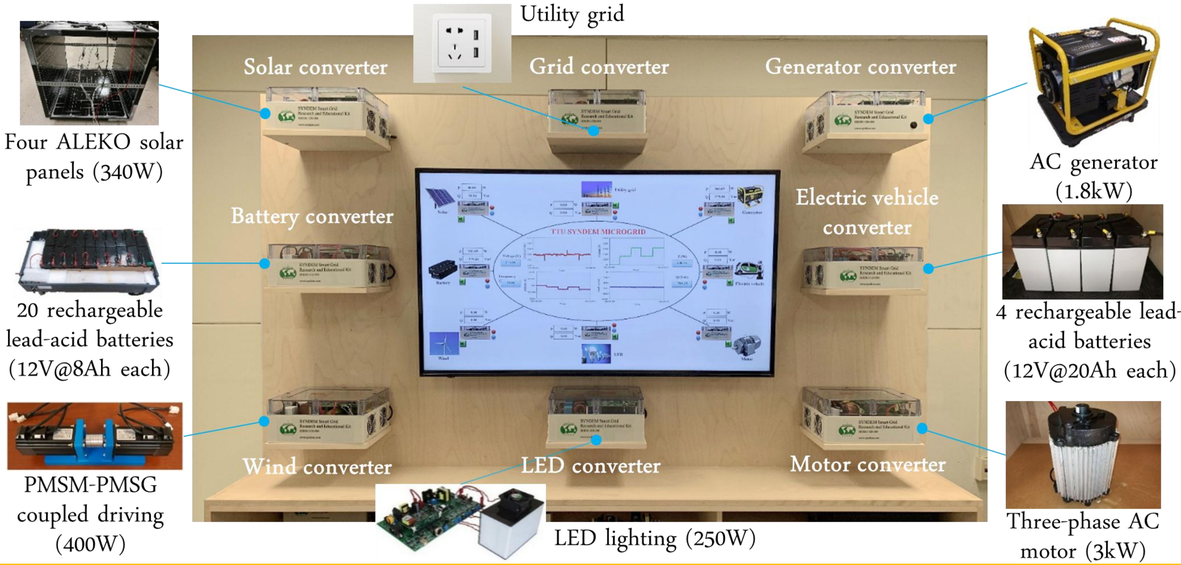


Four ALEKO solar panels (340W)

20 rechargeable lead-acid batteries (12V@8Ah each)

PMSM-PMSG coupled driving (400W)

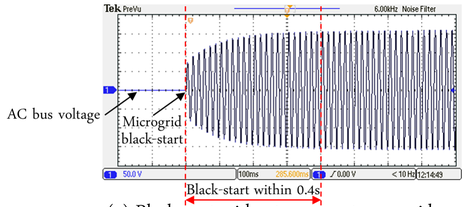
LED lighting (250W)

AC generator (1.8kW)

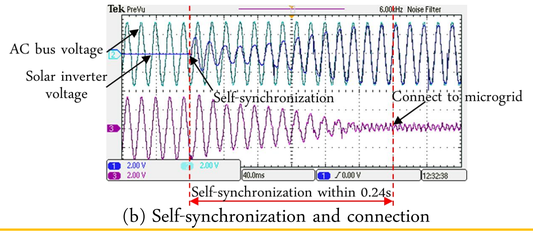
4 rechargeable lead-acid batteries (12V@20Ah each)

Three-phase AC motor (3kW)

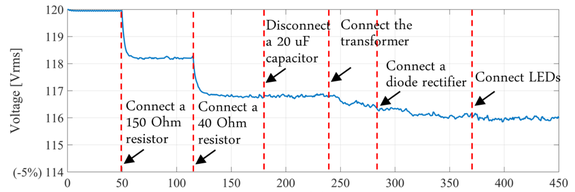
Experimental Results



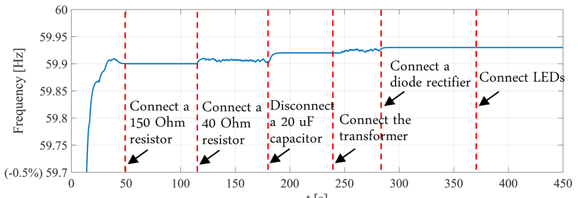
(a) Black-start without a generator or grid



(b) Self-synchronization and connection



(c) Voltage regulation with load changes



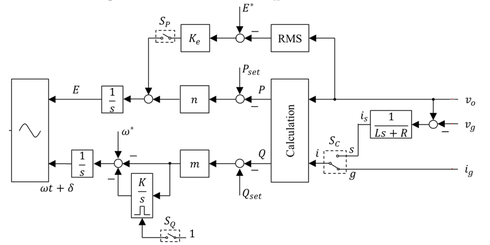
(d) Frequency regulation with load changes

Key Innovations

1. Black-start without a generator or grid
2. Self-synchronization
3. Grid-forming capability
4. No communication network
5. Seamless mode change between grid-connected operation and islanded operation

Control Algorithm

Grid-forming universal droop control [1].



Acknowledgements

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Disclaimer: The views expressed herein do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

Reference

[1] Q.-C. Zhong. Power electronics-enabled autonomous power systems: next generation smart grids. John Wiley & Sons, 2020.