CPS: Small: Controlling Sub- and Supersynchronous Oscillations in Inverter-dominated Energy CPS

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Subsynchronous oscillations (SSOs) stemming from inverter-based resources (IBRs) in Energy CPS causing **interruptions Worldwide**. The project introduces ***dynamic phasor-based computationally manageable and linearizable SSO modeling*** framework and ***SSO damping control*** with ***interdependent*** physical and cyber layers.

Key Challenges

Modeling system with SSO:

- High computational complexity due to dynamic modeling of transmission system
- Accommodating unbalance in presence of IBRs and synchronous generators

Cyber attack-resilient SSO damping control:

- SSO source detection and remedial action-based is an open problem
- Decentralized damping control with unknown/uncertain model
- Anomaly/attack-resilient damping control is an open problem

Proposed Solution

Modeling system with SSO:

- A scalable, computationally manageable, and linearizable dynamic phasor-based modeling framework with unbalance simulation capability is proposed

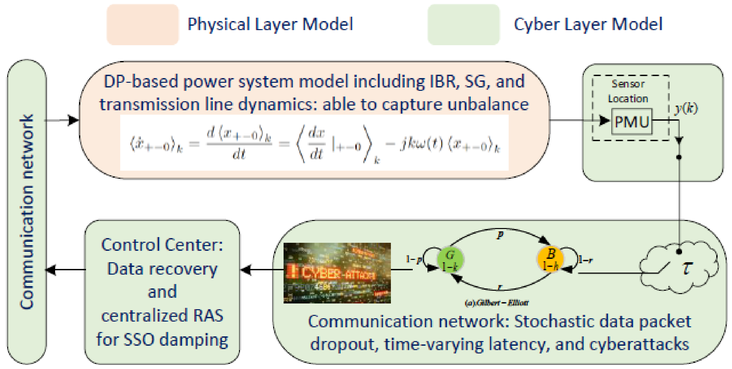
Cyber attack-resilient SSO damping control:

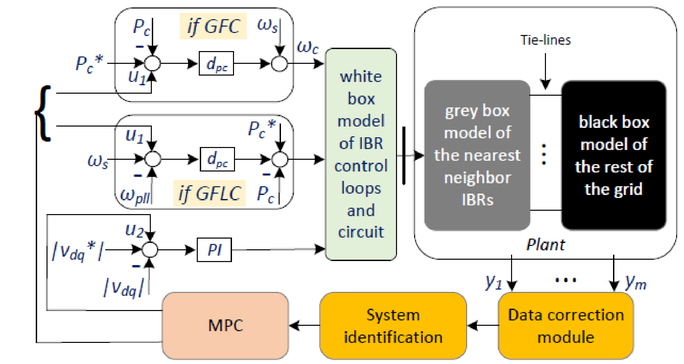
- Corruption resilience: phasor measurement unit (PMU) placement/grouping using sparse recovery guarantees
- SSO source detection through dissipative energy flow and redispatch-based damping
- Neural network—assisted model predictive control (MPC)

Evaluation/experimental plan:

- Test systems: IEEE 4 machine, IEEE 16 machine, and 2383-bus Polish network

Scientific Impact





Broader Impacts

- Summer camp – APOGEE summer amp organized by the EE department
- High school lectures at PSU
- Visit ISO and give talk

Scientific & Societal Broader Impacts

- Introduces computationally manageable CPS model capturing SSOs ***for the first time.***
- Proposed solutions prevent significant loss of revenue and enables massive renewable integration. ***Has direct impact on human society and economy.***

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