

# **FACTS/Energy Storage Project**

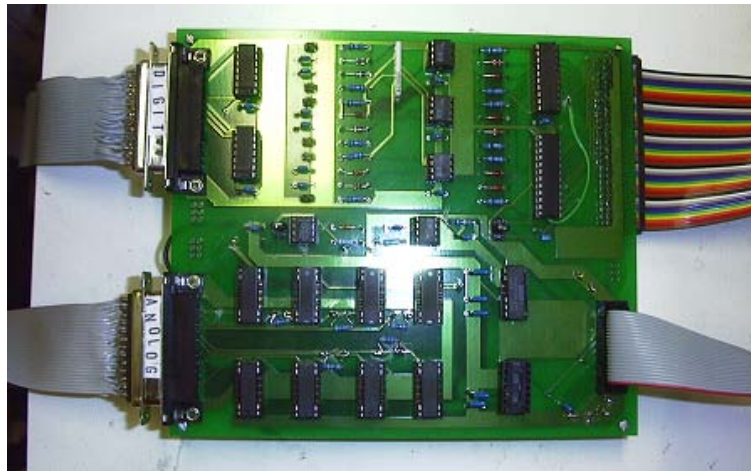
**Mariesa Crow**

Presented by: Keyou Wang

**Missouri University of Science &  
Technology**

# Background:

Integrate BESS with  
existing STATCOM



STATCOM/BESS  
Data Acquisition System

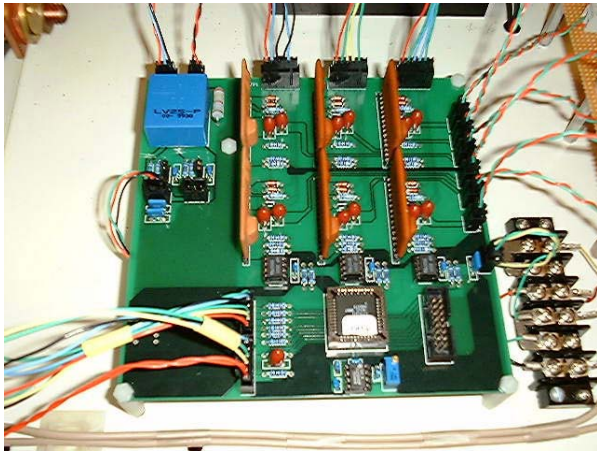


Original  
STATCOM

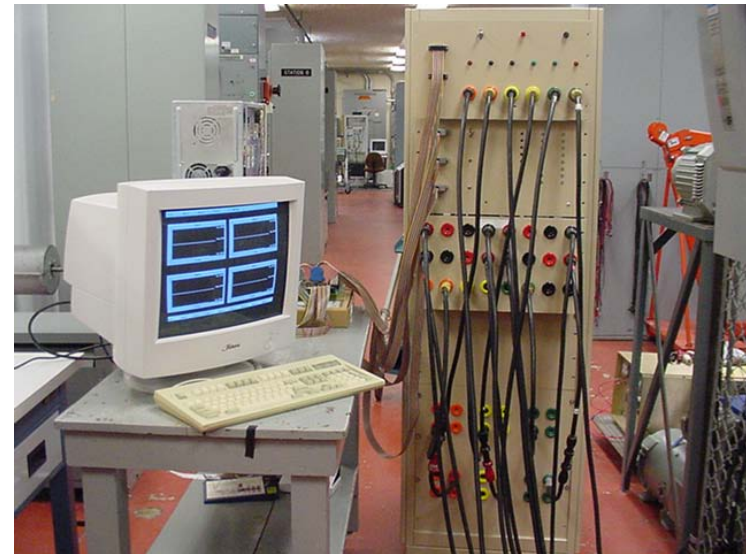
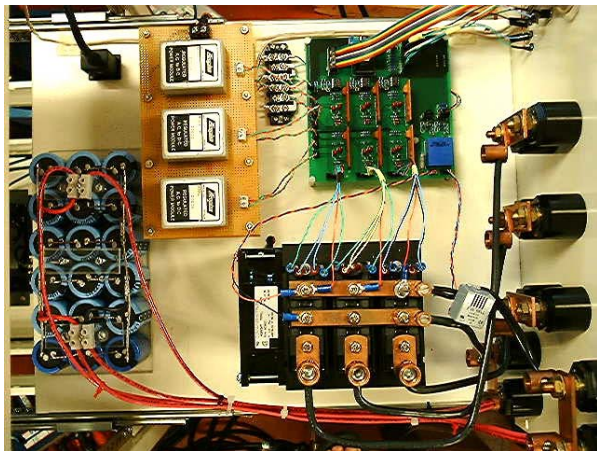
BESS



# Extend to SSSC/BESS



IGBT Driver and Protection Board



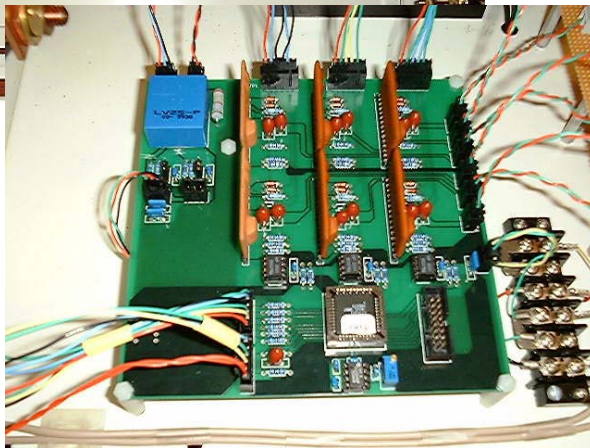
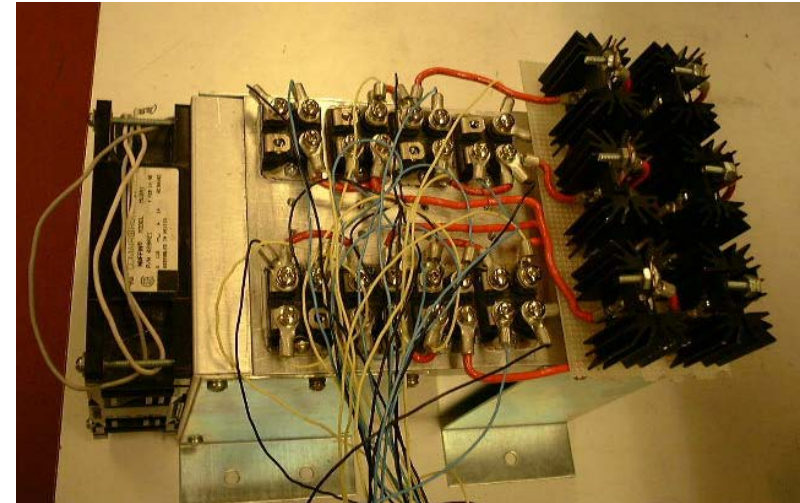
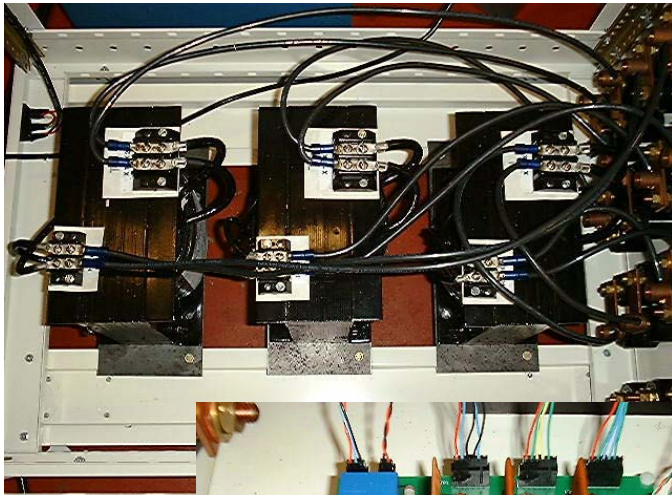
Control Rack



# Multilevel Topologies

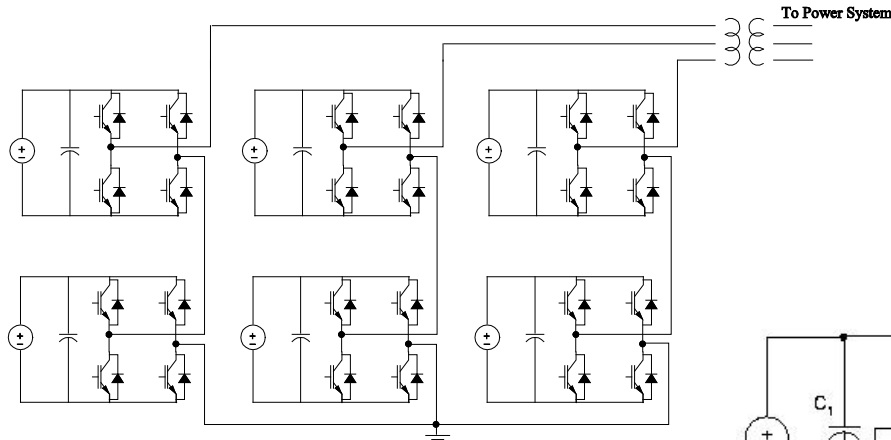
Diode-clamped

Hardware Design

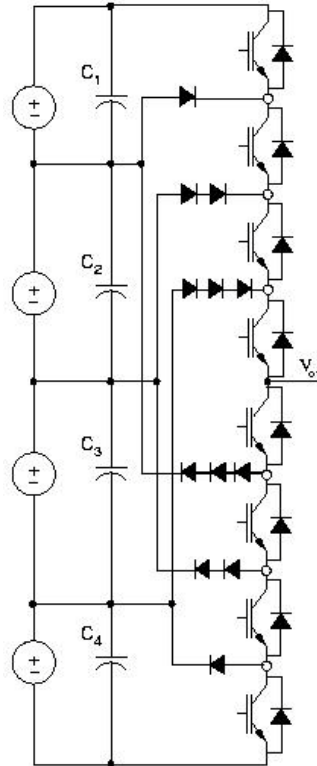


Cascaded

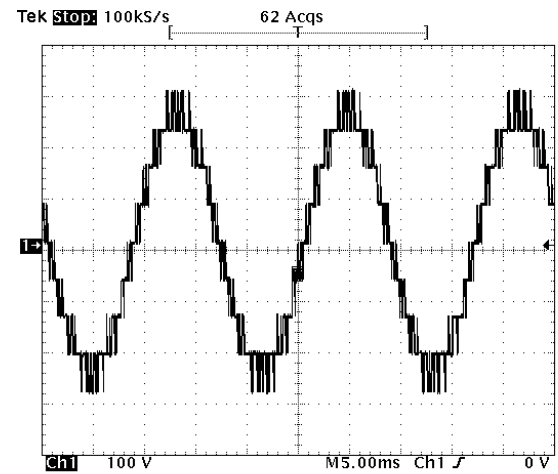
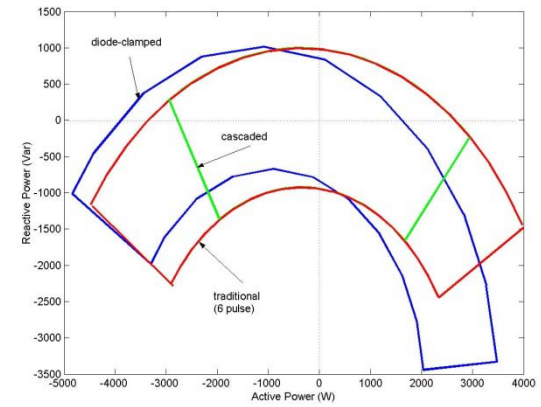
# Operating Regions



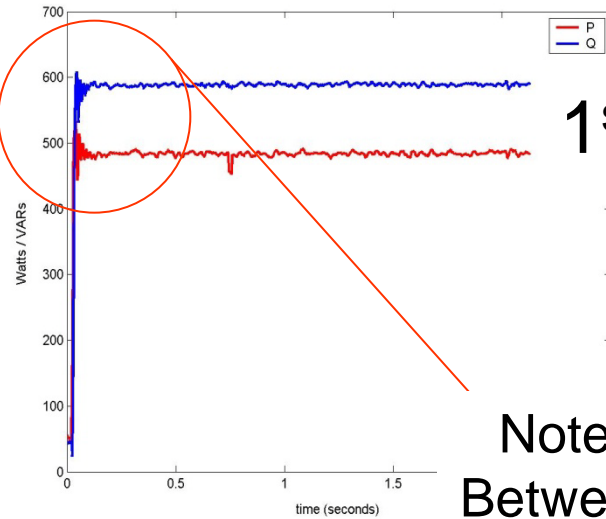
Cascaded



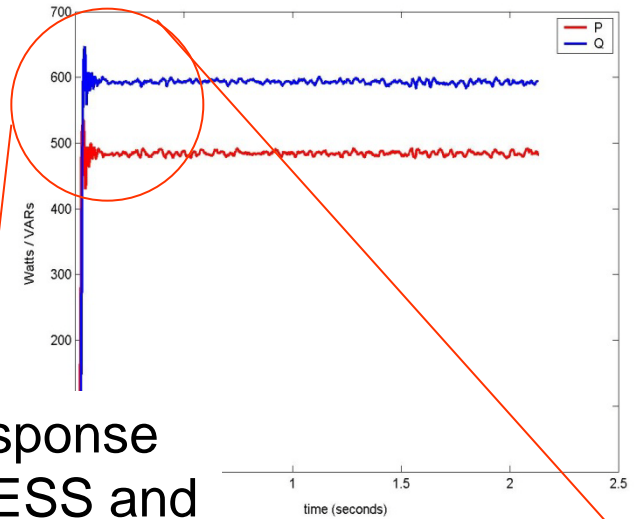
Diode-clamped



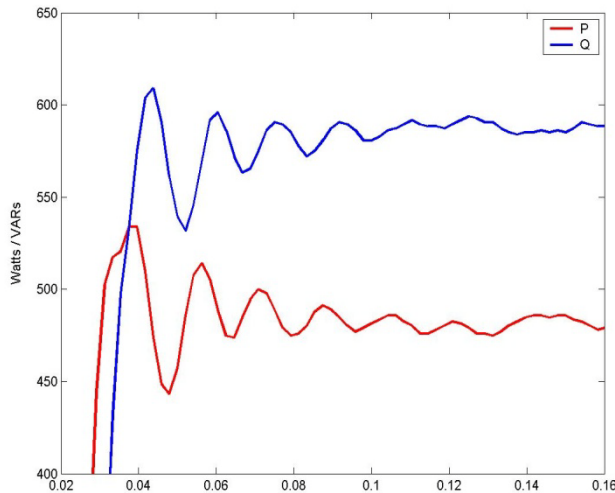
# BESS vs EC (UCAP)



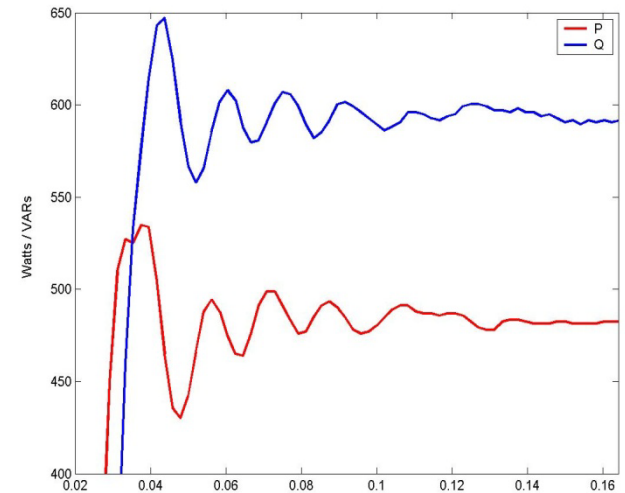
1<sup>st</sup> Quadrant



Note Similarity of Response  
Between STATCOM/BESS and  
STATCOM/UCAP

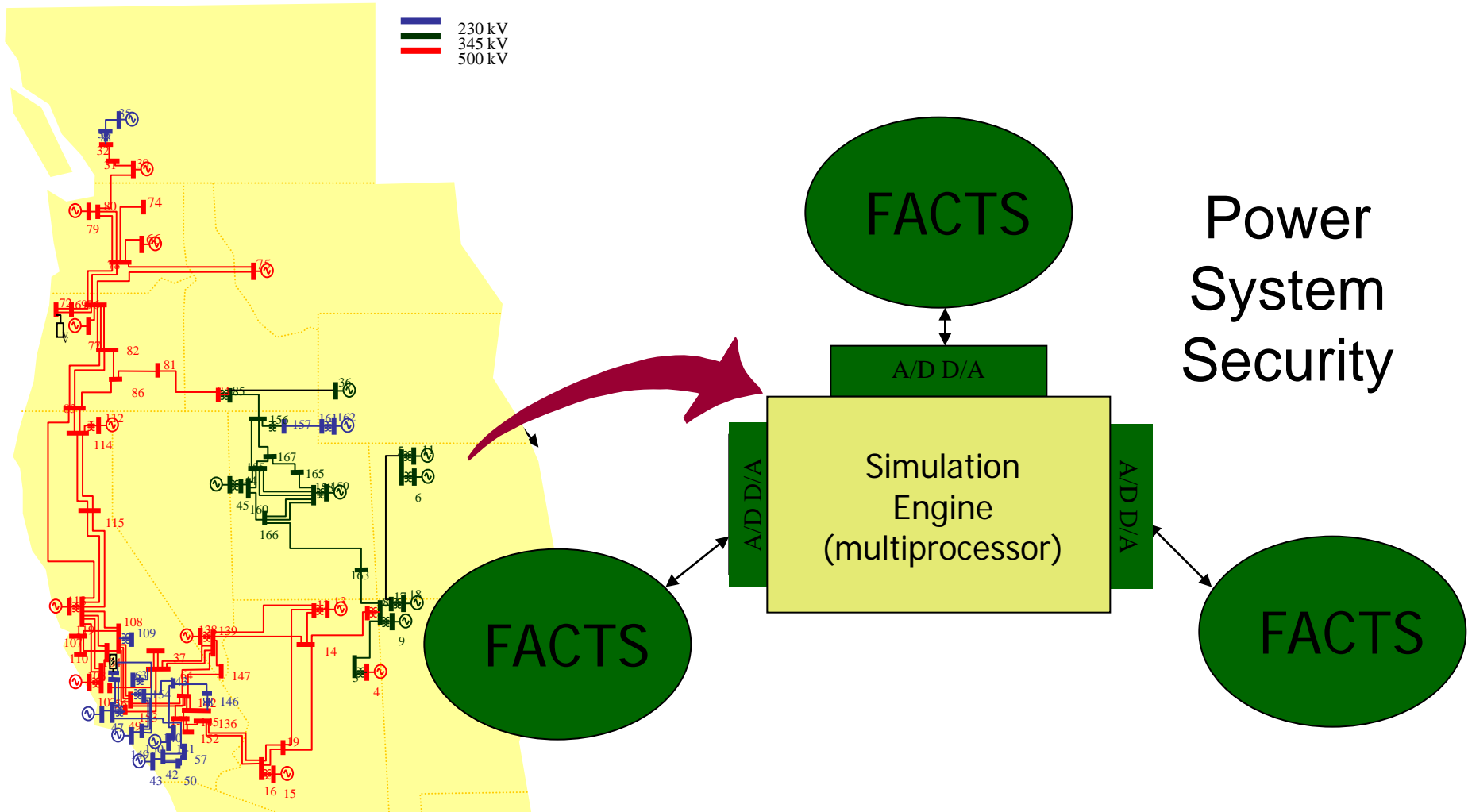


STATCOM/BESS



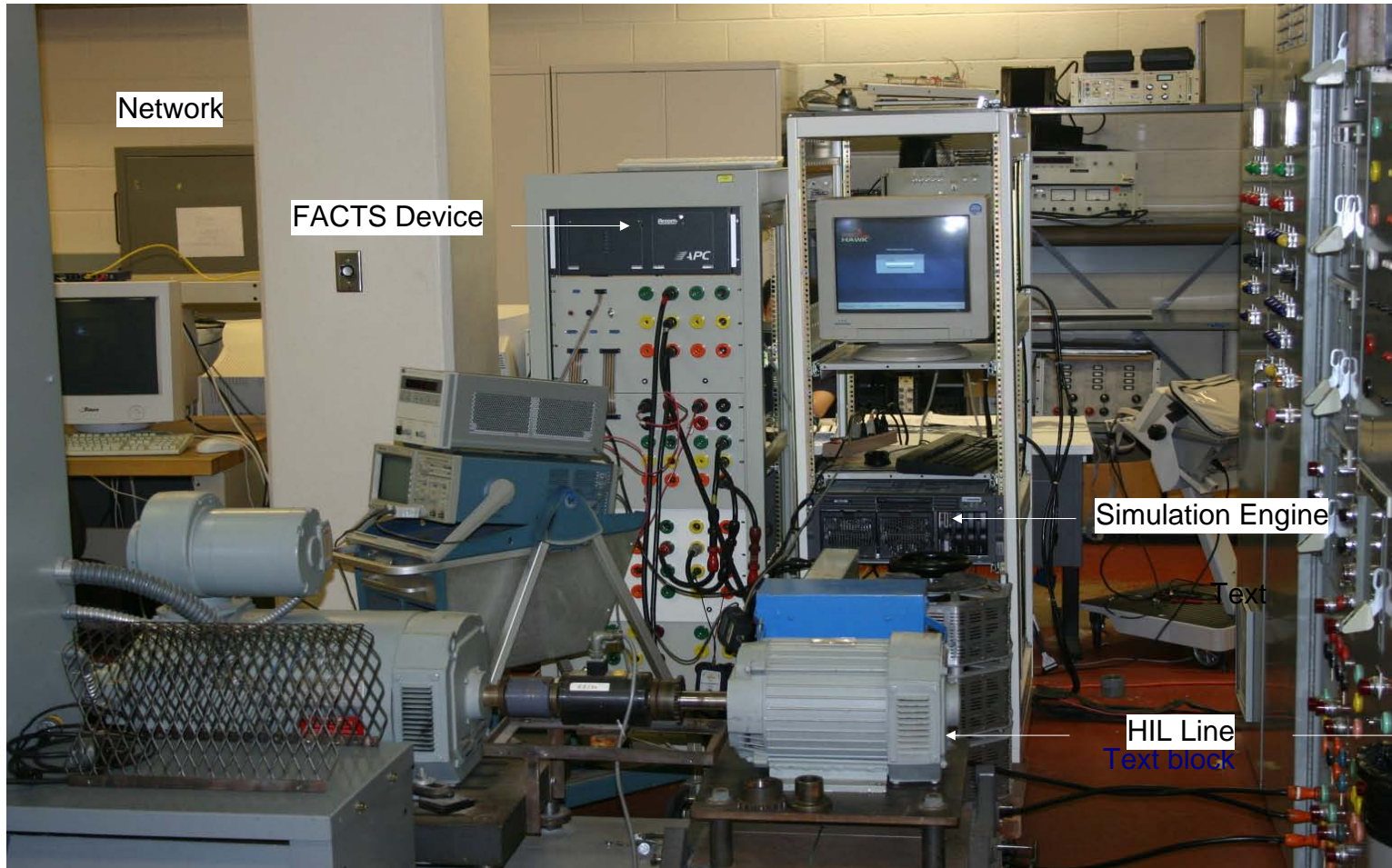
STATCOM/UCAP

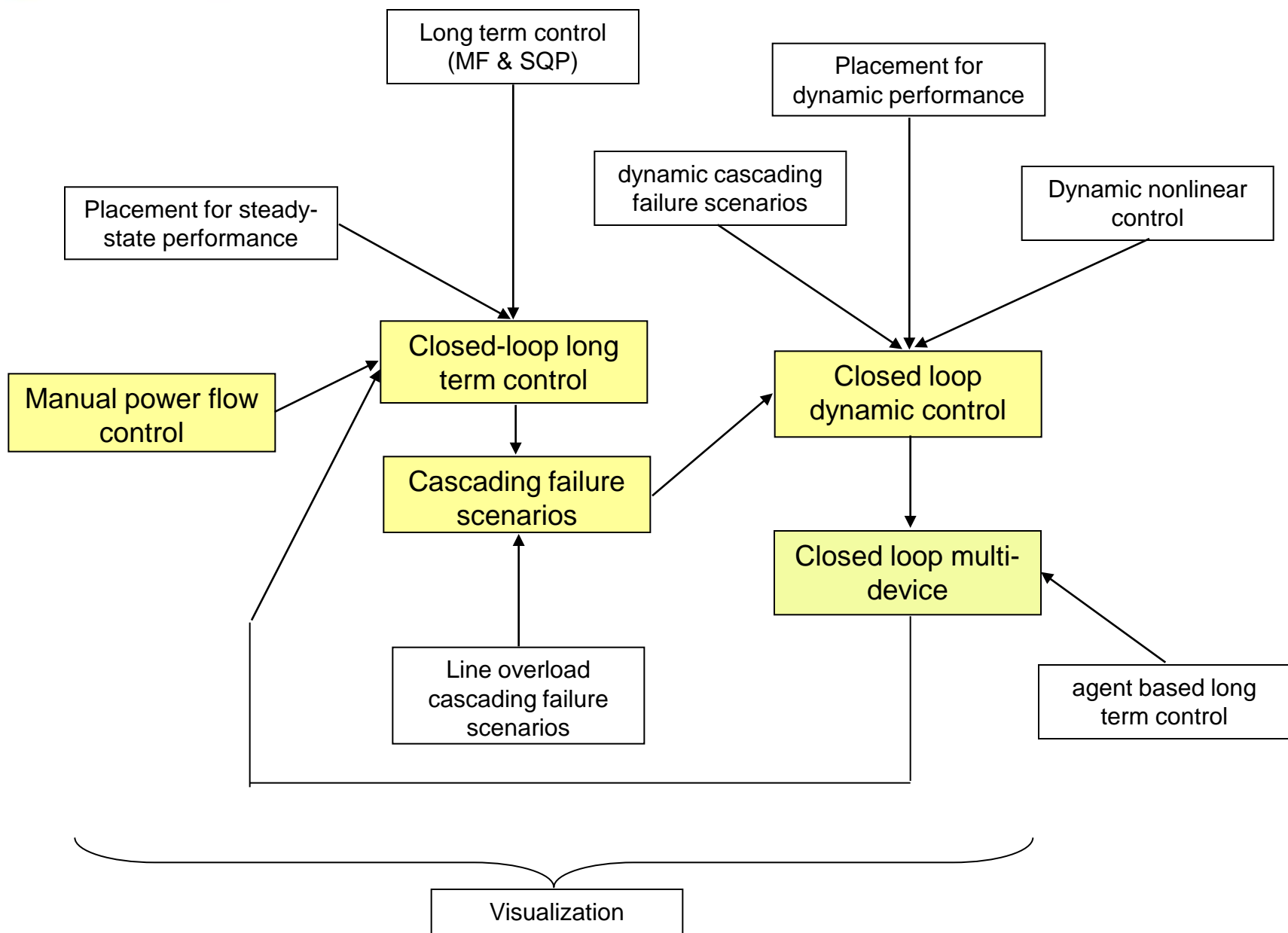
# Hardware in the loop simulations



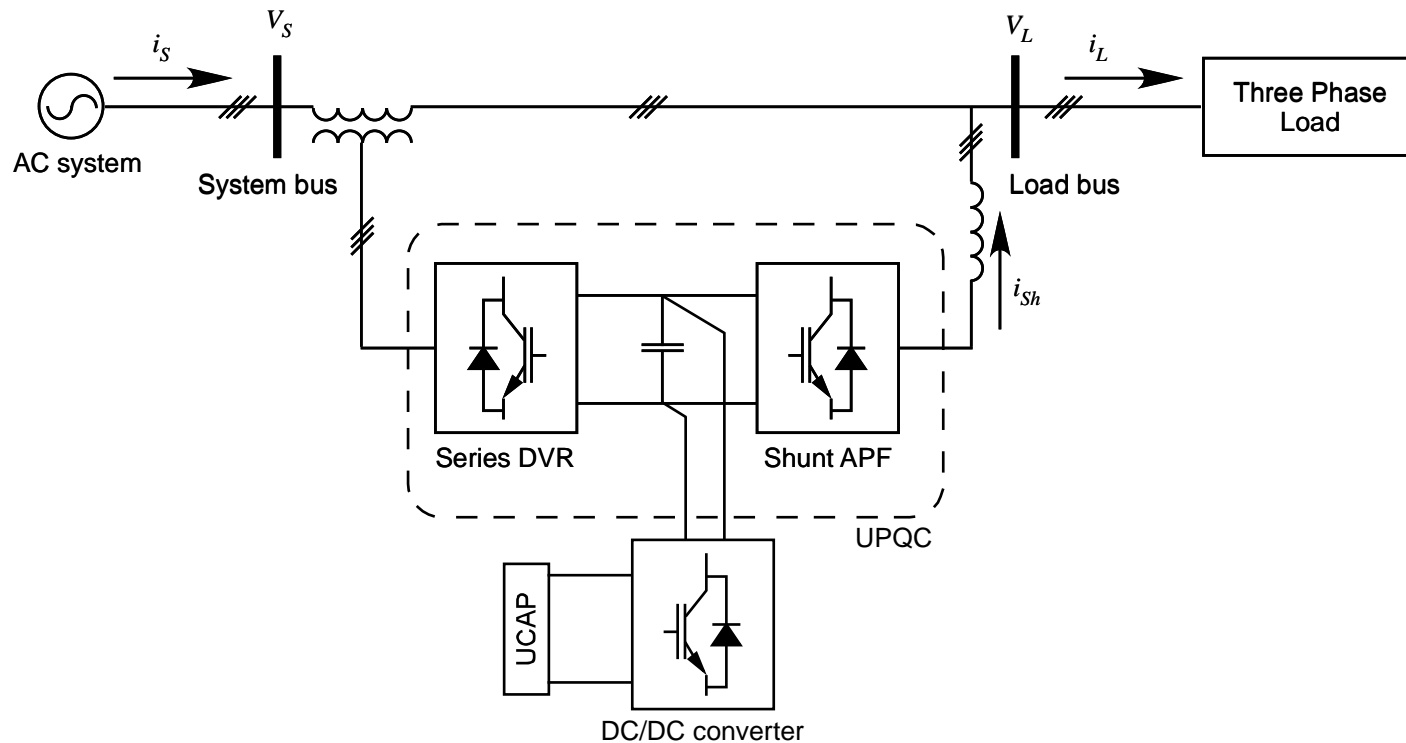




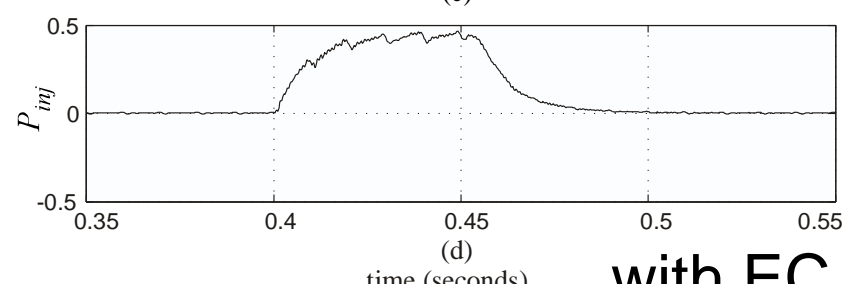
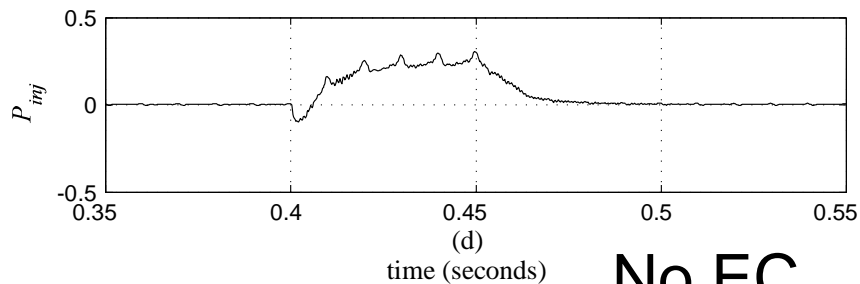
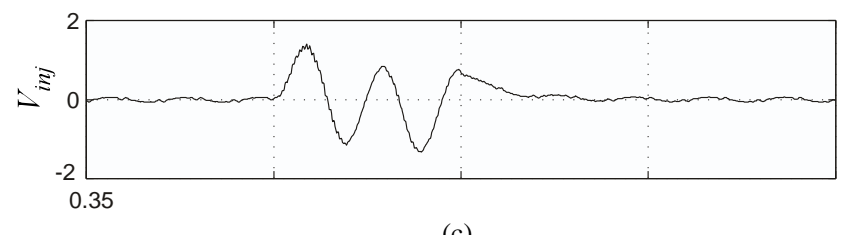
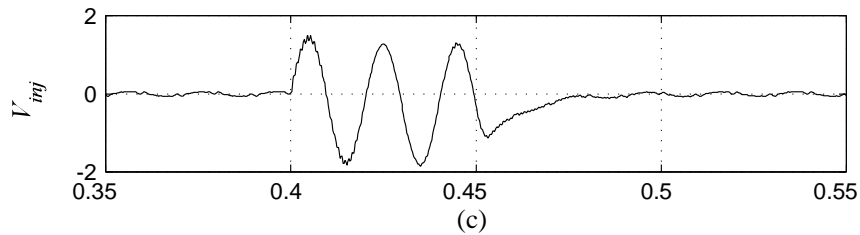
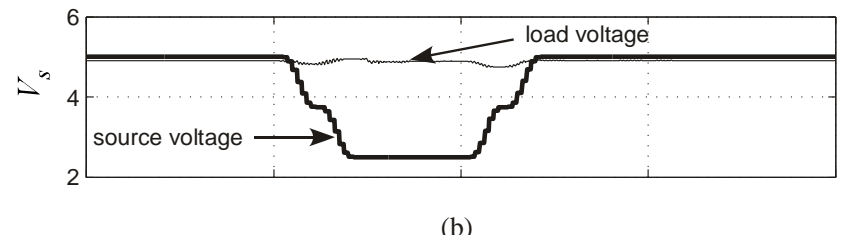
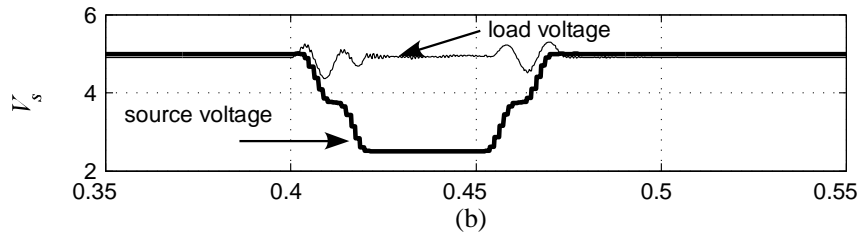
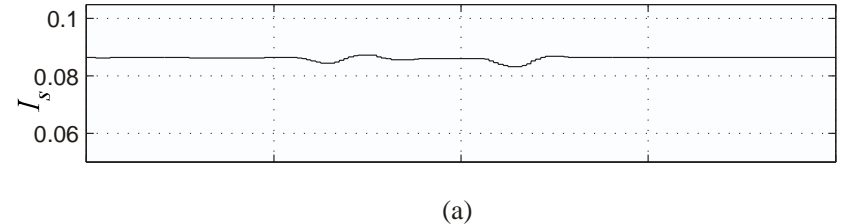
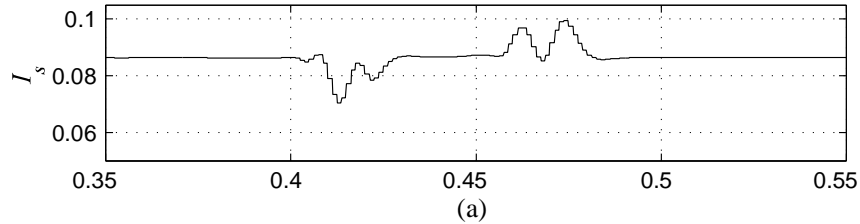




# Unified Power Quality Conditioner with EC



# Dynamic voltage regulation

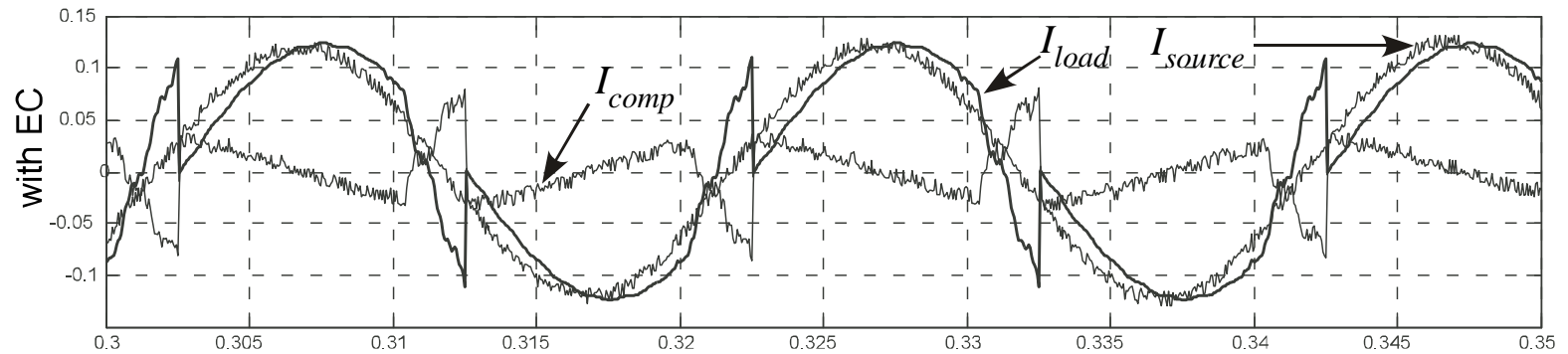
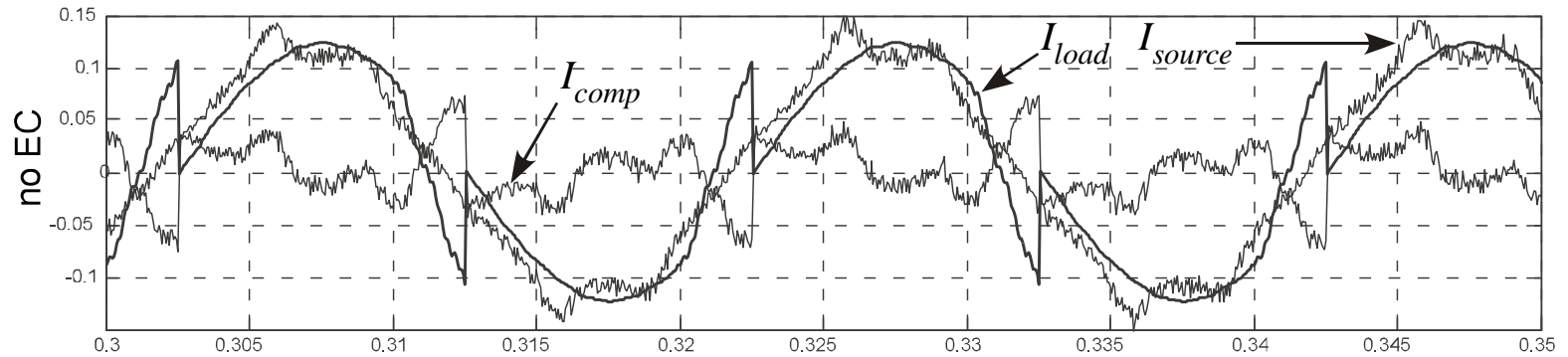


time (seconds) **No EC**

time (seconds) **with EC**



# Active filter

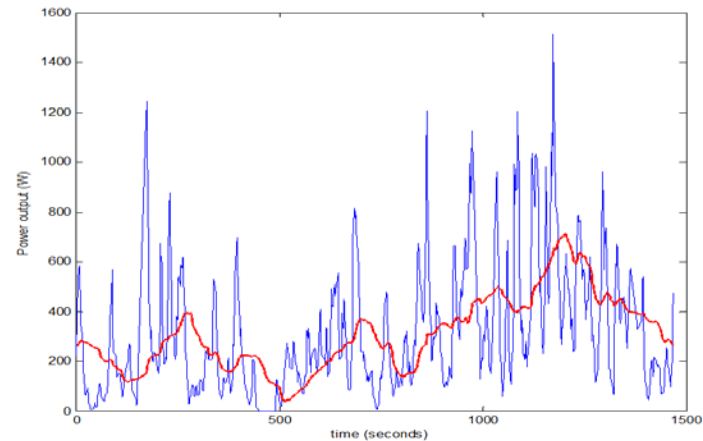


time (seconds)

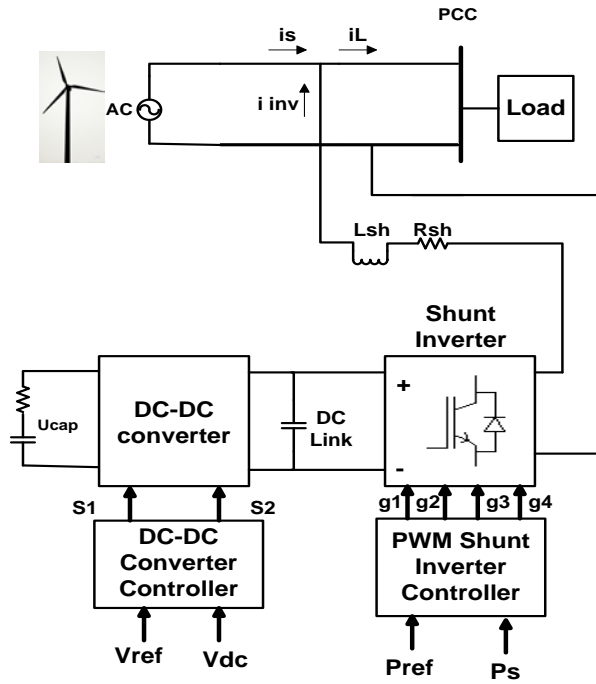
# Using power electronics and EC to improve residential wind turbine response



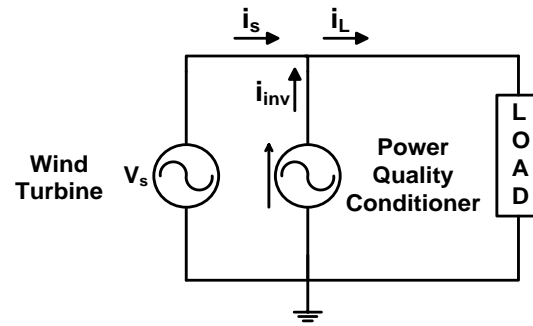
Skystream 3.7



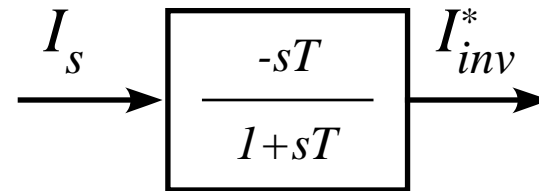
Measured wind turbine power output



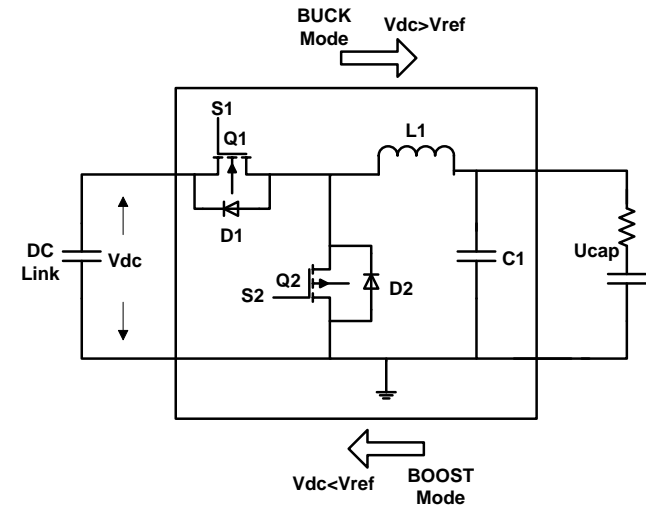
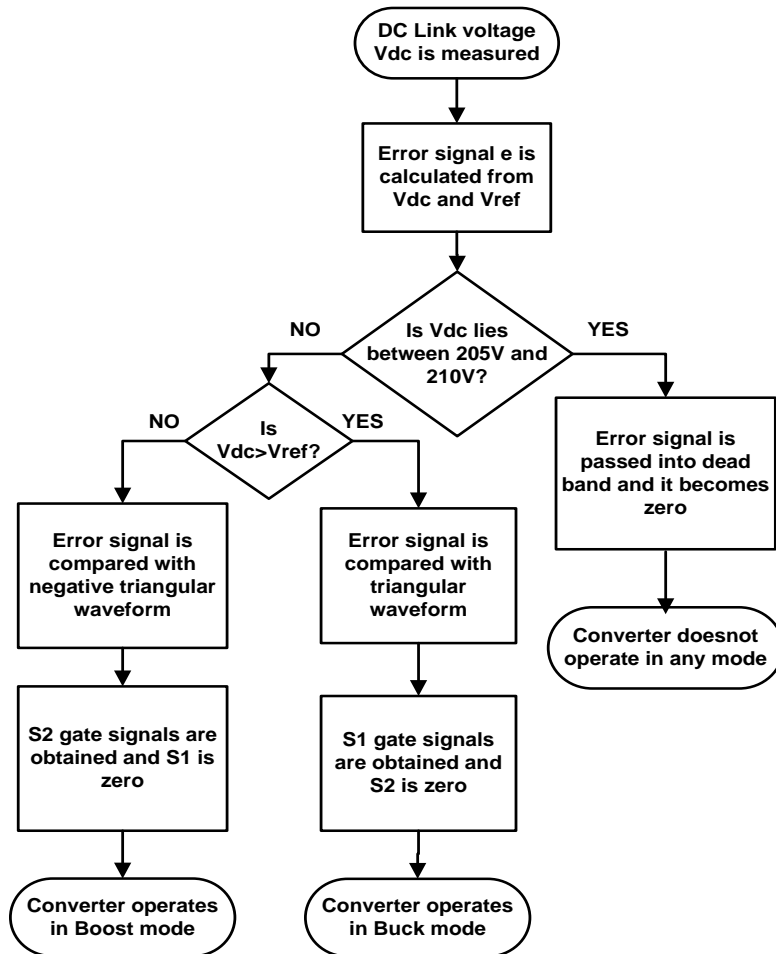
Power quality conditioner



Simplified functional circuit



# Control



Bi-directional DC/DC converter

Hardware development and validation is continuing for the UPQC and the power quality conditioner



# Publications (selected)

- K. Wang\*, M. L. Crow, B. McMillin, S. Atcitty, “A Novel Real-Time Approach to Unified Power Flow Controller Validation,” *IEEE Transactions on Power Systems* (to appear)
- M. Zarghami\*, M. L. Crow, S. Jagannathan, S. Atcitty, “A Novel Approach to Inter-Area Oscillation Damping by Unified Power Flow Controllers Utilizing Ultracapacitors,” *IEEE Trans. on Power Systems*, vol. 25, no. 1, February 2010.
- W. Siever\*, D. Tauritz, A. Miller, B. McMillin, M. Crow, and S. Atcitty, “Symbolic Reduction for High-Speed Power System Simulation,” *Simulation: Transactions of the Society for Modeling and Simulation International*, vol. 84, no. 6, June 2008.
- Y. Cheng, C. Qian, M. L. Crow, S. Pekarek, S. Atcitty, “A Comparison of Diode-Clamped and Cascaded Multilevel Converters for a STATCOM with Energy Storage,” *IEEE Transactions on Industrial Electronics*, vol. 53, no.5, October 2006.
- L. Zhang, C. Shen, M. L. Crow, S. Atcitty, L. Dong\*, S. Pekarek “Performance Indices for the Dynamic Performance of FACTS and FACTS with Energy Storage,” *Electric Power System Components and Systems*, vol. 33, no. 3, March 2005.
- L. Dong, M. L. Crow, Z. Yang\*, S. Atcitty, “A Reconfigurable FACTS System for University Laboratories,” *IEEE Transactions on Power Systems*, vol. 19, no. 1, pp. 120-128, February 2004. (Awarded IEEE PES prize paper)

# Special Thanks

- **Imre Gyuk - DOE**
- **Stan Atcitty - Sandia National Laboratories**
- **John Boyes - Sandia National Laboratories**