CENTER FOR ULTRA-WIDE-AREA RESILIENT ELECTRIC ENERGY TRANSMISSION NETWORKS

Case Study on a Real Oscillation Event

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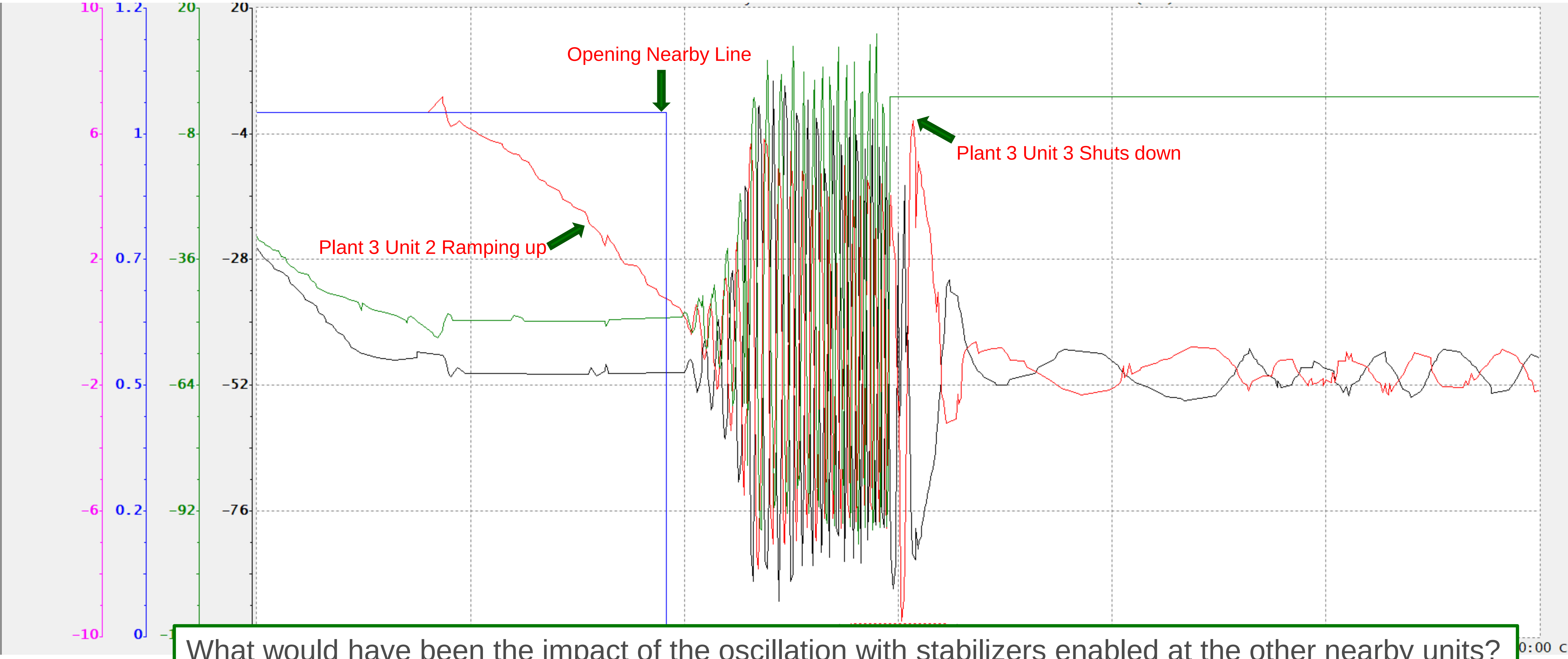
Event Details

- Event occurs in March 2022
- 100 MW undamped oscillation at plant 3 lasted ~5 minutes
  - Precipitated by switching line
- Plant 3 has a history of being involved in oscillations
  - Mitigation during event is to **remove one of plant 3 units** from service and reduce plant output
  - Plant operational guide is to **reduce output** of plant until cause is determined
- Several lines out-of-service in the event area
- Oscillations impact felt across the territory and **nearby plants**

CURENT

Event Snapshot – Oscillations at Plant 3



What would have been the impact of the oscillation with stabilizers enabled at the other nearby units?

Simulation Case Details

- Start with 2019 MMWG series – 2024 spring light load planning case
- Tuned with state estimator snapshot just prior to event
  - **Generation, line** status, **shunt compensation**, and **load**
- Challenges:
  - Difficulty in matching bus names/numbers between cases
  - Manual case tuning is required
  - Grid updates may have occurred since MMWG case released (gen limits, lines added/removed, etc.)

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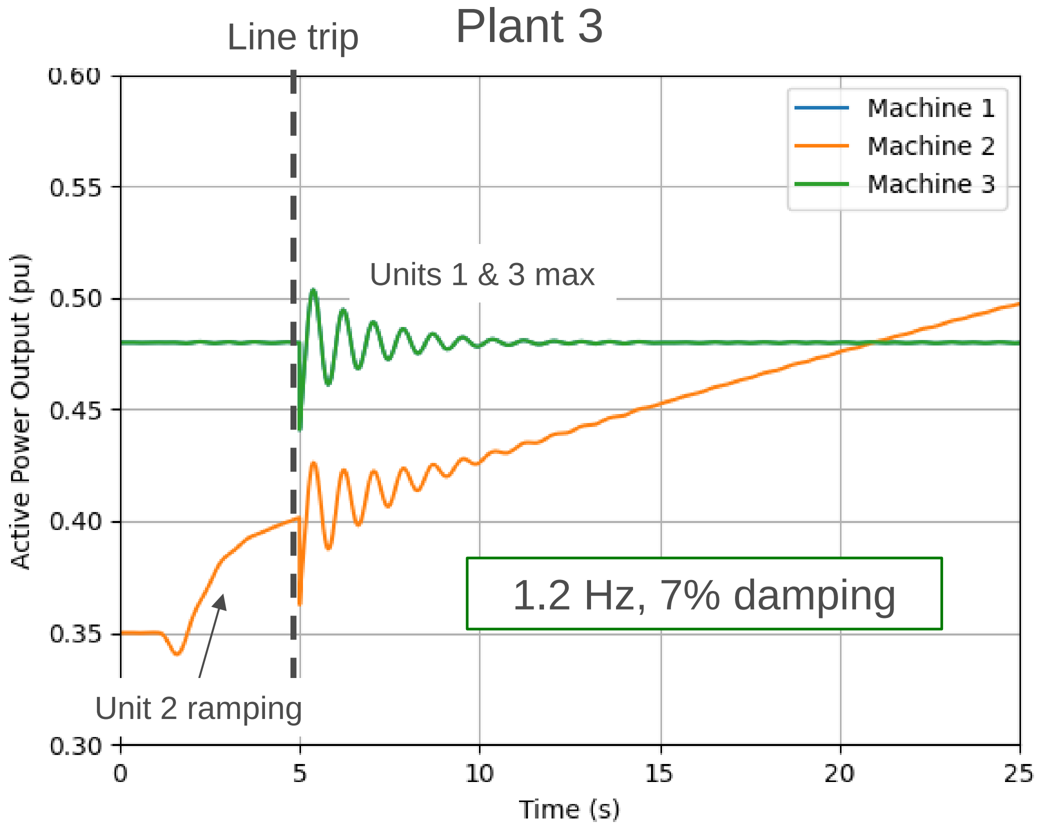
Attempt to Replicate Event in MMWG Model

- True event has **1.4 Hz** oscillation with near zero damping
- Simulated event has **1.2 Hz** oscillation with 7% damping



Simulation does not match true event; need another method to study.

GOVERNOR-BASED FORCED OSCILLATION

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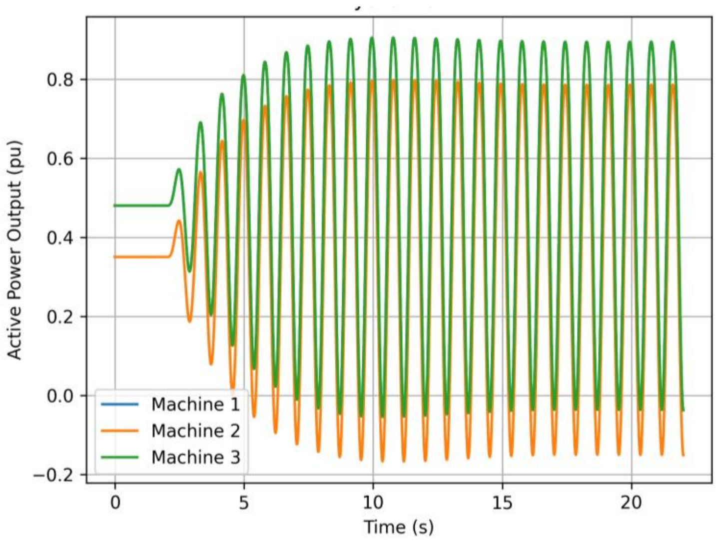
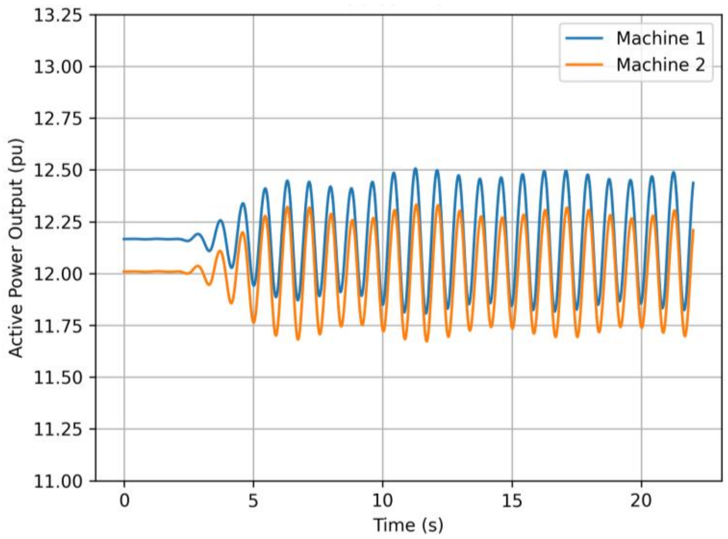
1.2 Hz Forced Oscillation of Plant 3 Units

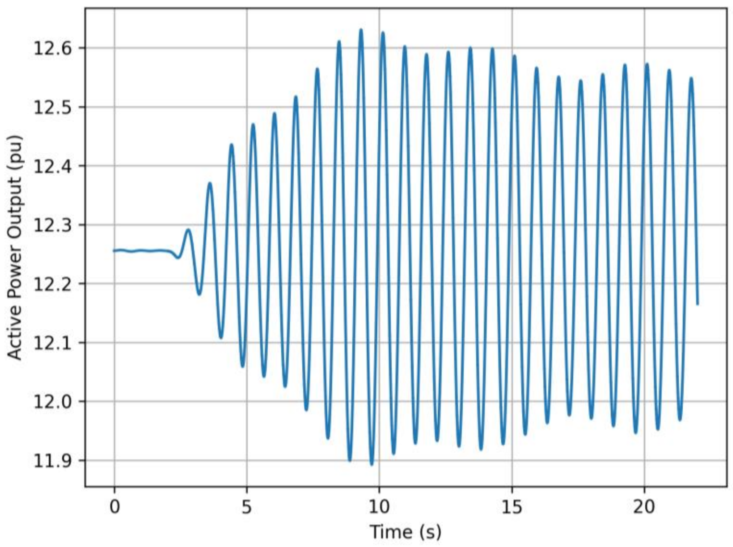
- Forced oscillation through reference of plant 3 governors
- Without any stabilizers at plants 1 and 2



Plant 3 ~100 MW oscillations



Plant 1 ~70 MW oscillations



Plant 2 ~75 MW oscillation

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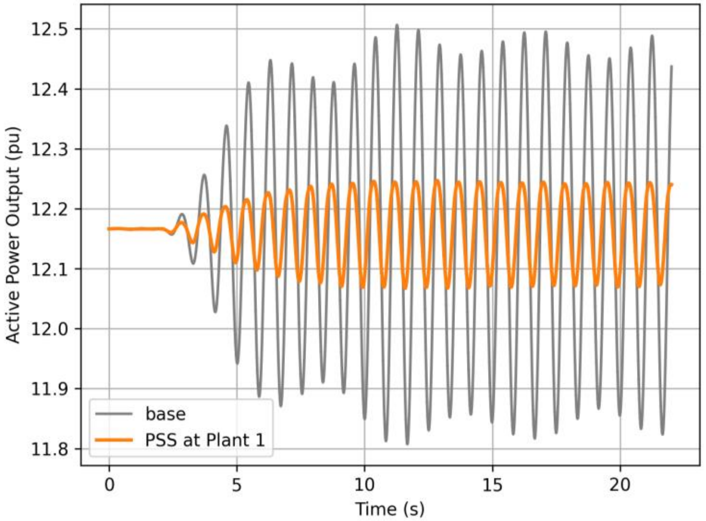
1.2 Hz Forced Oscillation at Plant 3 with PSS at Plant 1

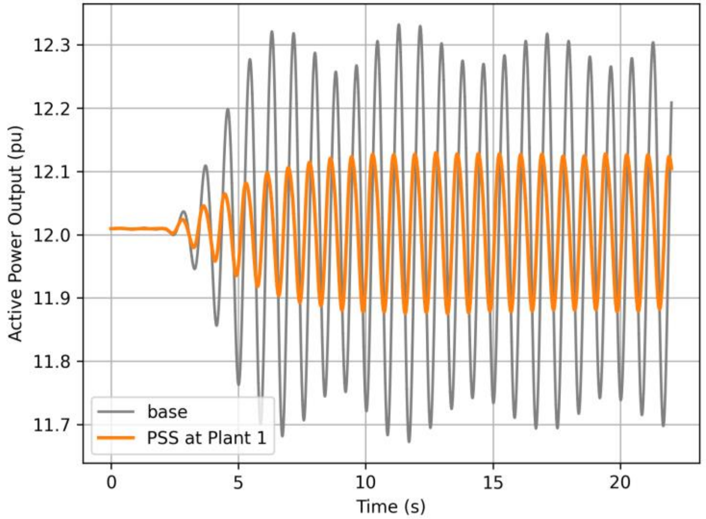
- PSS on both machines at plant 1
- Plants 1 and 2 are located within 20 – 30 electrical miles with larger distance to source

Plant 1, unit 1



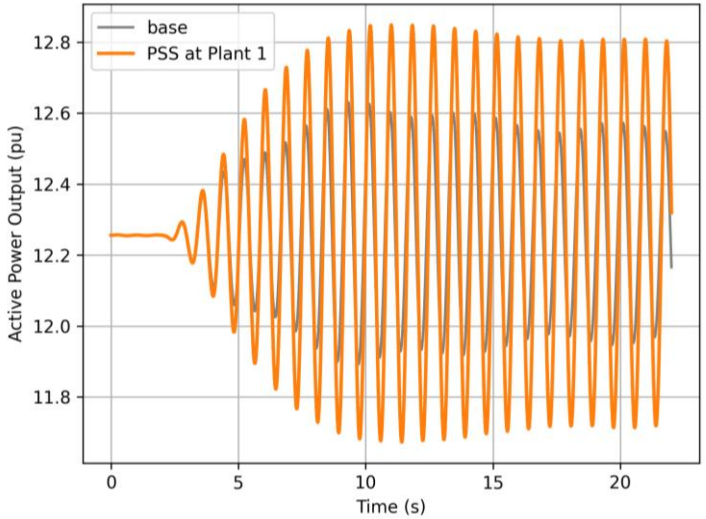
Oscillations decrease 74%

Plant 1, unit 2



Oscillations decrease 61%

Plant 2



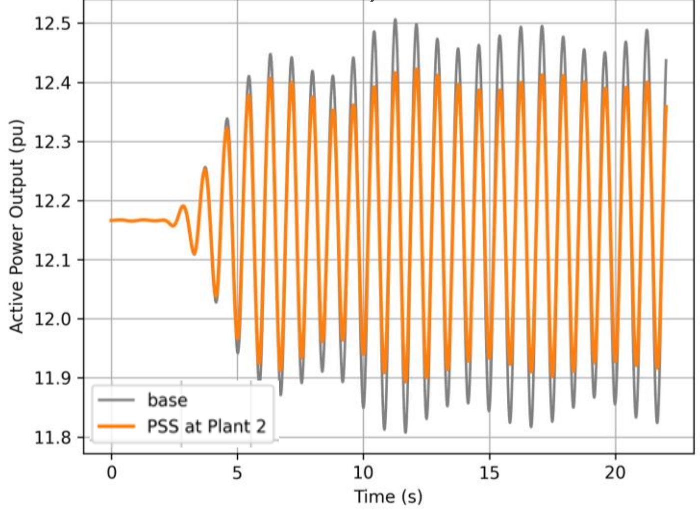
Oscillations increase 59%

Placing PSS at plant 1 has negative impact to plant 2 oscillations.

1.2 Hz Forced Oscillation at Plant 3 with PSS at Plant 2

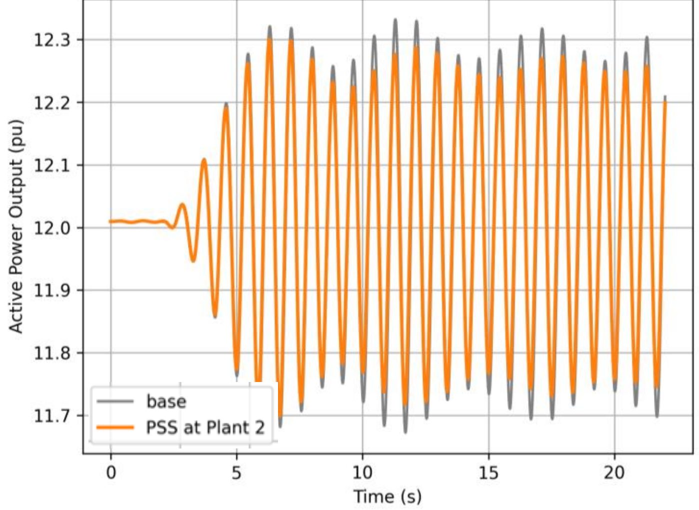
- PSS at plant 2

Plant 1, unit 1



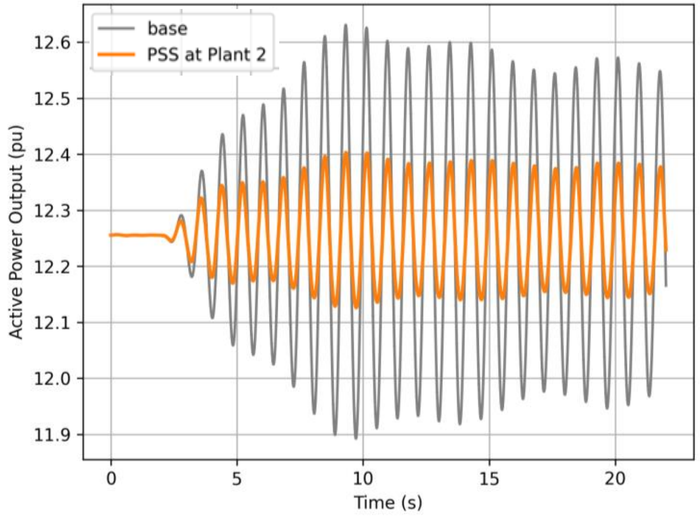
Oscillations decrease 24%

Plant 1, unit 2



Oscillations decrease 9%

Plant 2



Oscillations decrease 62%

Placing PSS at plant 2 also decreases oscillations at plant 1.

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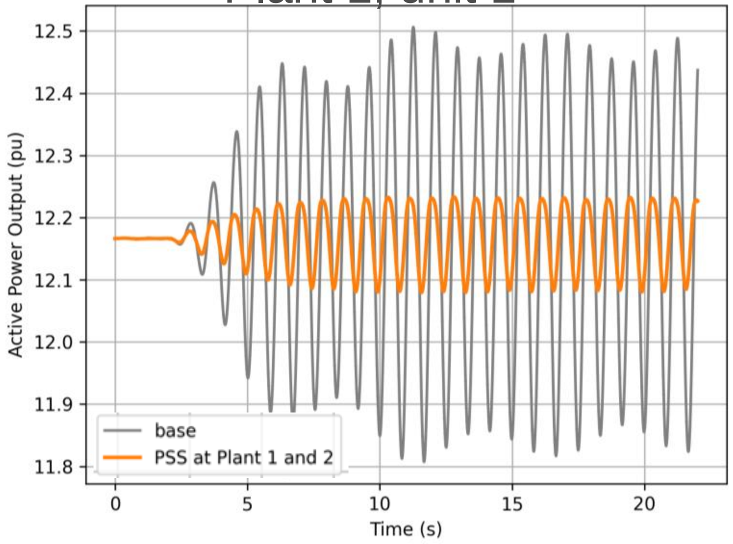
1.2 Hz Forced Oscillation at Plant 3 with PSS at Both Plants

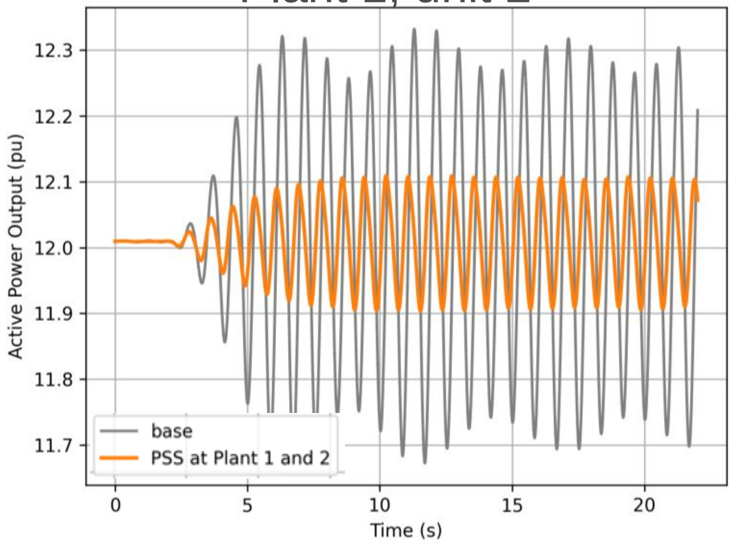
- PSS at both plants 1 and 2

Plant 1, unit 1



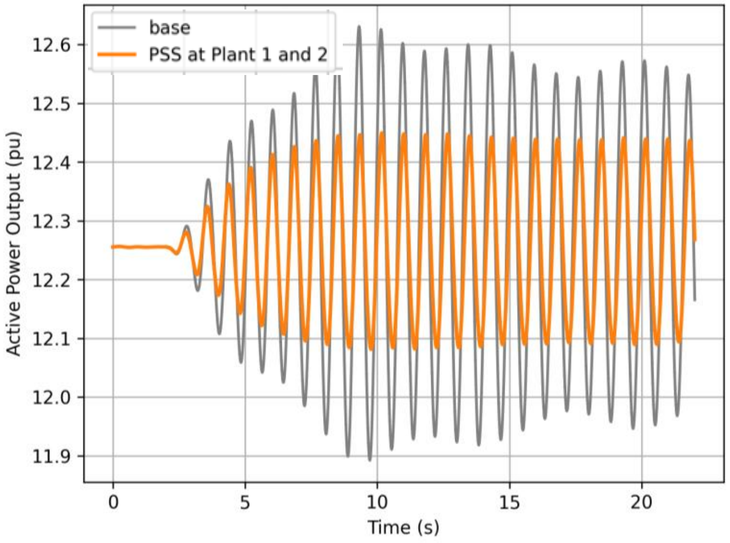
Oscillations decrease 78%

Plant 1, unit 2



Oscillations decrease 68%

Plant 2



Oscillations decrease 50%

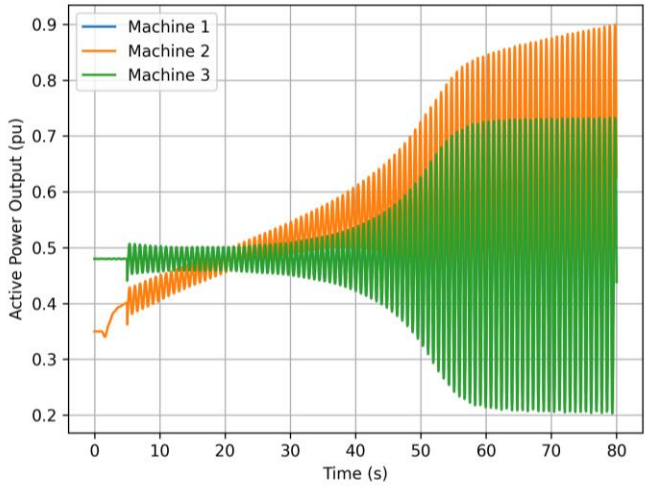
PSS at both plants provides best damping scenario.

EXCITER-BASED NATURAL OSCILLATION

Adjusting Exciter Gain at Plant 3

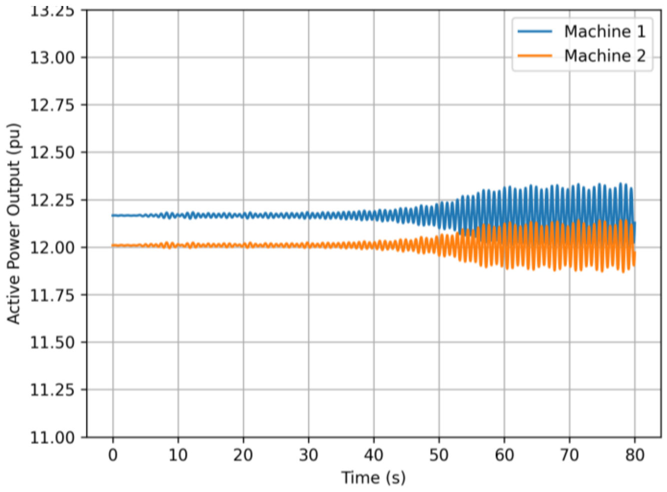
Exciter Gain 100 → 1000
Event: Unit 2 of plant 3 ramping up then line opening in the nearby area

Plant 3



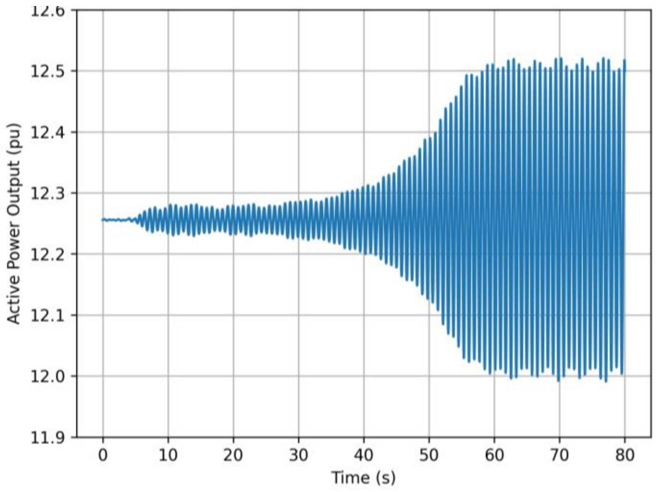
~55 MW
Oscillation

Plant 1



~30 MW
Oscillation

Plant 2

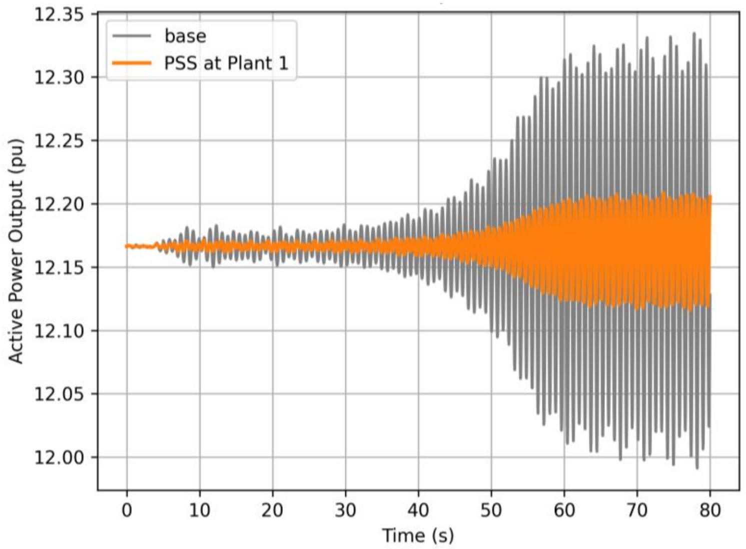


~50 MW
Oscillation

Adjusting Exciter Gain at Plant 3, PSS at Plant 1

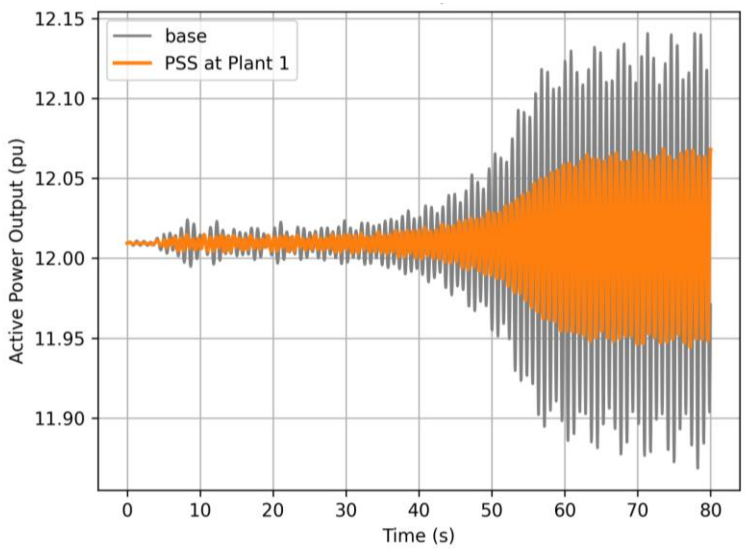
Exciter Gain 100 → 1000
Event: Unit 2 of plant 3 ramping up then line opening in the nearby area

Plant 1, unit 1



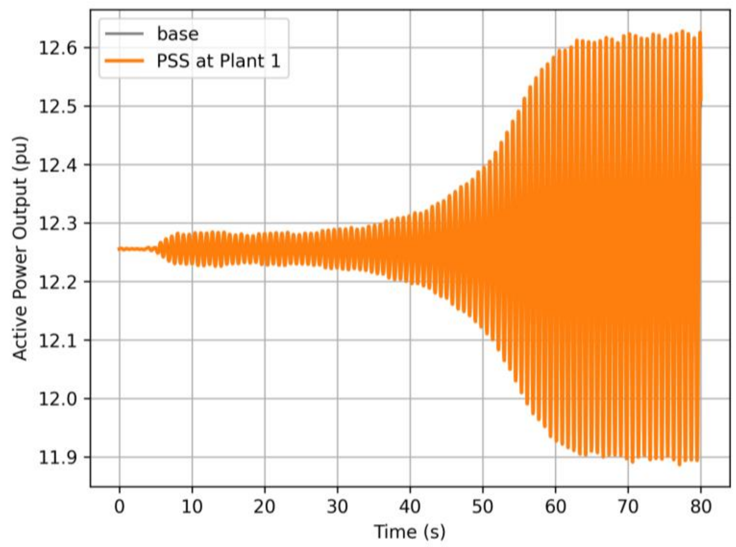
73% reduction

Plant 1, unit 2



54% reduction

Plant 2

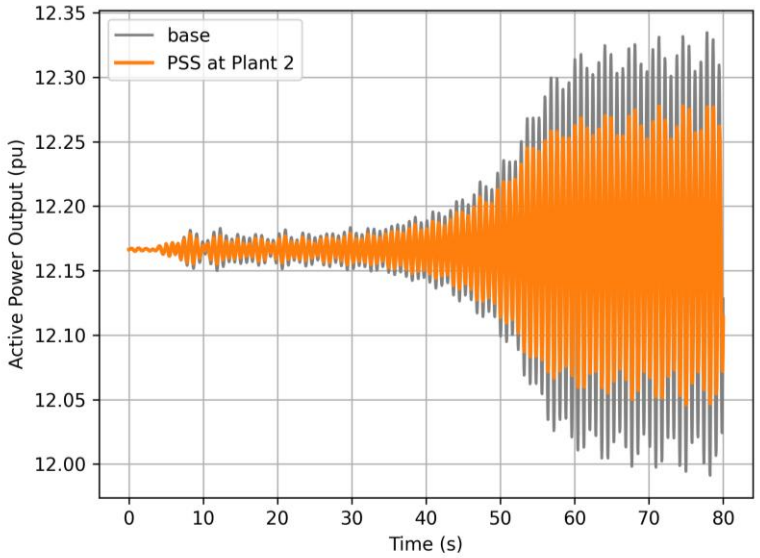


39% increase

Adjusting Exciter Gain at Plant 3, PSS at Plant 2

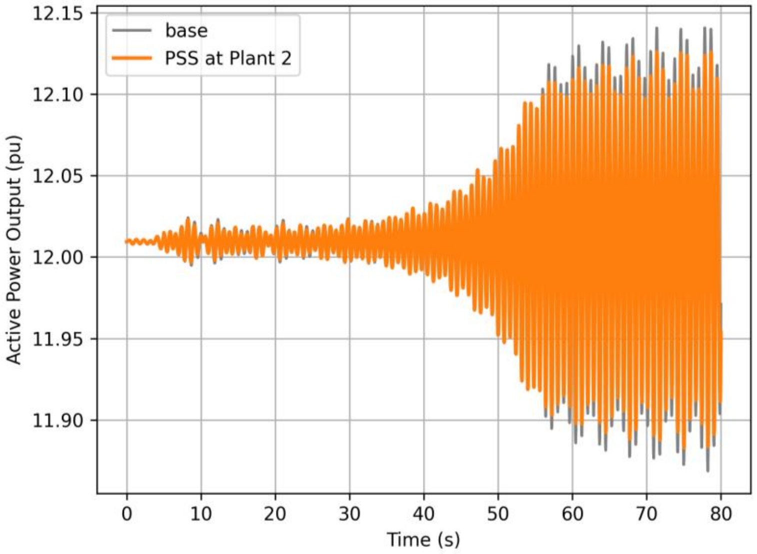
Exciter Gain 100 → 1000
Event: Unit 2 of plant 3 ramping up then line opening in the nearby area

Plant 1, unit 1



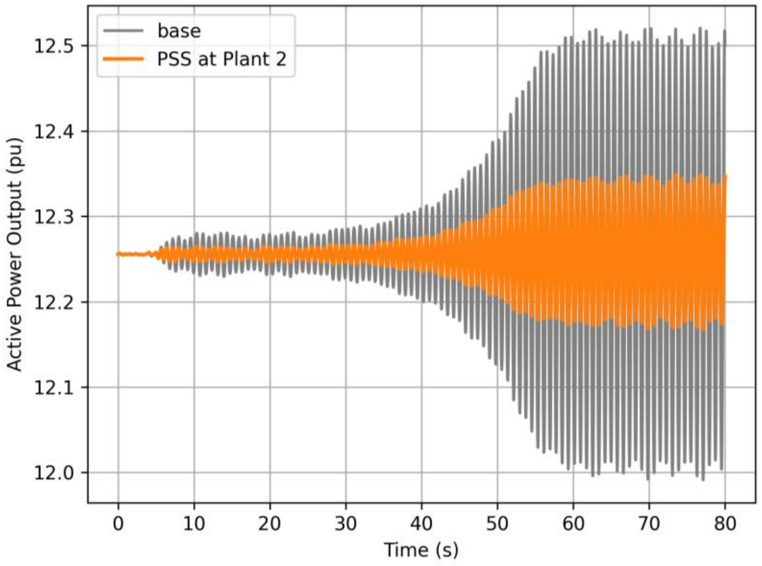
32% reduction

Plant 1, unit 2



10% reduction

Plant 2



65% reduction

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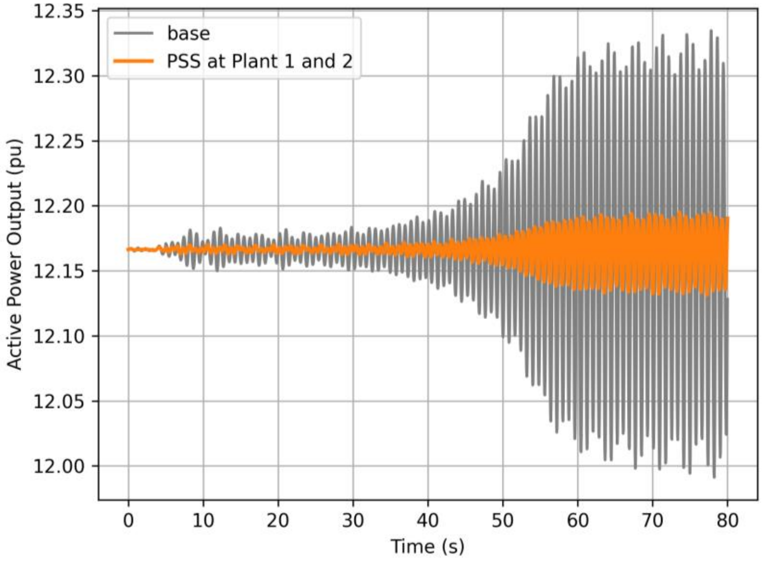
Adjusting Exciter Gain at Plant 3, PSS at Plant 1 and 2

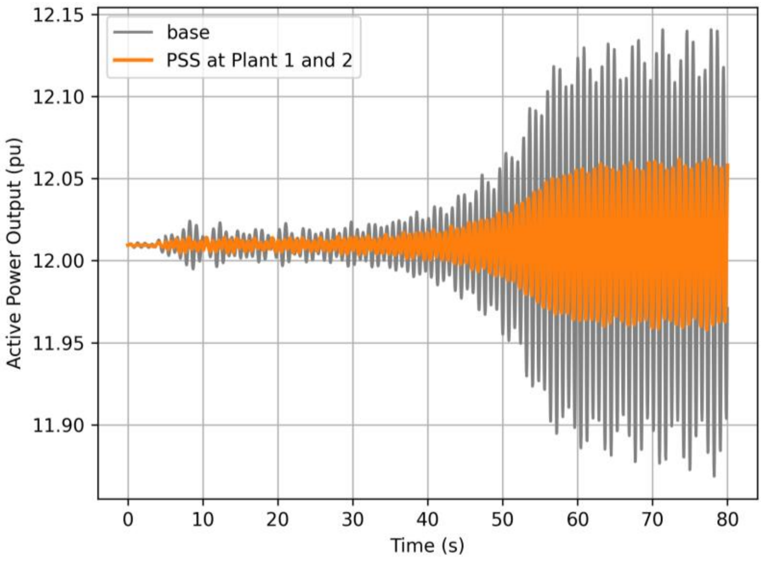
Exciter Gain 100 → 1000
Event: Unit 2 of plant 3 ramping up then line opening in the nearby area

Plant 1, unit 1



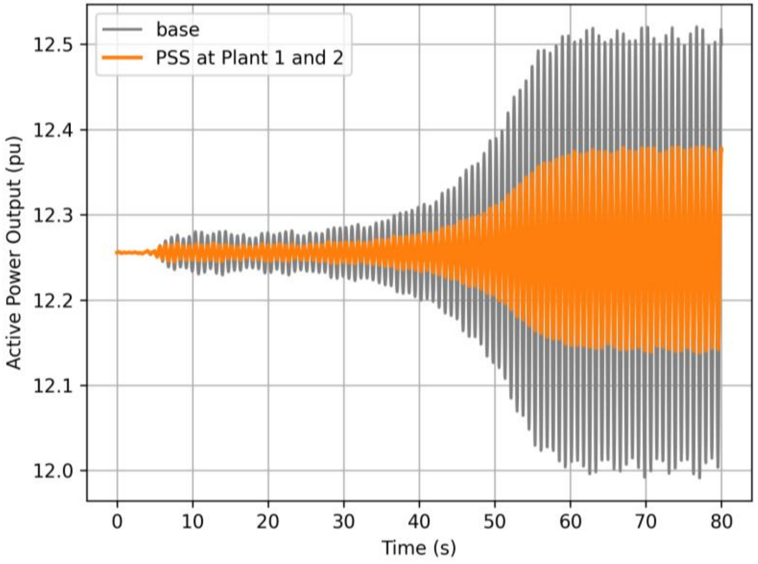
81% reduction

Plant 1, unit 2



61% reduction

Plant 2



54% reduction

Summary

- Having PSS at both plants 1 and 2 provides good damping of oscillations.
- If PSS only at plant 1, then plant 2 may experience worse oscillation.
- Oscillation damping achieved by the PSS is similar in both the exciter-based and governor-based simulations.