

# A MOTOR-GENERATOR AND SUPERCAPACITOR BASED SYSTEM FOR MICRO-GRID FREQUENCY STABILIZATION

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# Project Objective

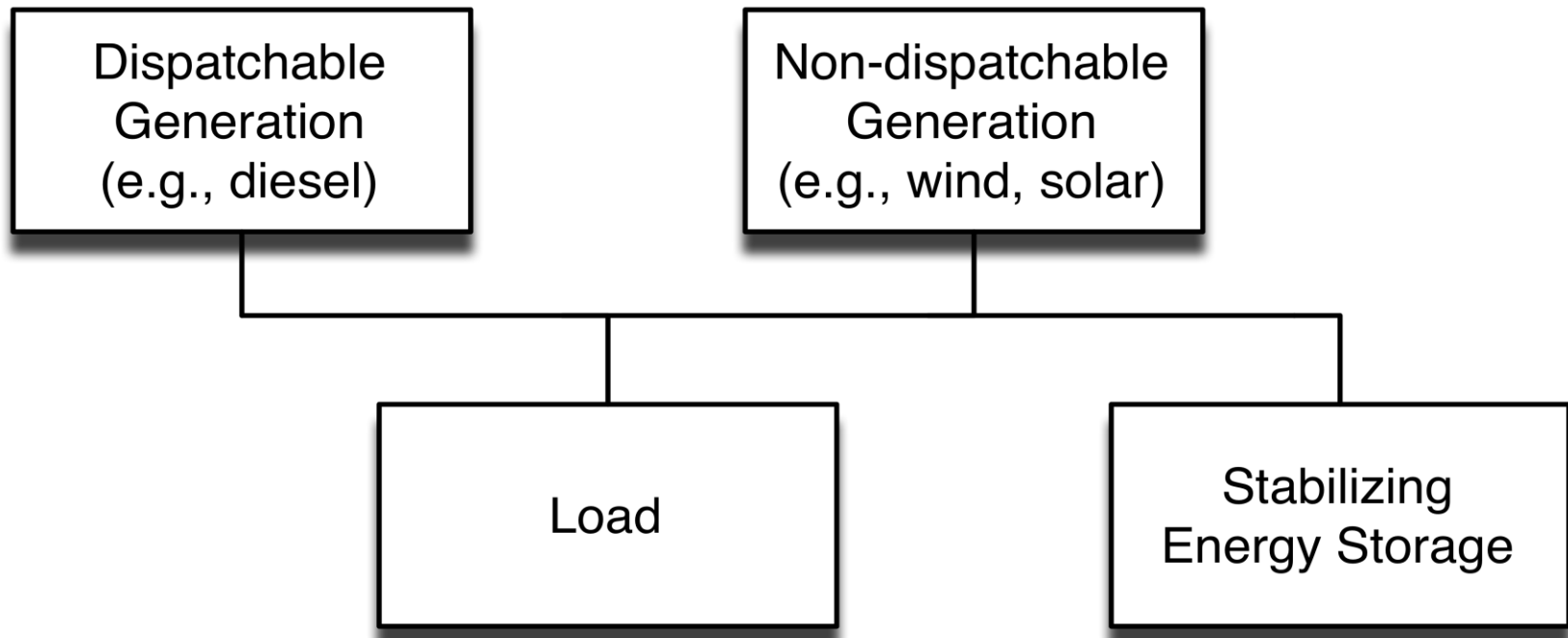
- This project presents a combined inertia and supercapacitor-based energy storage system for stabilizing microgrids.
- Microgrids generally have low inertia, and in the case of high-penetration of renewable power sources, light droop characteristic.
- The proposed energy storage system adds both via real inertia, and line frequency dependent operation of a supercapacitor energy storage bank.

# Background

- Grids typically are stabilized with control operation at four timescales: inertial, primary, secondary, and tertiary.
- Inertia energy storage acts instantaneously.
  - $E = 0.5 J \omega^2$
  - $P = dE/dt = J \omega d\omega/dt$
- Primary control response quickly (a few seconds or less) arrests frequency deviations
  - $P = k*(f - 60 \text{ Hz})$
- Both functions are provided by large, dispatchable synchronous generation (e.g., hydro, coal, etc...)
- Non-dispatchable generation (e.g., wind, solar, etc...) typically provide little to none of inertia or primary control.
- From *Power System Stability and Control* by Kundur, typical thermal generation moment of inertia constants are 2 to 10 seconds

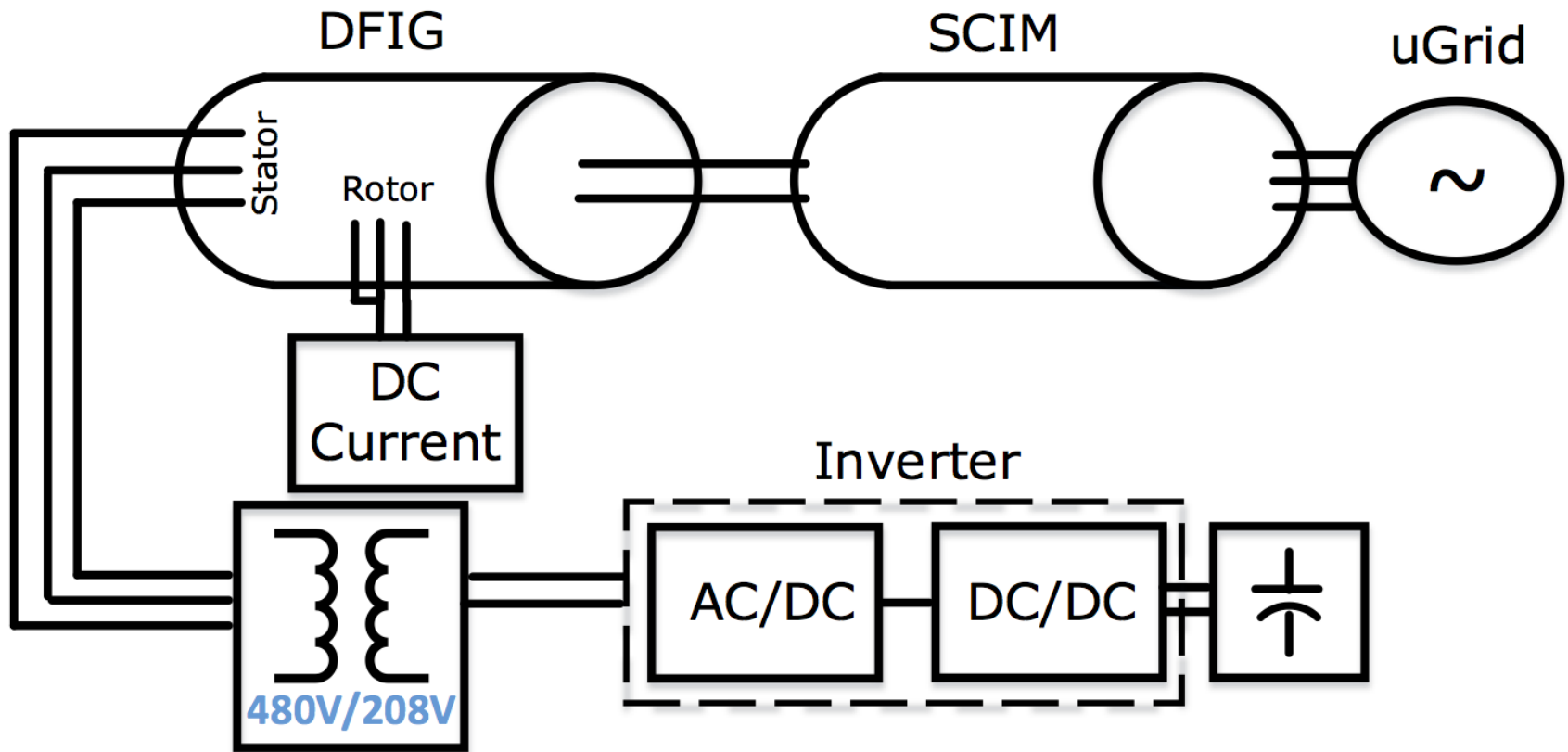
# Microgrid

Add stabilizing energy storage to arrest and correct frequency deviations

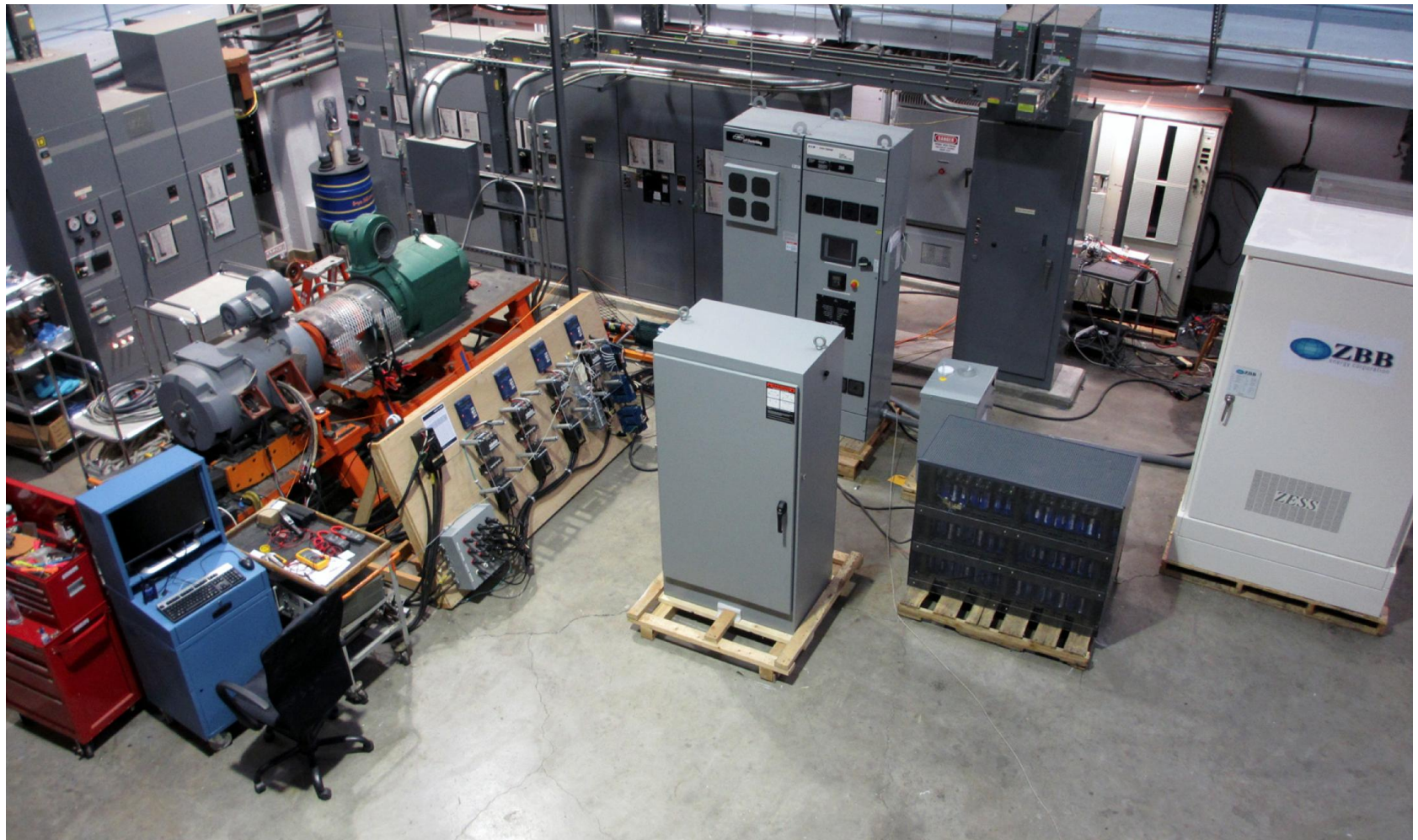


# System Overview

DC/AC conversion, inertia, energy storage



# Wallace Energy Systems and Renewables Facility (WESRF)

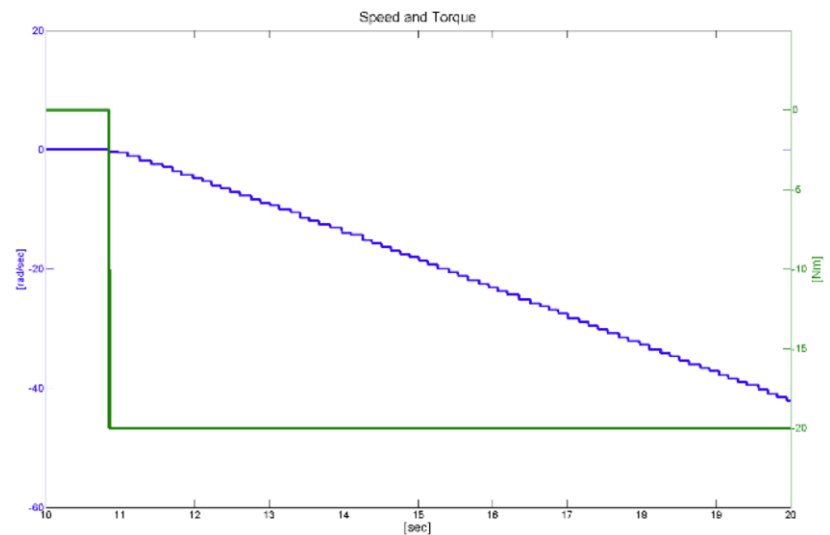




# Motor Generator Set for Inertia



- $J = 4.29 \text{ kg-m}^2$
- $H = 1.69 \text{ seconds}$



# Supercapacitors



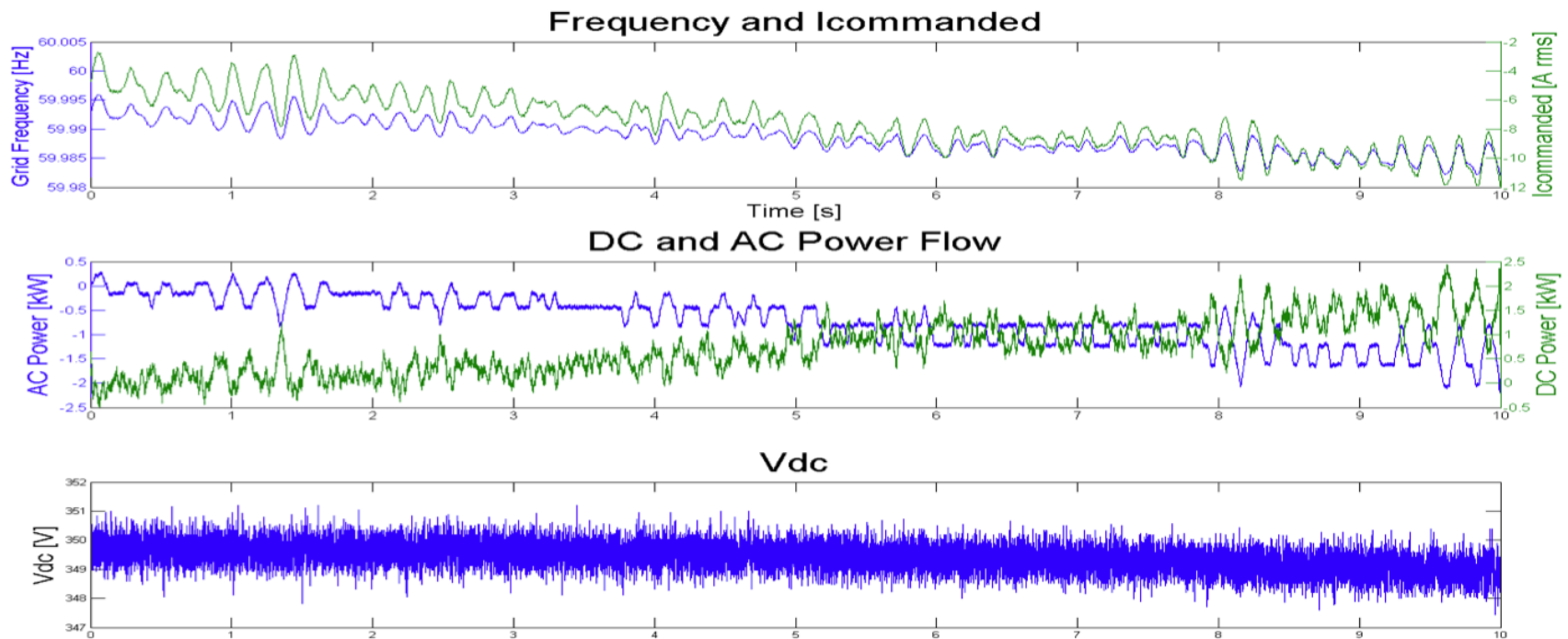
- 30 kW
- 90 seconds



# Primary Frequency Response

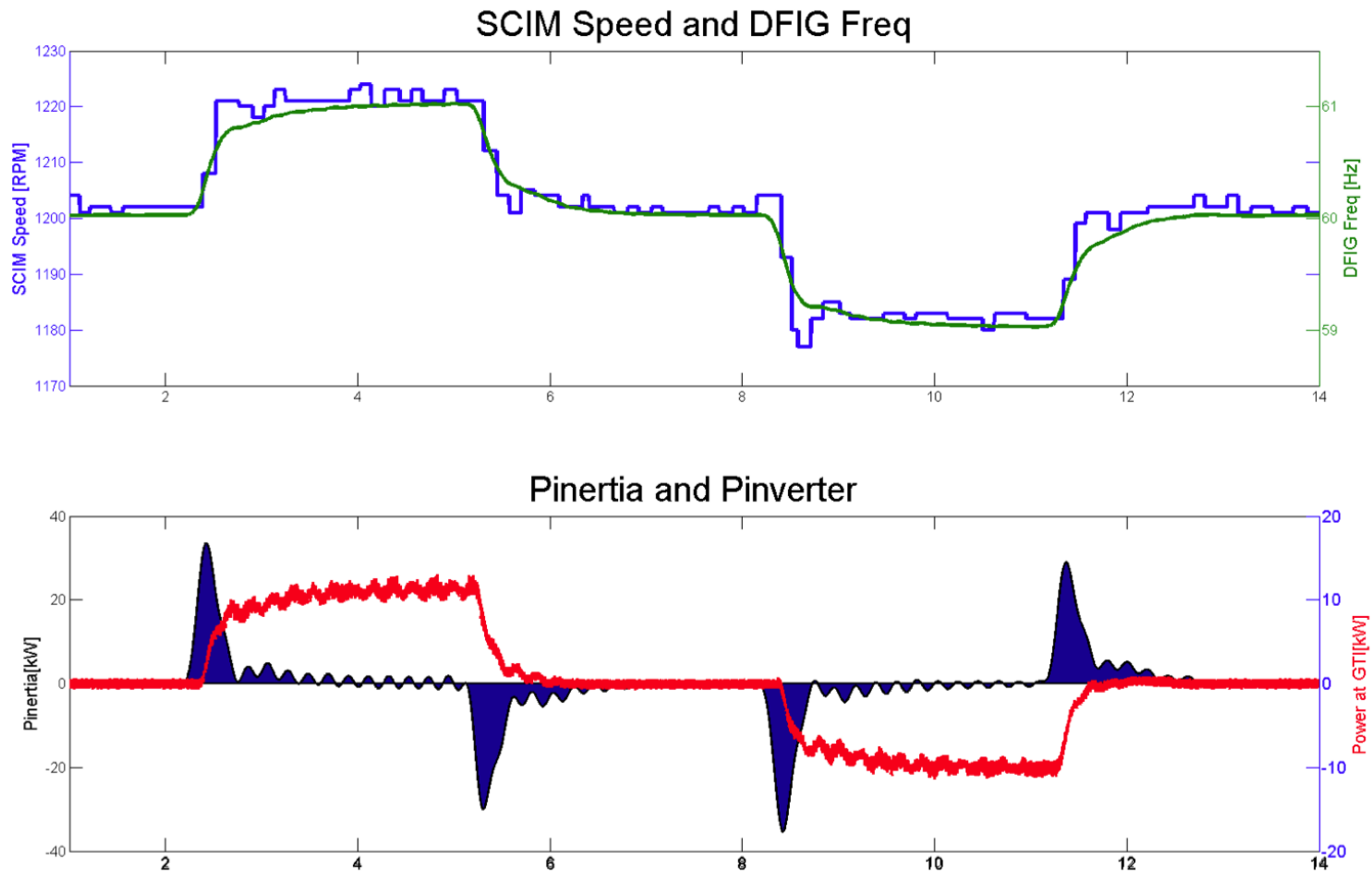
If grid frequency  $> 60$  Hz, sink power

If grid frequency  $< 60$  Hz, source power



# Inertial Response

Inertia power responds immediately to frequency deviation, before primary response



# Conclusion

- A energy storage system for providing inertia, primary frequency response, and voltage conversion for microgrid applications has been presented.
- Inertial response is important and responds before primary control.
- Future work: expand to a doubly-fed based motor-generator set to utilize a broader speed range and more inertial storage.