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# Potential Impacts of Misconfiguration of Inverter-Based Frequency Control

*Felipe Wilches-Bernal, Ricky Concepcion, Jay Johnson, Raymond H. Byrne*

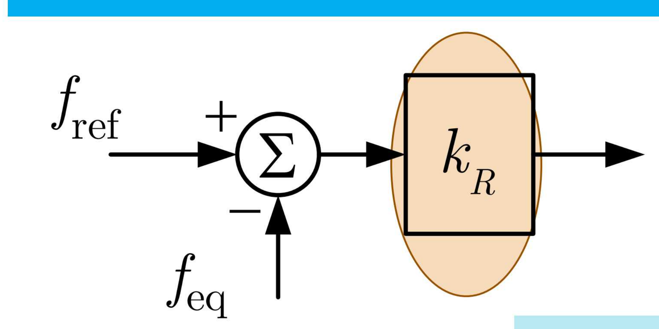
## Introduction

- Today's grid is facing considerable increases in the installation of converter interfaced generation (CIG)
- If this type of generation is uncontrolled, then the stability of the system is compromised
- Control schemes for CIGs may use global information (feedback signals and/or coordination)
- But **what happens if control schemes are misconfigured**? This work tries to answer that question
- With a focus on frequency regulation control schemes

## Power System Model

- Reduced model of the US Northeast Power Coordinated Council (NPCC)
- 48 generators and 140 buses
- Around 50% of the total generation (26 generators) were replaced by converter-interfaced generators
- Event under consideration is the loss of 2.3% of the total power (from a unit in the Midwest region)

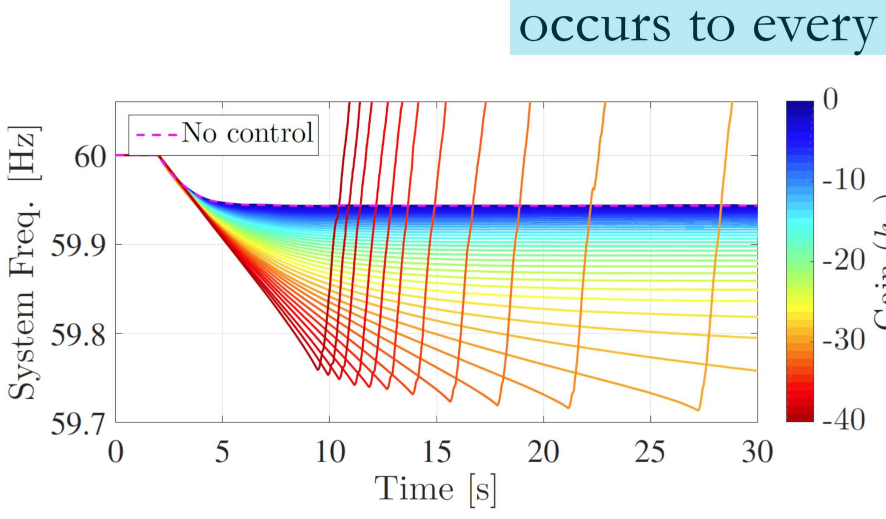
## Frequency Droop



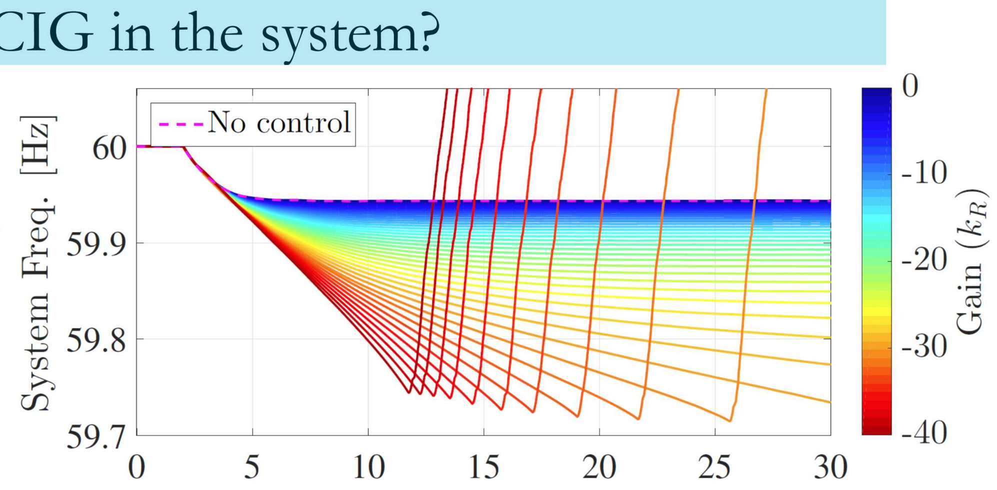

Communication-enabled (CE):

$$f_{\text{eq}} = \sum_{j=1}^{N} k_j f_j \qquad k_j = \frac{H_j}{\sum_{i=1}^{N} H_i}$$

What if the Droop gain is misconfigured?
And what if this misconfiguration is widespread and occurs to every CIG in the system?

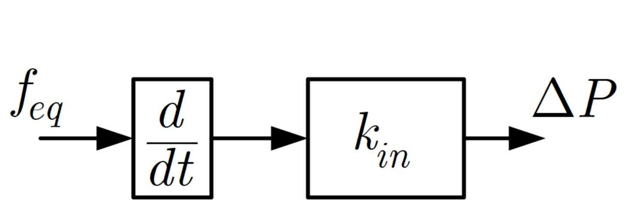



CE-Droop




CE-Droop with a 500ms delay

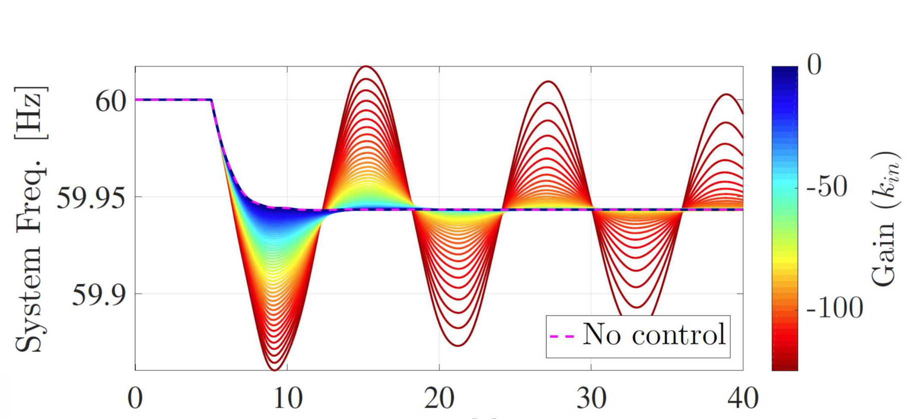
## Synthetic Inertia (SI)



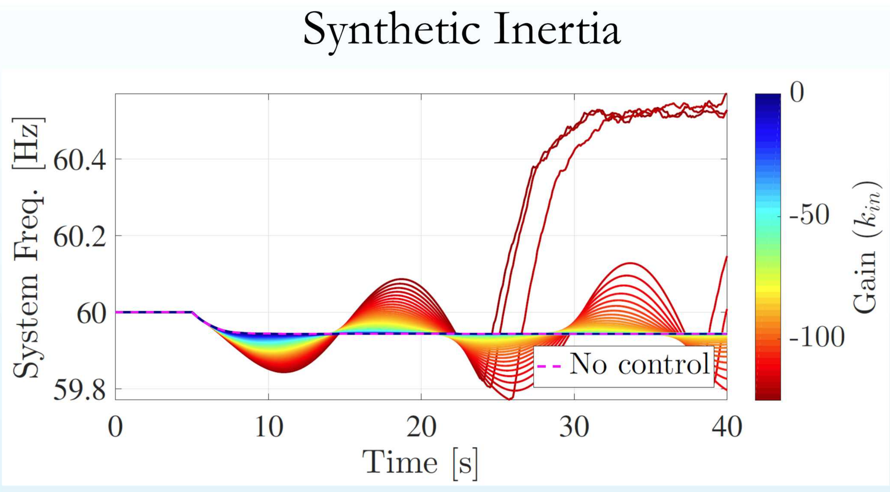

Communication-enabled (CE):

$$f_{\text{eq}} = \sum_{j=1}^{N} k_j f_j \qquad k_j = \frac{H_j}{\sum_{i=1}^{N} H_i}$$

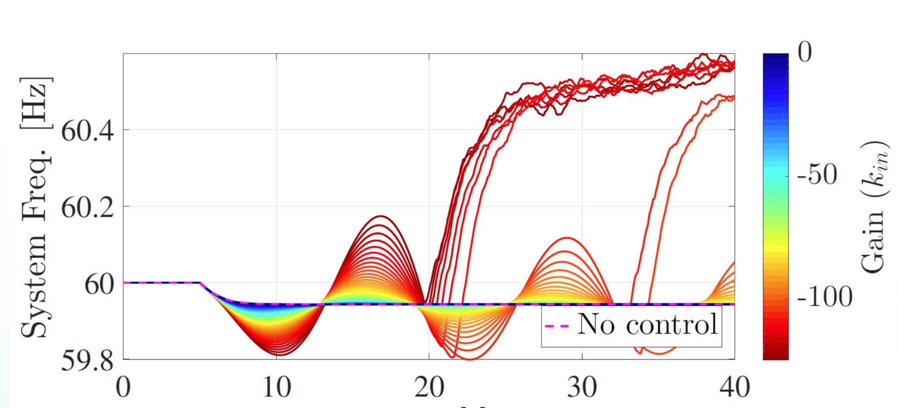
What if the SI gain is misconfigured?




Synthetic Inertia



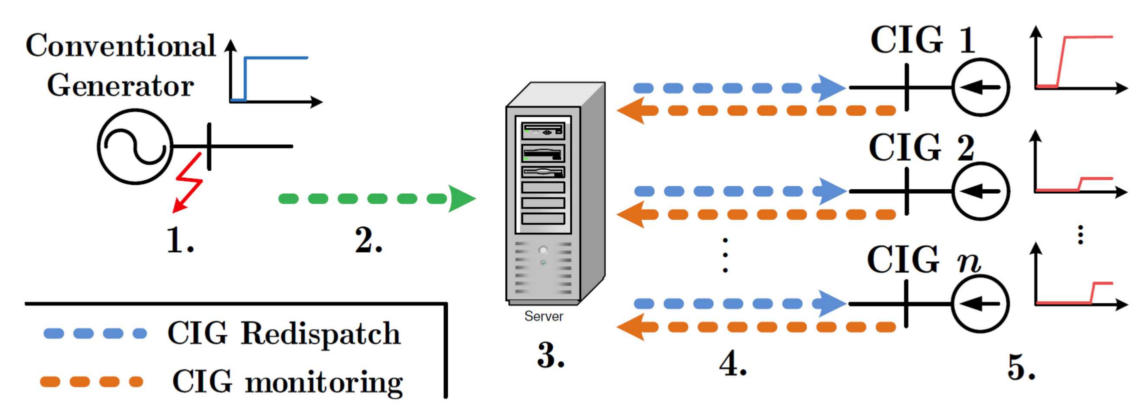

CE Synthetic Inertia with a 500ms delay




CE Synthetic Inertia

## Feedforward Control (CE-FAIR)

- Communication-Enabled Fast-Acting Imbalance Reserve

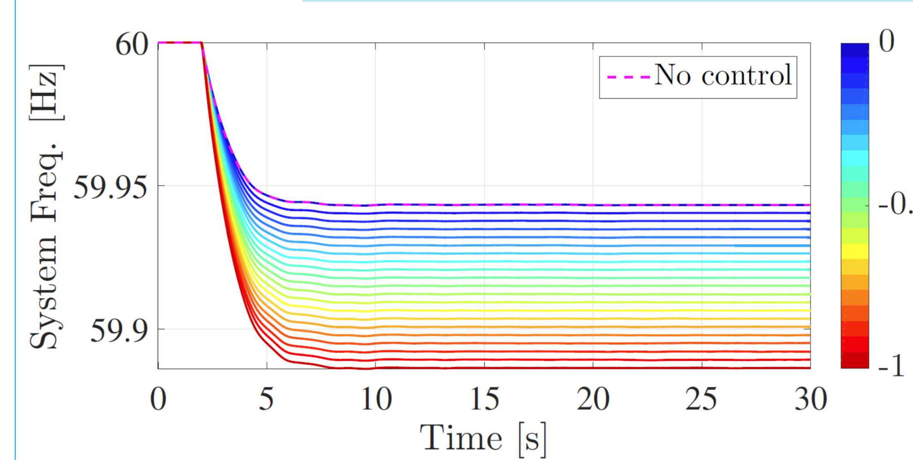



$$\Delta P_i = K_{FF}^i P_{\text{imb}}$$

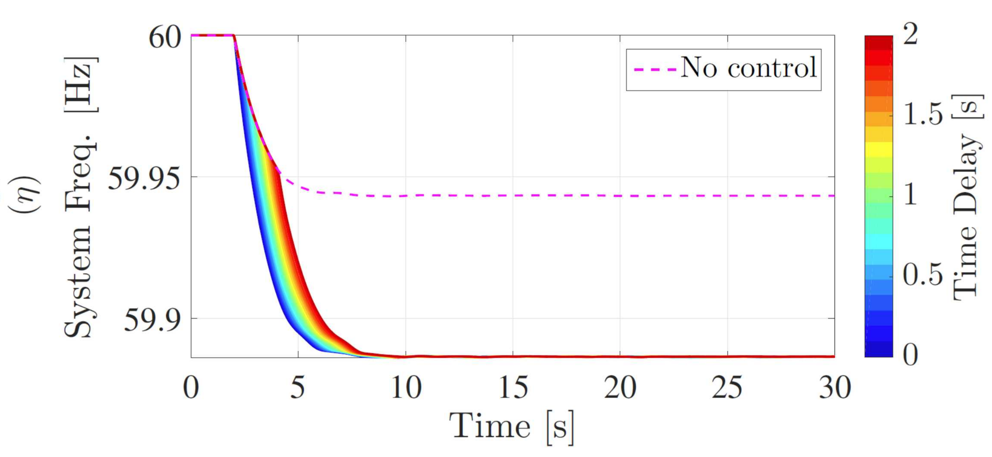
$$K_{FF}^i = \eta \frac{P_i}{P_{\text{available}}}$$

$$P_{\text{available}} = \sum_{j=1}^{N} P_j$$

What if $\eta$ is misconfigured?




Freq. response with CE-FAIR for different power compensation values ($\eta$)




Freq. response when $\eta$=-1 for different delays in the control action

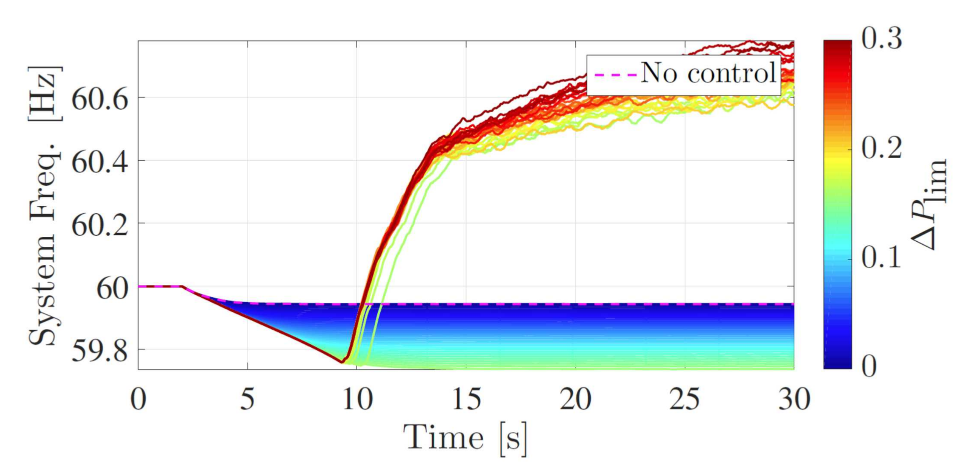
## Bounded Active Power Modulation

- A possible solution to mitigate parameter misconfigurations is to impose limits on the amount of CIG-controllable active power

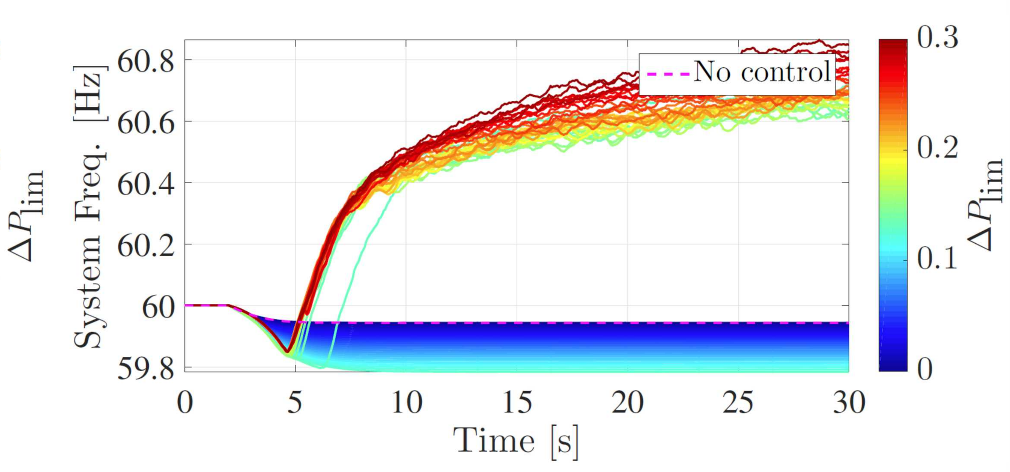
$$P_{\max} = P_{\text{sched}}(1 + \Delta P_{\text{lim}})$$
$$P_{\min} = P_{\text{sched}}(1 - \Delta P_{\text{lim}})$$

$\Delta P_{\text{lim}}$ was varied from 0% to 30%

- **Frequency Droop:**



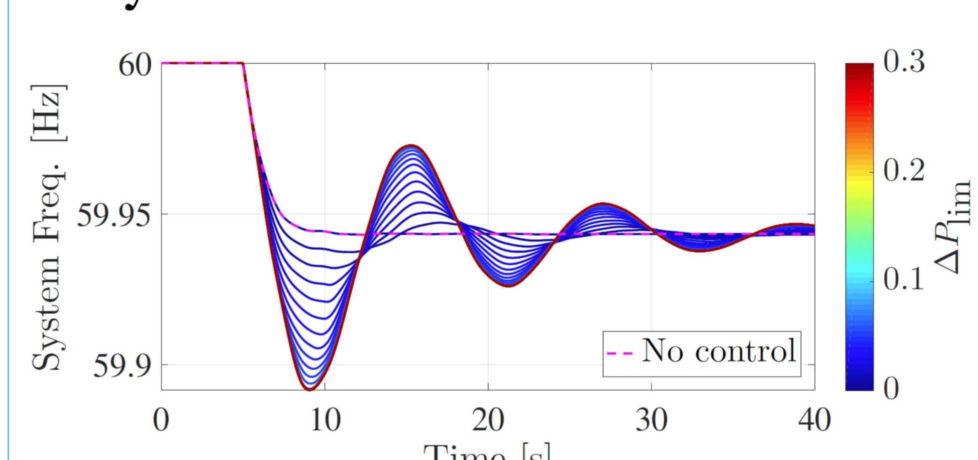

CE-Droop with $k_R = -40$



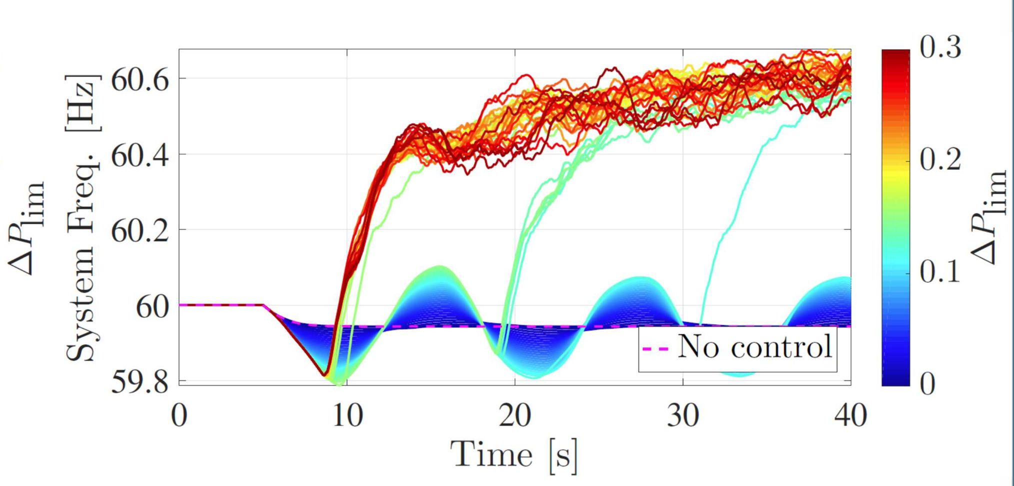

CE-Droop with $k_R = -100$

- Results are comparable for the regular droop scenarios

- **Synthetic Inertia:**




Synthetic Inertia with $k_{in} = -100$




Synthetic Inertia with $k_{in} = -150$

- Results are comparable for the CE Synthetic Inertia cases

## Conclusions

- This work analyzes the effects of widespread misconfiguration of frequency regulation controllers in CIG on a power system with high penetration of them
- Feedback control schemes (frequency droop and synthetic inertia) are sensitive to parameters causing positive feedback. The system may even lose synchronism
- The feedforward control case (CE-FAIR) is more tolerant to parameter misconfiguration
- Bounding the controllable power of CIG is effective to mitigate the effects of widespread misconfiguration



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contact: fwilche@sandia.gov