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Optimizing Power System Stability Margins After Wide-Area Emergencies

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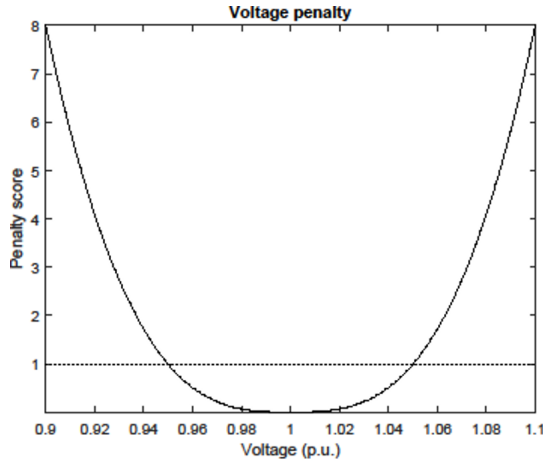
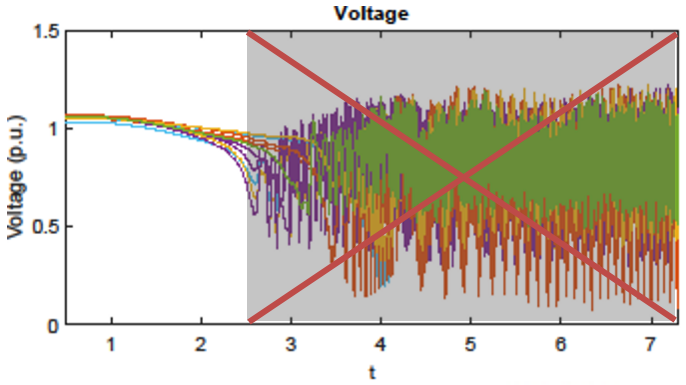
Background

- Interested in system resilience/survival in major emergencies involving many contingencies (i.e., *n-k* scenarios)
- Resulting steady state may be precarious
  - Close to stability limits or protective device setpoints
  - Prone to additional failure/cascade upon further perturbation
- Develop proof-of-concept for coordinated wide-area control to improve safety margin once steady state achieved
  - Dynamic formulation inspired by TSCOPF/TSEC literature

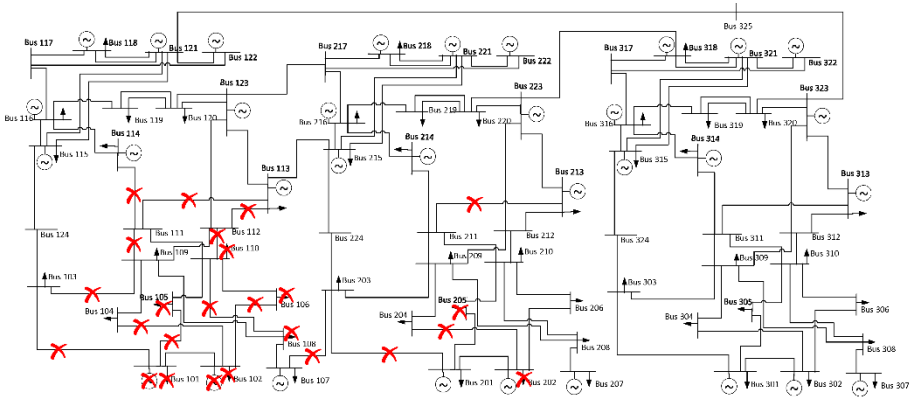
Method

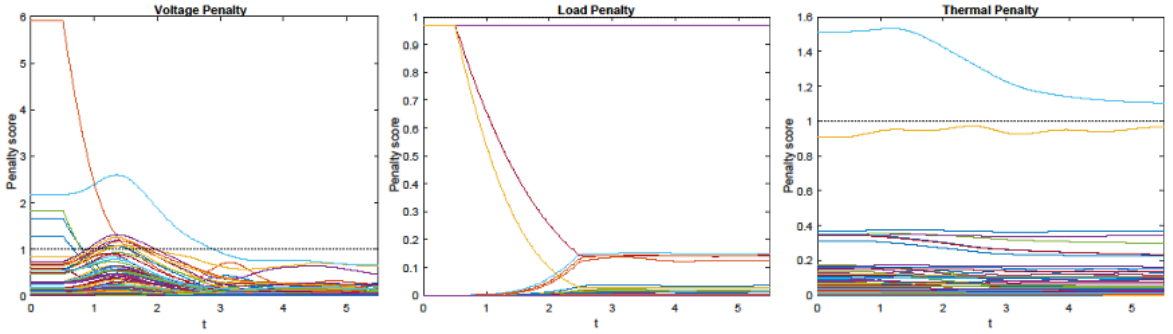
- Formulation with gen/load dynamics; direct method
  - assess transient stability
  - ensure protective tripping thresholds not exceeded
  - ensure control actions implementable/safe
- Nonlinear penalty objective terms
  - Voltage, frequency, line powers, transient stability, load shed
- Controls: gen P/V setpoints and load factors
- Sequential discretization
  - efficient high-fidelity adaptive DAE solver
  - interrupt expensive, practically infeasible simulations

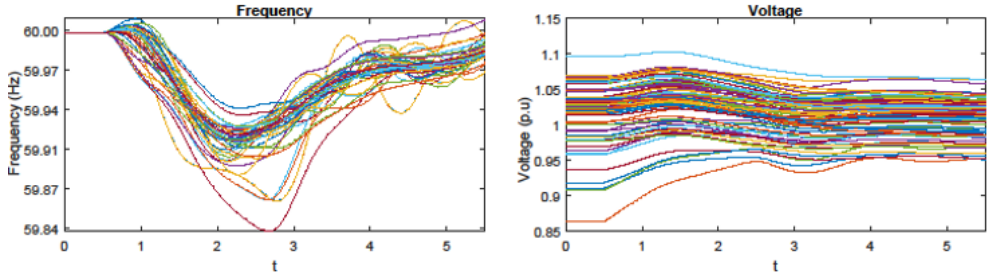


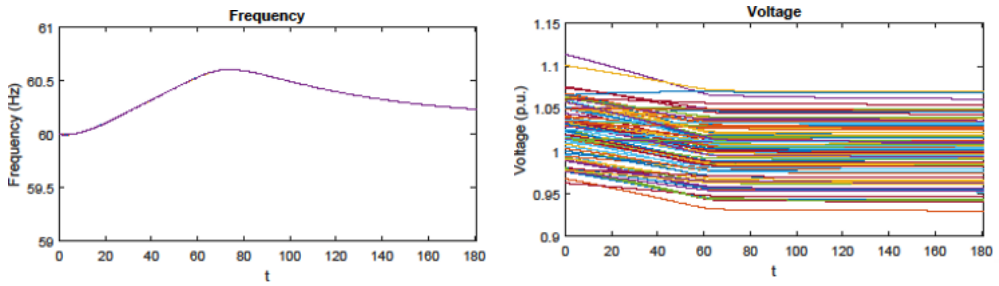


Results









- RTS-96 major failure scenario
- Can significantly improve voltage/thermal margins & restore some load while maintaining frequency & transient stability
- Also works on longer time horizons

Conclusions

- Contribution: proof of concept for improving safety margin of key metrics using coordinated wide area control
  - Better power quality, more room for error, better start for recovery
- Novel aspects include focus on *n-k* scenarios, nonlinear safety margin objectives, infeasible simulation interruption
- Future work opportunities: scalability, additional stability metrics, additional/ more realistic controls, evaluation on systems with significant renewable/DER/storage penetration