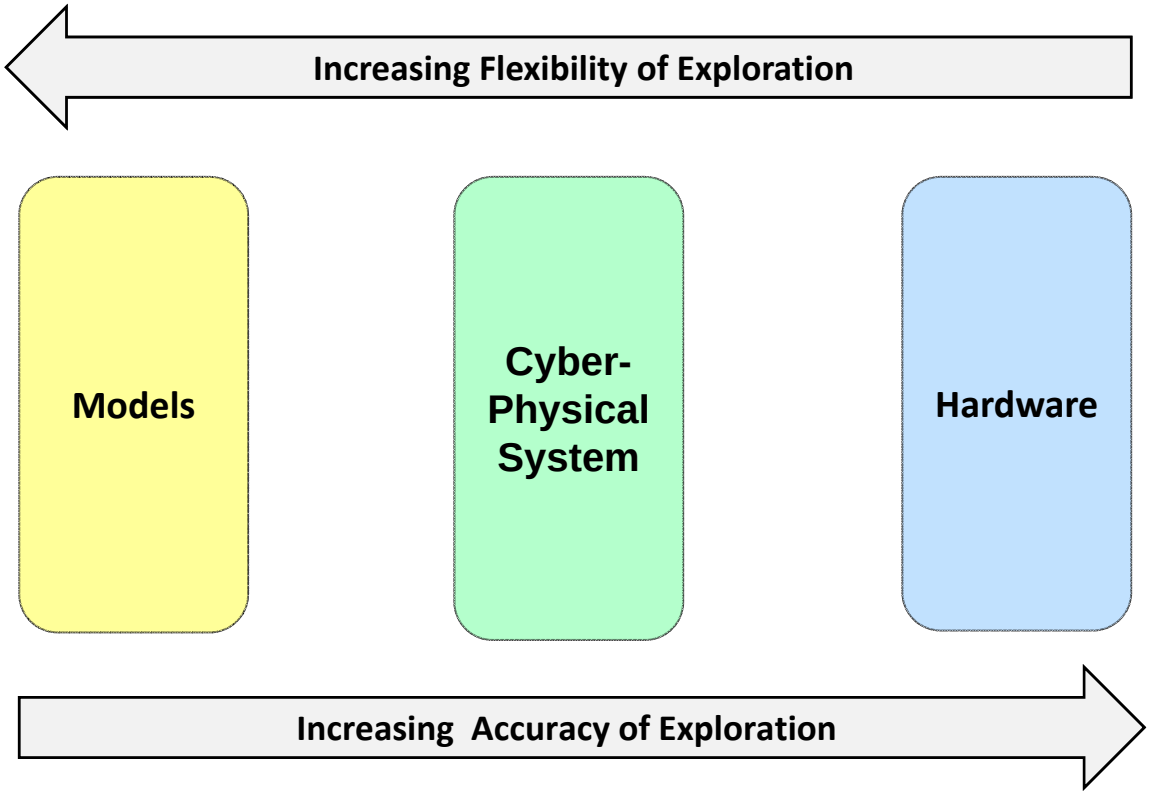
Building an Extensible Framework for Testing New Engineering Concepts

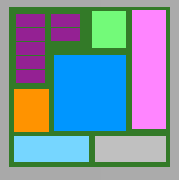
Dr. Paolo Pezzini
Mr. Peter Finzell
Dr. Mark Bryden

Advanced concept power systems are often tightly coupled and difficult to control

- Protect equipment
- Enable coupling of disparate thermal cycle and components
- Larger optimum control envelope
- Support transient operation

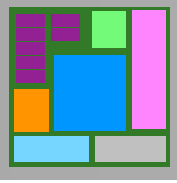
Current challenge





Cyber-Physical System

- Development and validation of novel sensor control strategies
- Testing of sensor hardware
- Low cost investigation for new engineering concepts
- Exploring other advanced computational algorithms

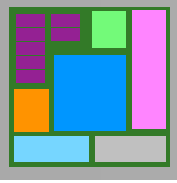


Goal – develop advanced concept power plants

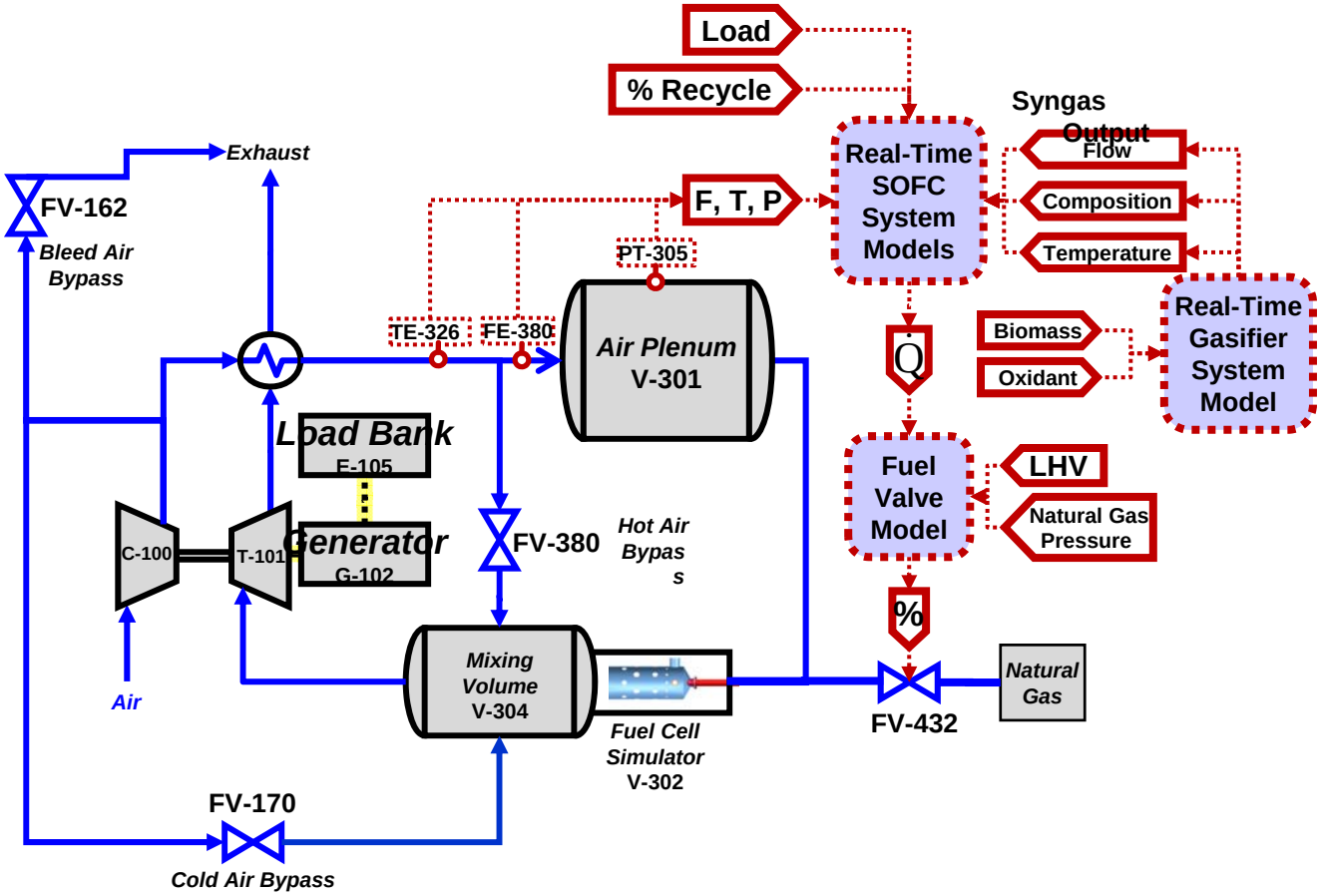
Multi-agents control solutions

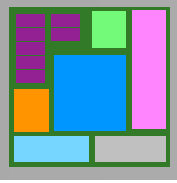
Multivariable control schema

- Development and validation of novel sensor control strategies
- Testing of sensor hardware
- Low cost investigation for new engineering concepts
- Exploring other advanced computational algorithms

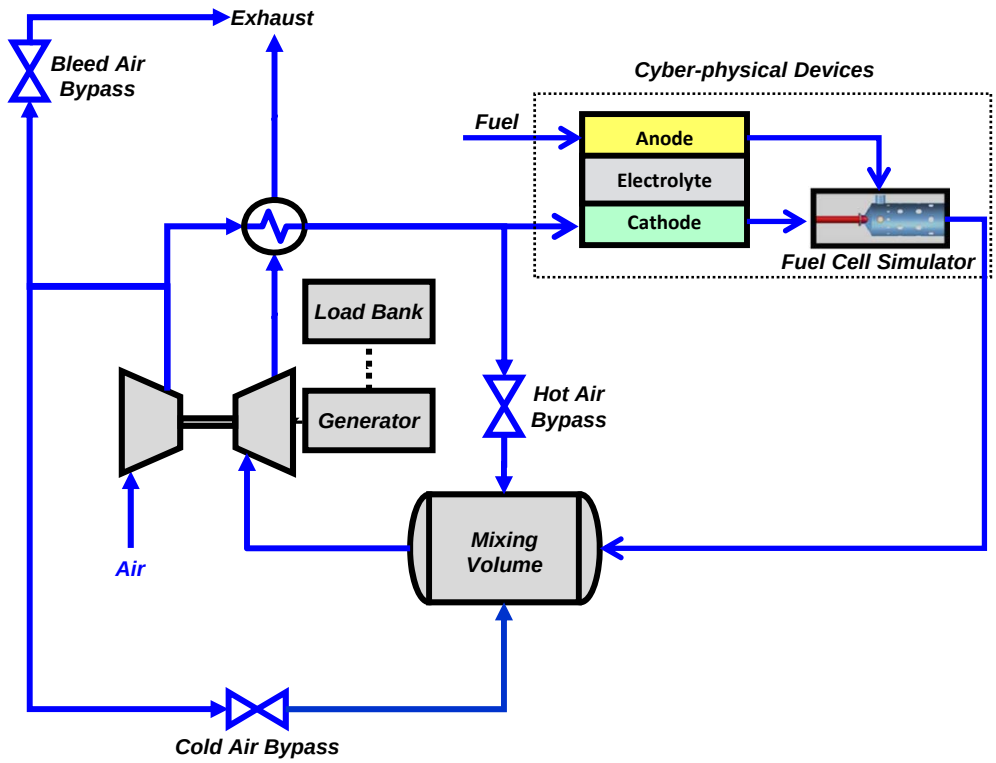


Today's discussion

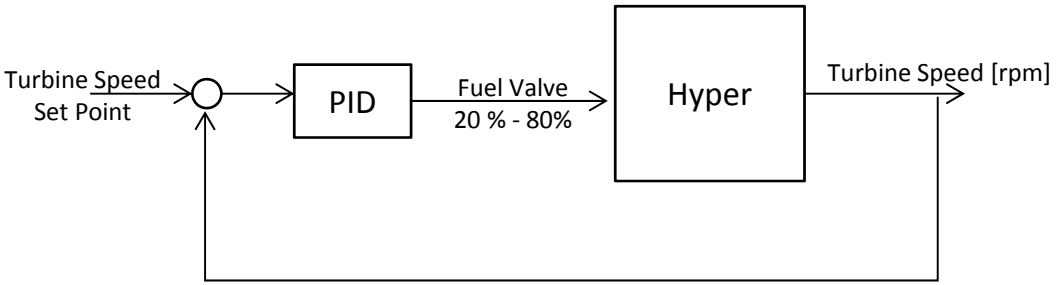

Load
% Recycle
Syngas Output
Flow
Composition
Temperature
Real-Time SOFC System Models
F, T, P
Exhaust
FV-162
Bleed Air Bypass
PT-305
TE-326
FE-380
Air Plenum V-301
Q
Biomass
Oxidant
Real-Time Gasifier System Model
Load Bank E-105
Generator G-102
C-100
T-101
FV-380
Hot Air Bypass
Fuel Valve Model
LHV
Natural Gas Pressure
%
Air
Mixing Volume V-304
Fuel Cell Simulator V-302
Natural Gas
FV-432
FV-170
Cold Air Bypass

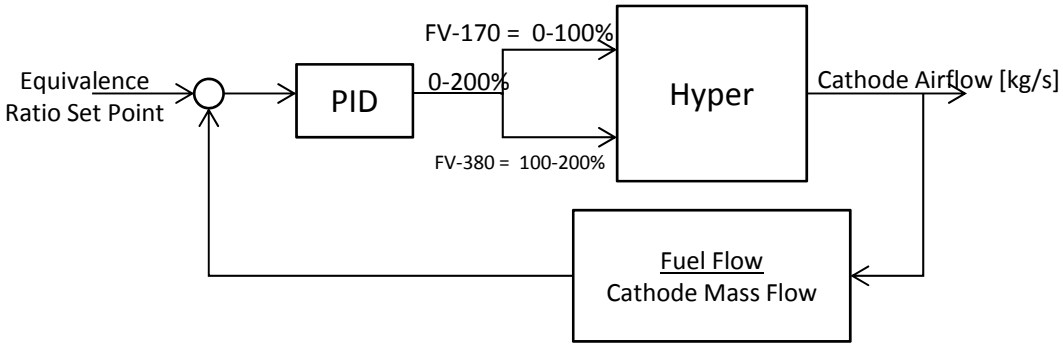


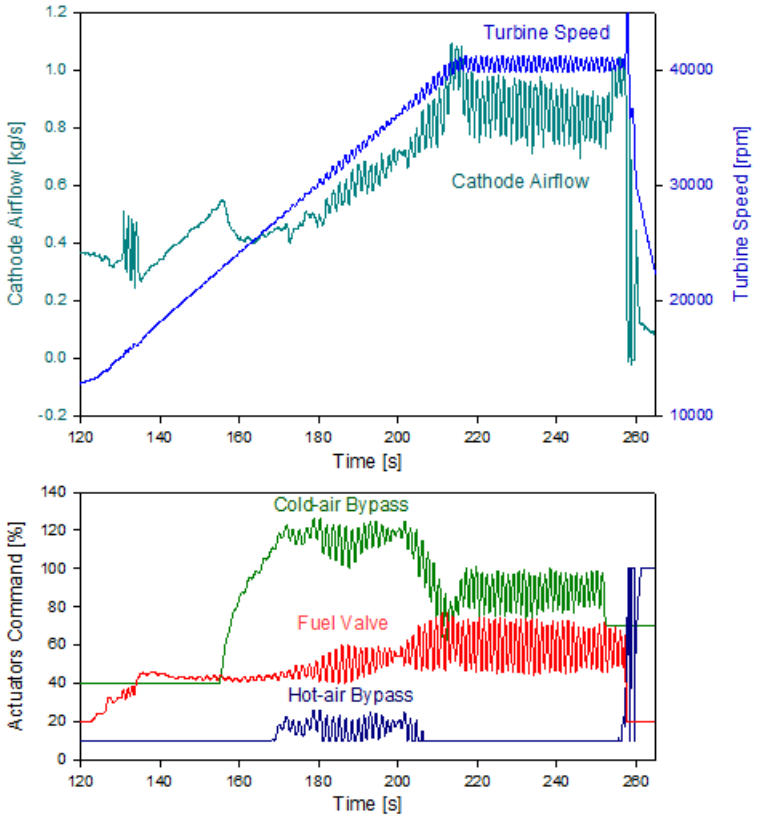
Motivation


Exhaust
Bleed Air
Bypass
Cyber-physical Devices
Fuel
Anode
Electrolyte
Cathode
Fuel Cell Simulator
Load Bank
Generator
Hot Air
Bypass
Air
Mixing
Volume
Cold Air Bypass

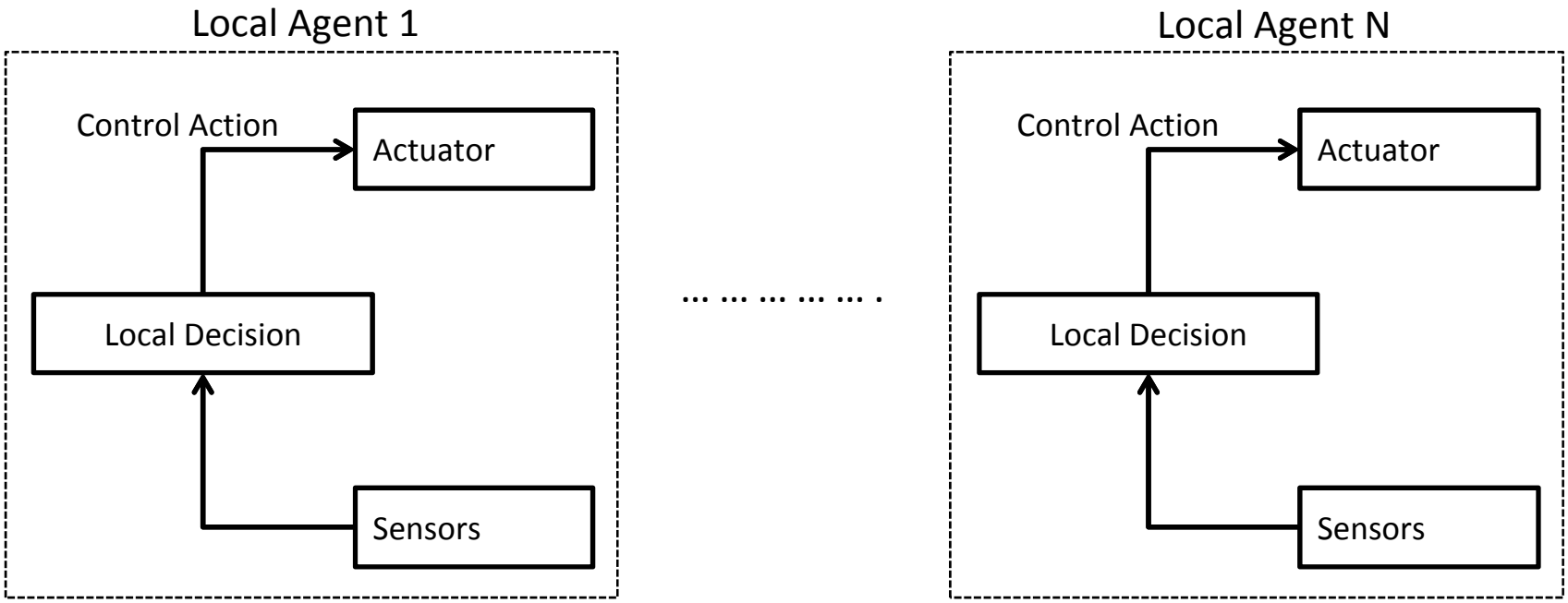
Motivation



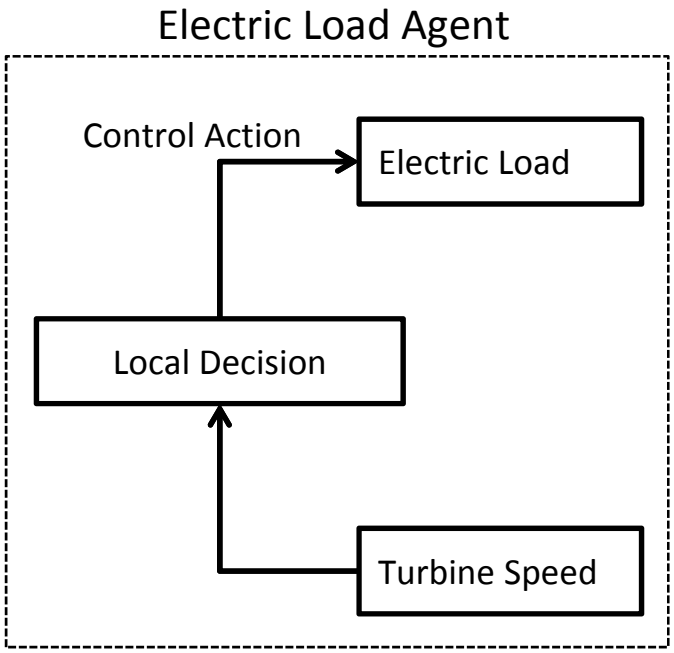


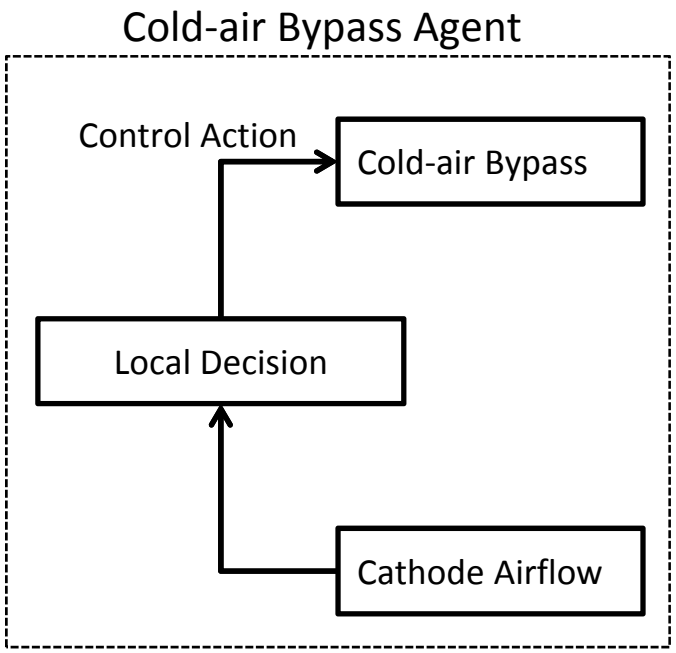


Traditional Single-input Single-output PIDs failed



Multi-agent Control Strategy

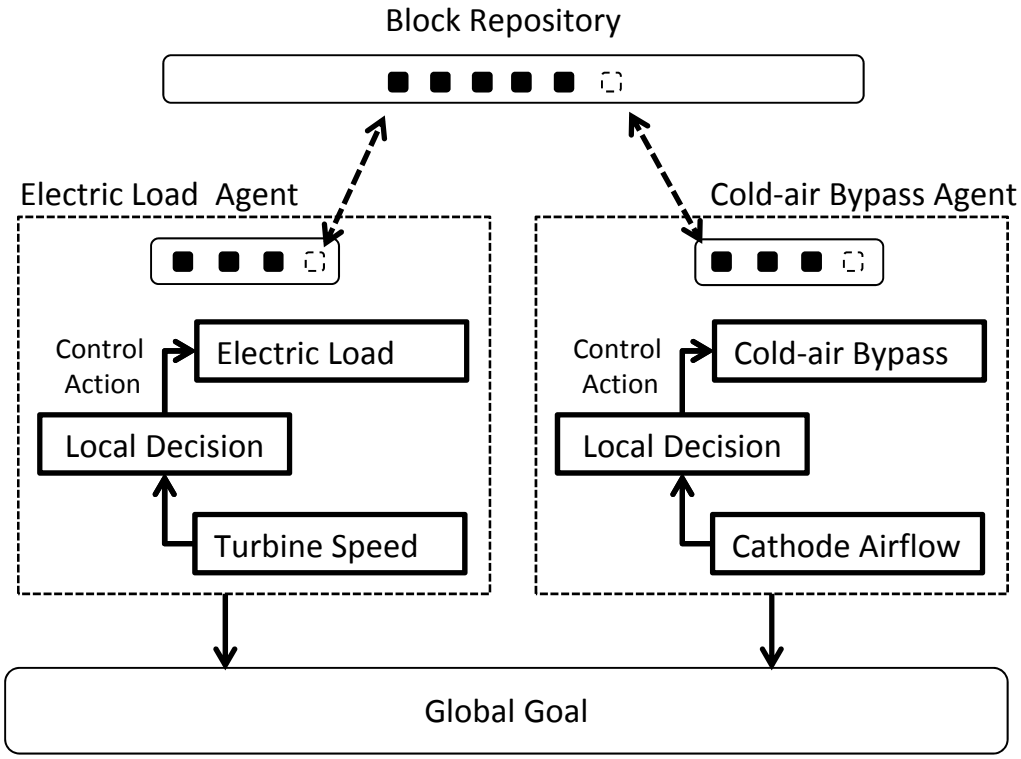


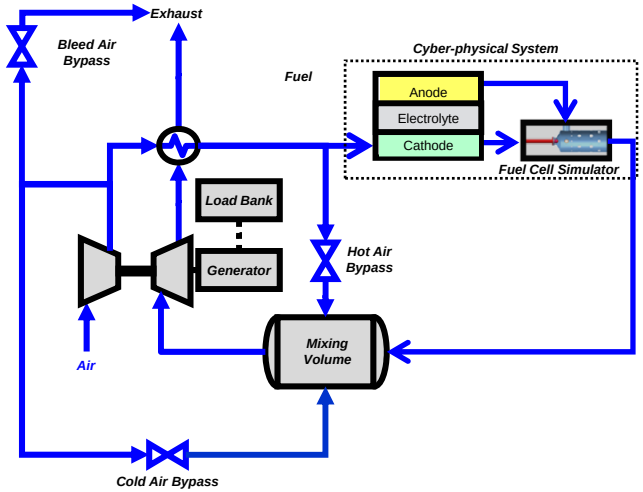


Multi-agent Control Strategy

Less Complexity

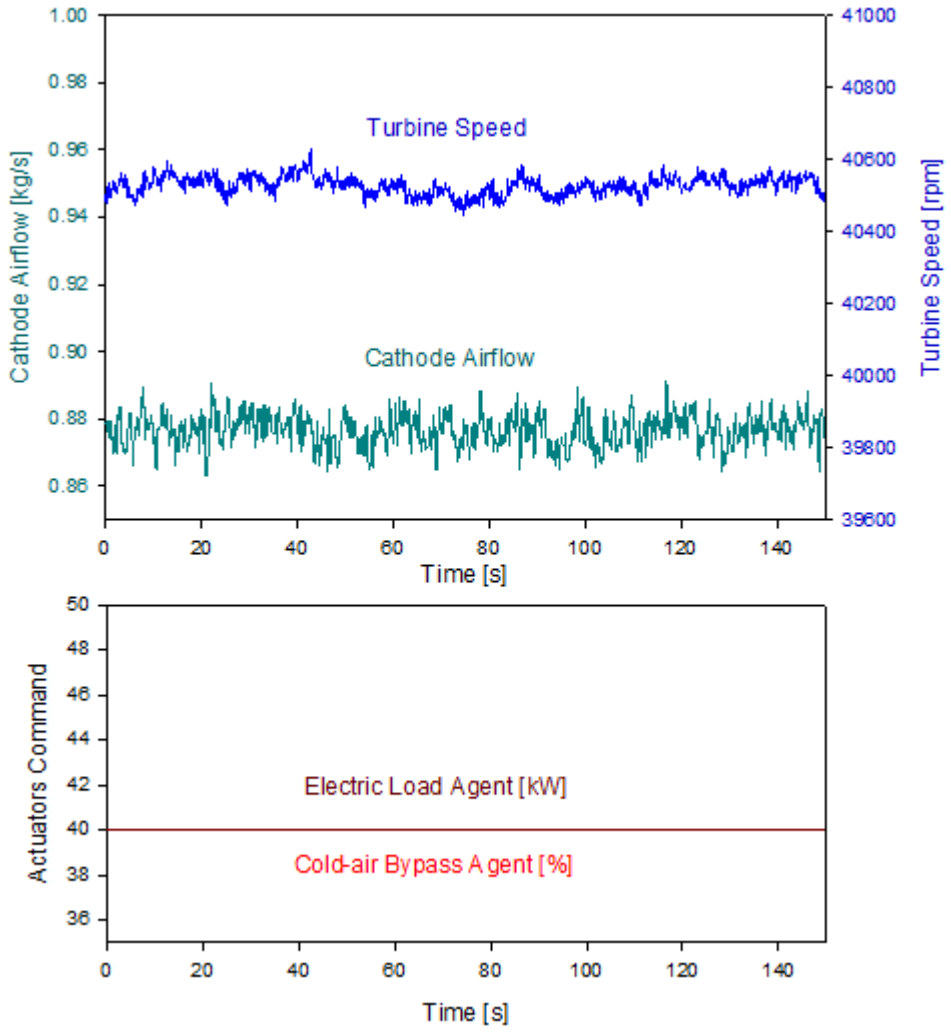
- No System Modeling
- Easy Tuning
- Easy Adaptability





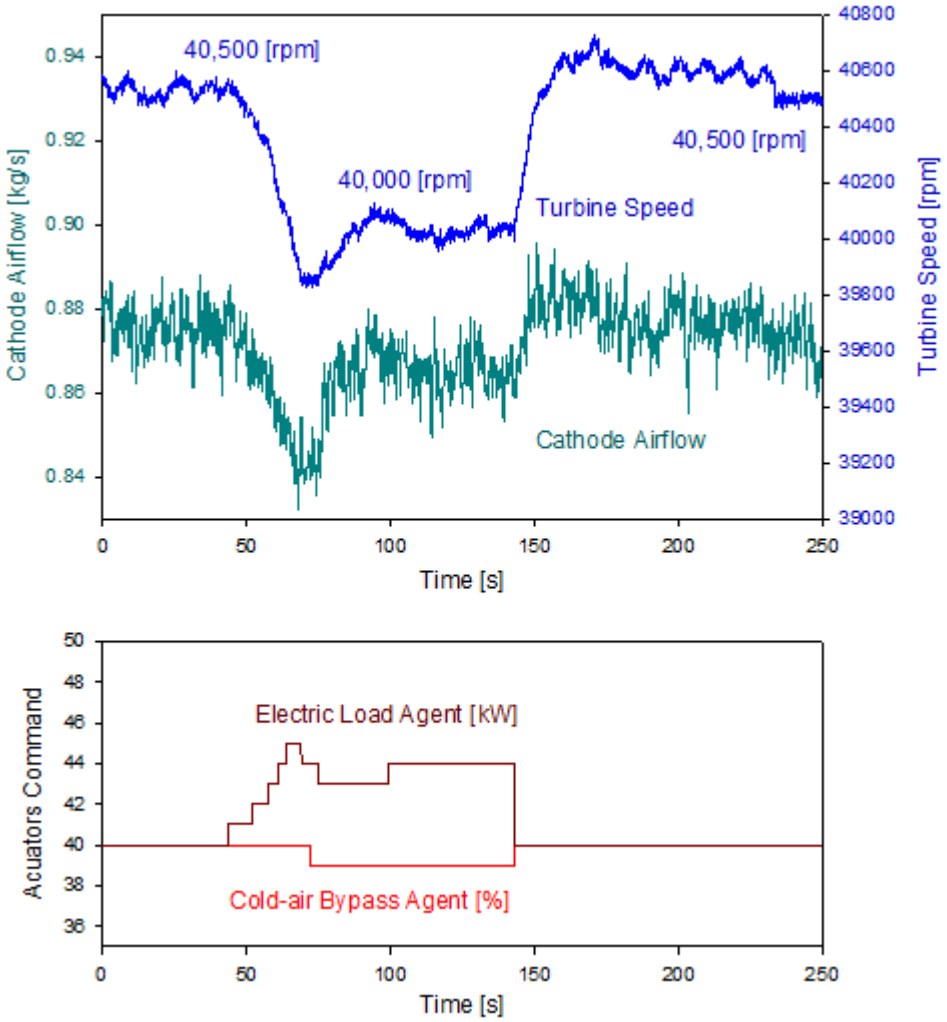
Multi-agent Control Schema

Stable control at steady state



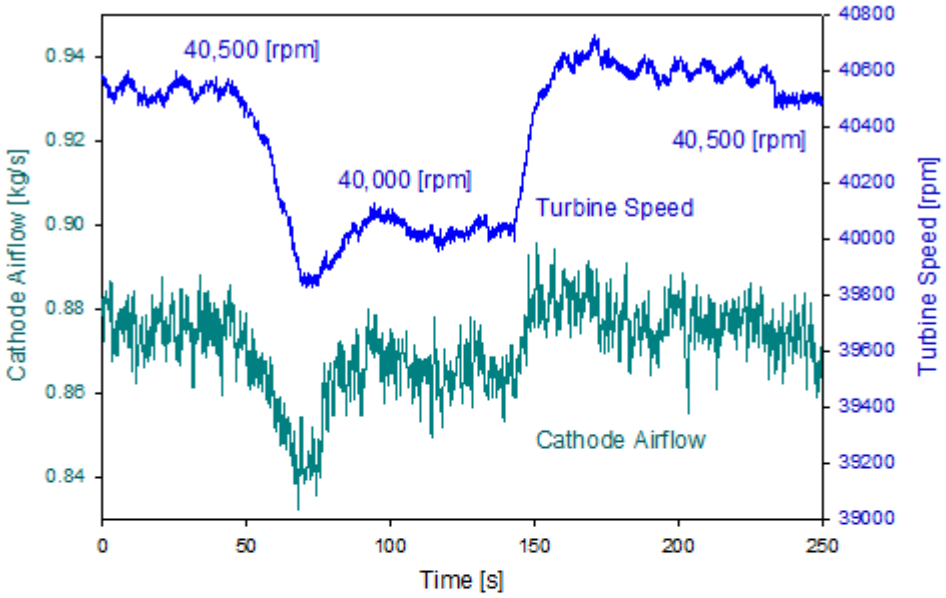
Multi-agent Steady State Results

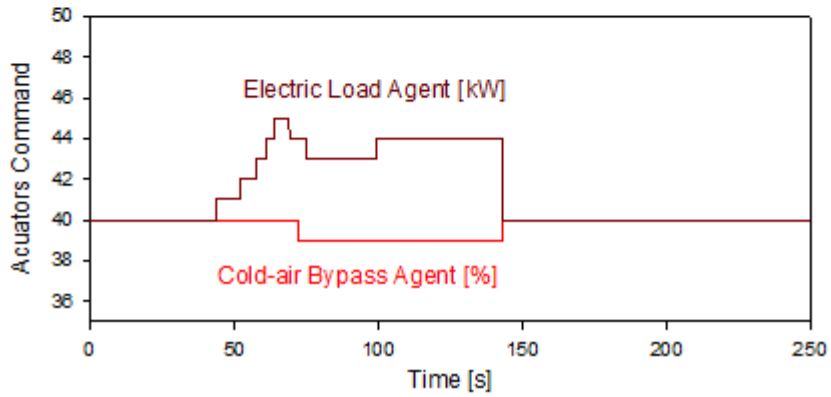
Slow Response during tracking



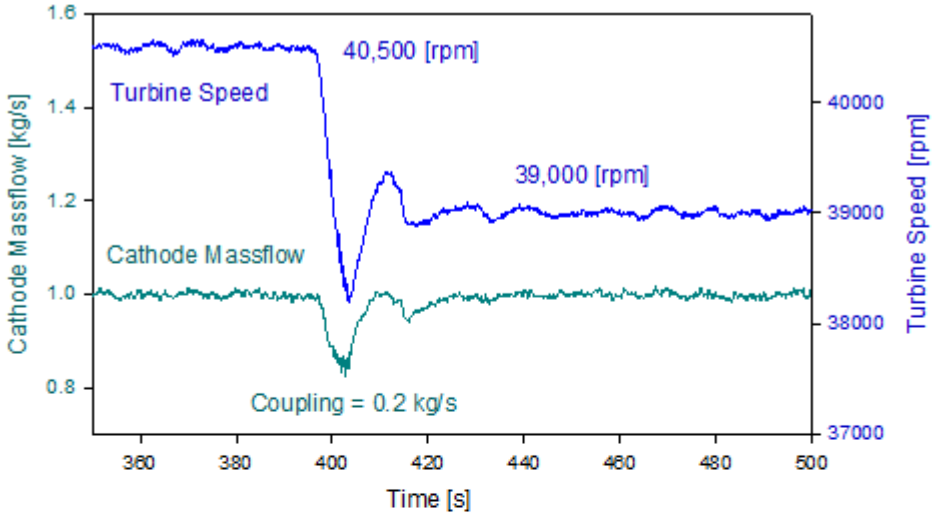
Multi-agent Transient Results

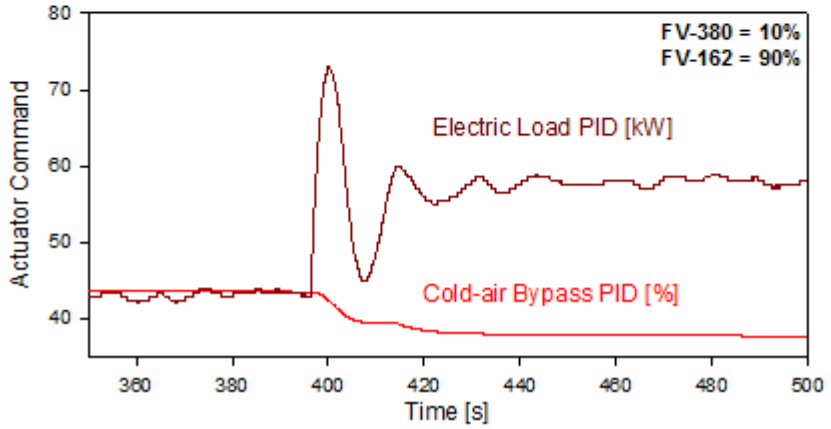
Multi-agent transient results

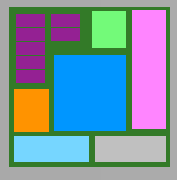




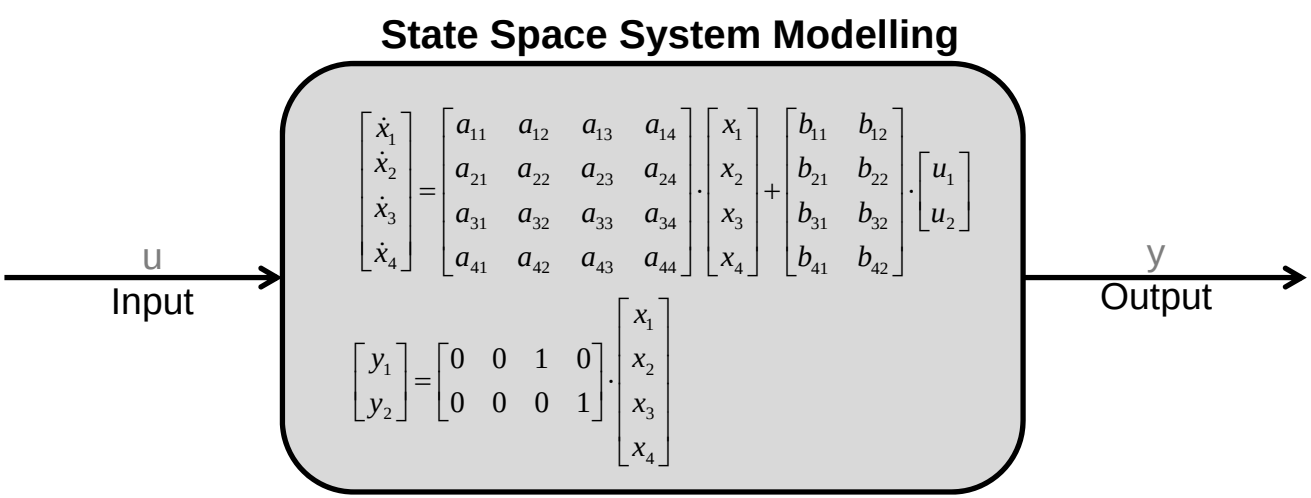
PIDs transient results





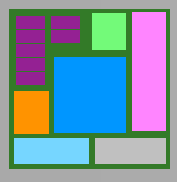


Multi-agent PID and Transients

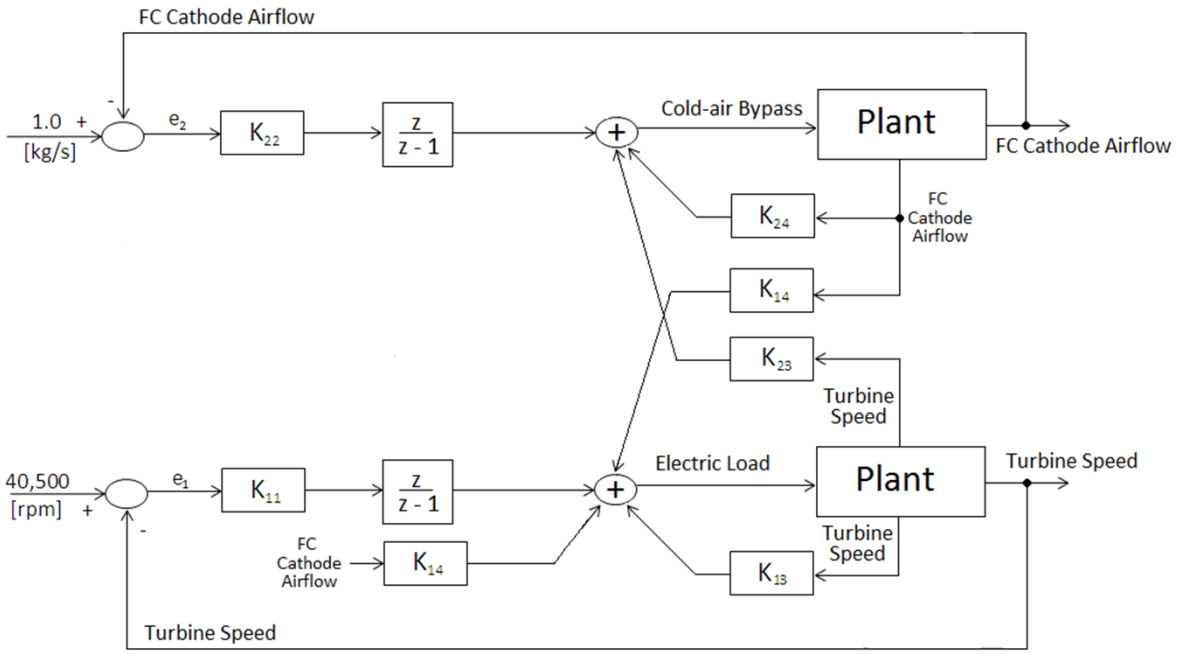


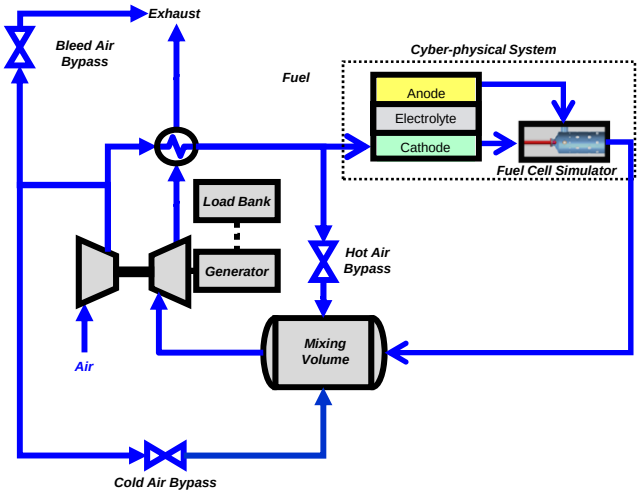
High Complexity in

- System Modeling
- Control Law
- Tuning
- Adaptability



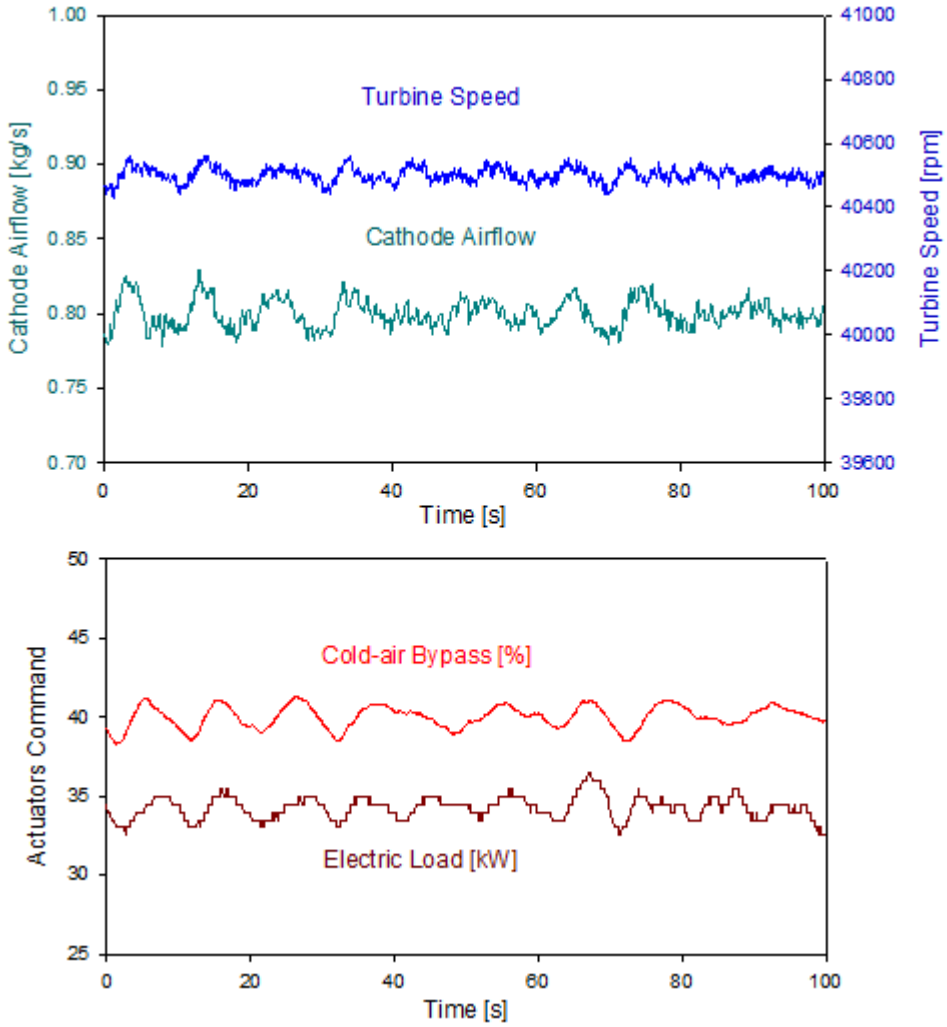
Developing a Multivariable Control Schema



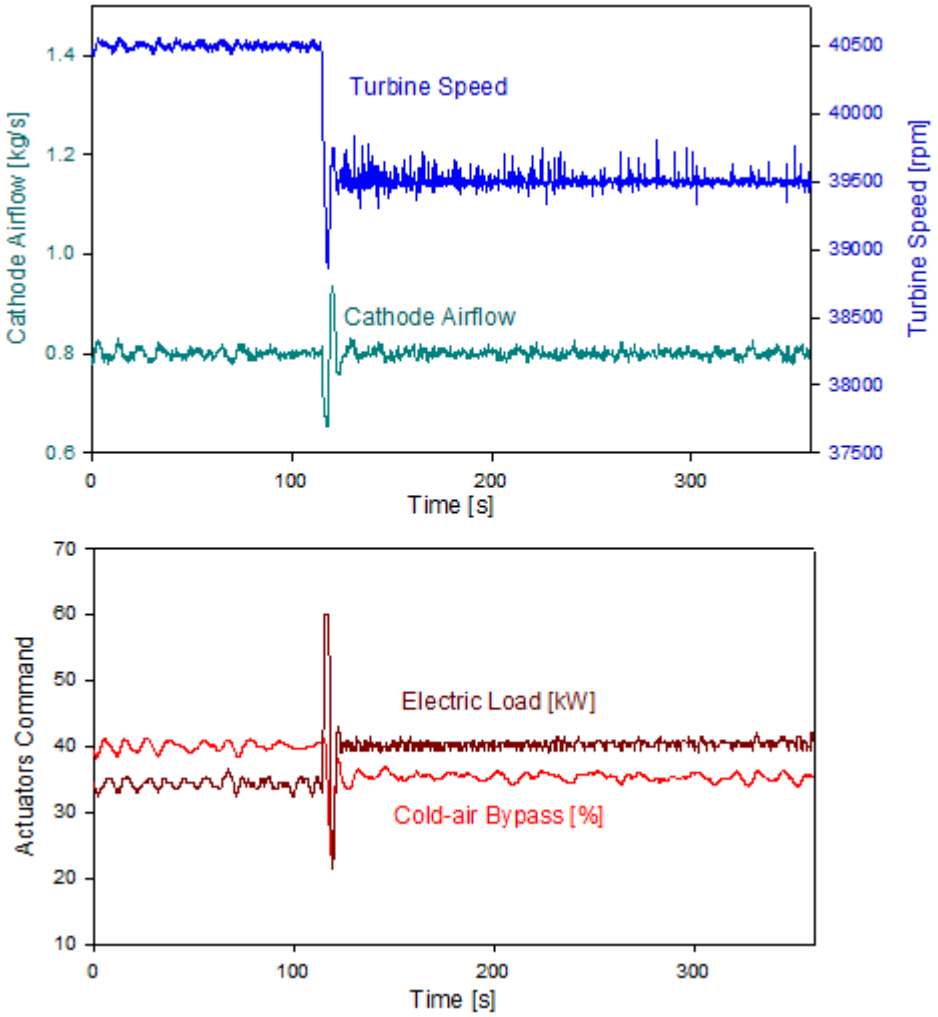


Mitigation of Centralized and Decentralized Interactions

Stable control at steady state

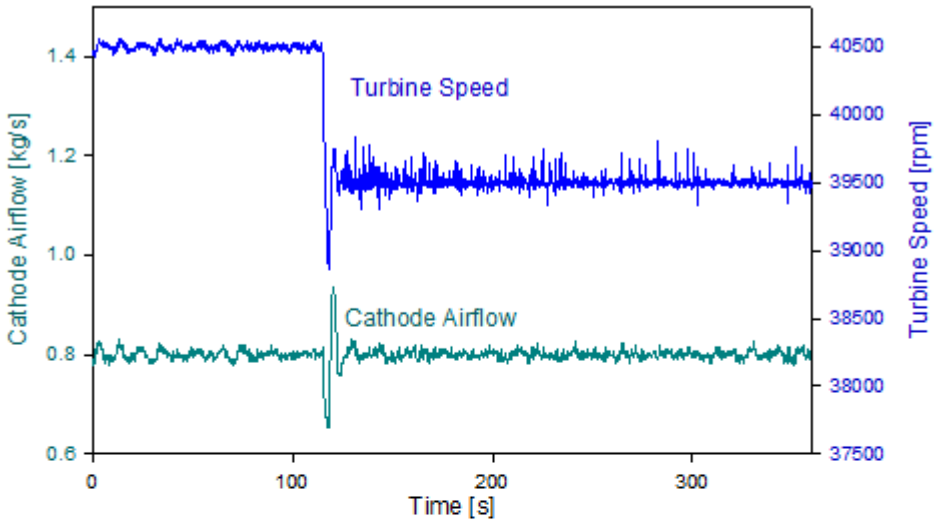


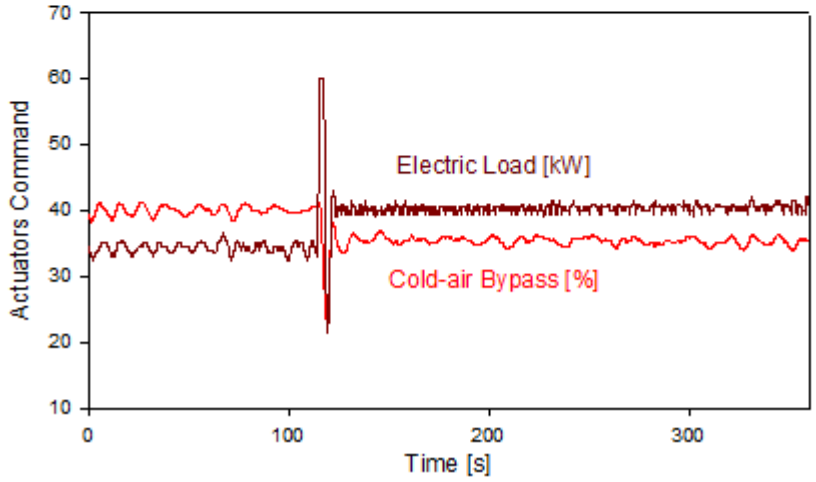
Multivariable Steady State Results



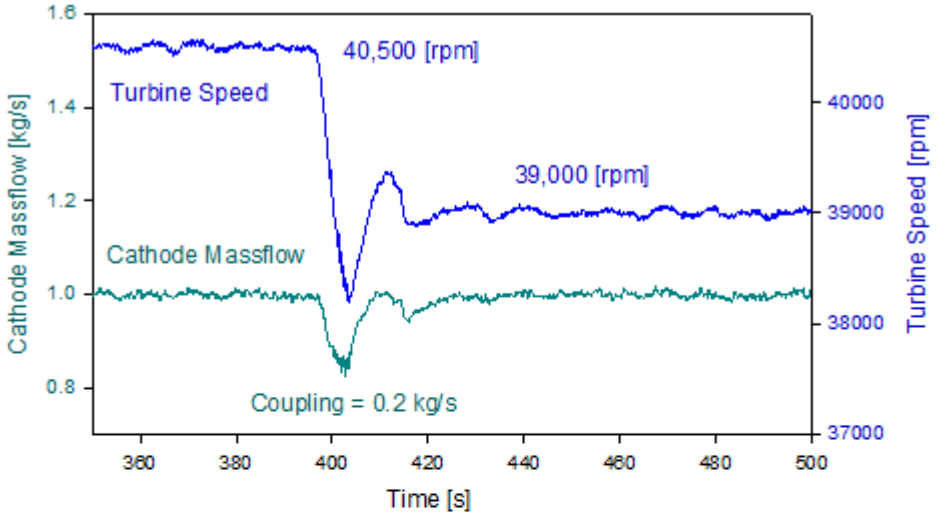
Multivariable Transient Results

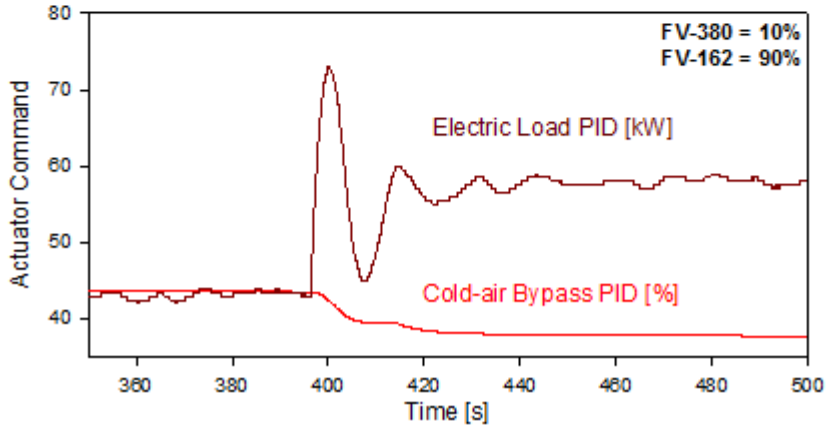
Multivariable transient results





PIDs transient results





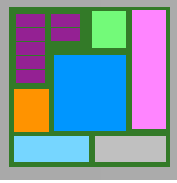
Multivariable PID and Transients

Multi-Agent Control Schema

- Stable control at nominal condition during the first implementation on a hardware system
- Slow response

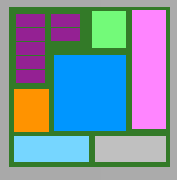
Multivariable Control Strategy

- Good performance under disturbance rejection and tracking
- Simultaneous control of actuators causes oscillations in advanced power systems

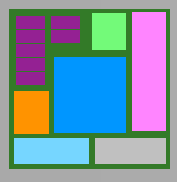


Summary

- Optimization for the multi-agent schema
- Reproducibility in the results
- Increase of the size for the multivariable controller



Future Work



Acknowledgements

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