



# Frequency control and stability requirements on hydro power plants

Sigurd Hofsmo Jakobsen

Department of electrical engineering

September 29, 2019



# Outline

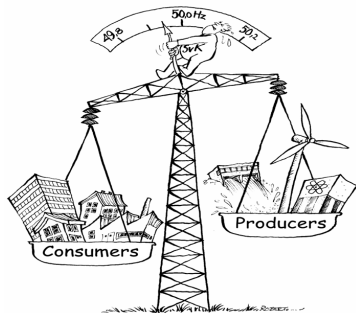


Problem

Paper I

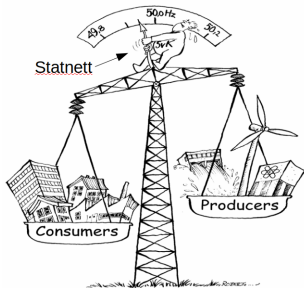
# Load and production balancing

- The power system frequency measures the power balance.



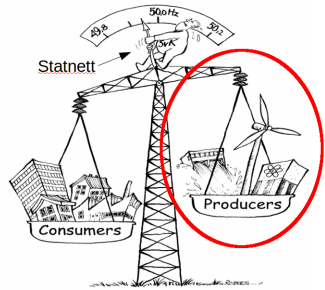
# Load and production balancing

- The power system frequency measures the power balance.
- It is the responsibility of Statnett to control the frequency.



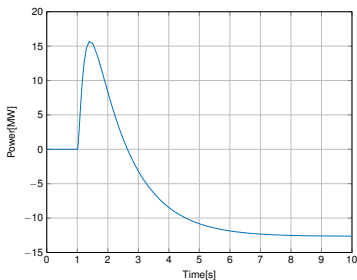
# Load and production balancing

- The power system frequency measures the power balance.
- It is the responsibility of Statnett to control the frequency.
- However, it is the power plant owners who can control the frequency.



# Buying frequency control

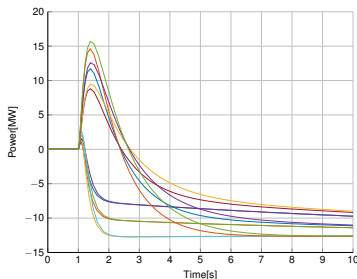
- Statnett pays all power plant owners to provide frequency control.



**Figure:** Frequency control response to step change in frequency

# Buying frequency control

- Statnett pays all power plant owners to provide frequency control.
- However, they don't provide the same quality of service.

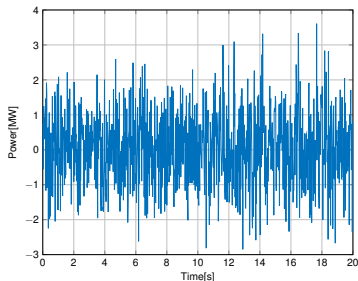


**Figure:** Frequency control response to step change in frequency



# Buying frequency control

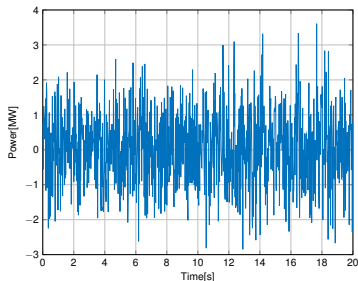
- Statnett pays all power plant owners to provide frequency control.
- However, they don't provide the same quality of service.
- Renewable energy sources such as wind and solar don't contribute.



**Figure:** Frequency control response to step change in frequency

# Buying frequency control

- Statnett pays all power plant owners to provide frequency control.
- However, they don't provide the same quality of service.
- Renewable energy sources such as wind and solar don't contribute.
  - Barrier for energy transition



**Figure:** Frequency control response to step change in frequency

# Future of frequency control



- Power plants have to pass tests to get paid to provide frequency control.
- Only those who pass the tests get paid for the service.

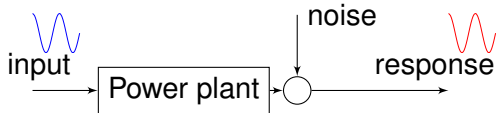


Figure: Test of power plant

# Tests proposed by the industry

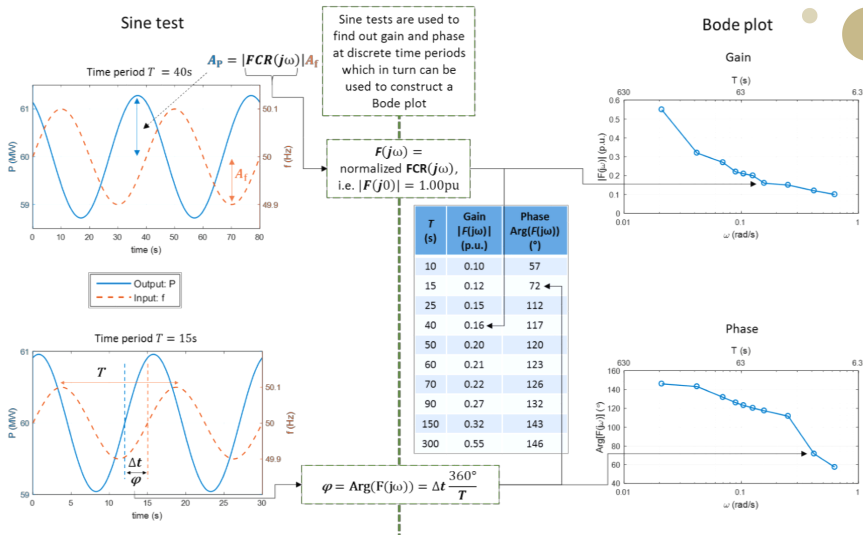
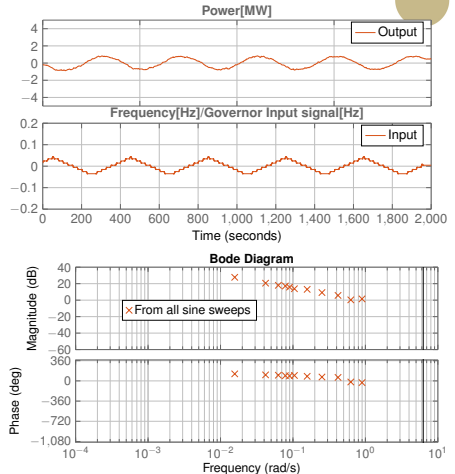


Figure: Testing procedure [source:ENTSO-E]

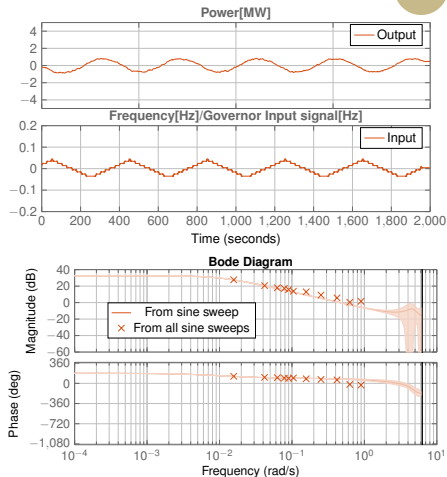
# Example from real tests

- The power plant needs to be disconnected
- Takes up to 20 hours.



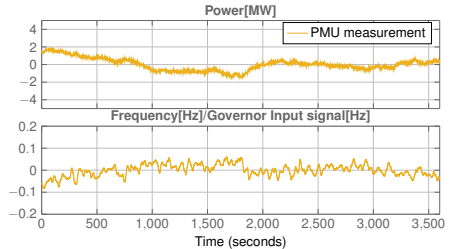
# Example from real tests

- The power plant needs to be disconnected
- Takes up to 20 hours.
- Only one sine test needed with model learning.



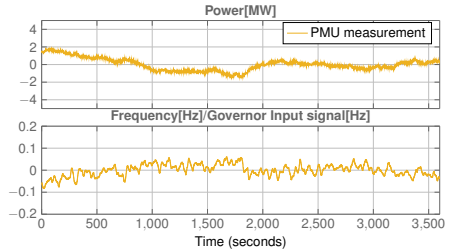
# Motivation

- The power system is never really in steady state.



# Motivation

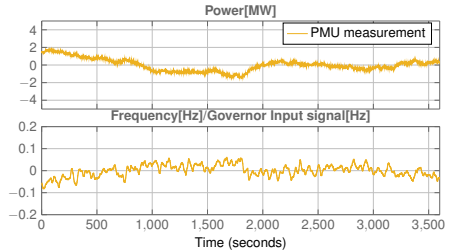
- The power system is never really in steady state.
- Can the power plant dynamics be identified from normal operation measurements?





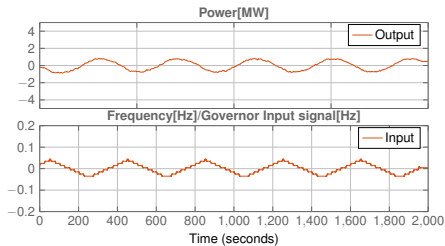
# Research questions

- Can power plant dynamics be identified using a PMU?



# Research questions

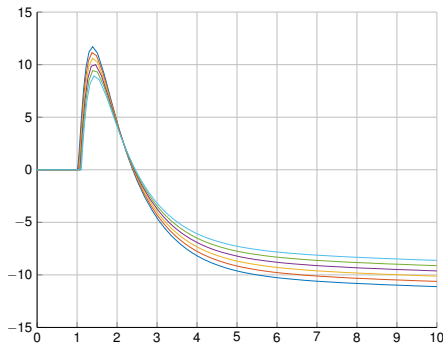
- Can power plant dynamics be identified using a PMU?
- Can power plant dynamics be identified using control system measurements without disturbing the operation of the plant?



# Research questions



- Can power plant dynamics be identified using a PMU?
- Can power plant dynamics be identified using control system measurements without disturbing the operation of the plant?
- What is the effect of nonlinearities on the identification?



# Outline



Problem

Paper I

# Main contributions



lol