



# Digital datadriven model learning for online testing of hydro power plants

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# Outline

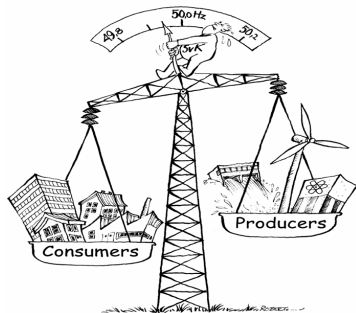


Problem

Solution

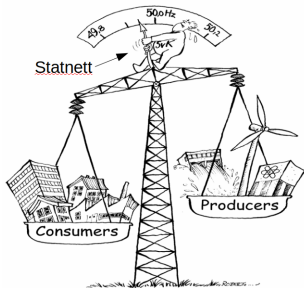
# Load and production balancing

- The power system frequency measures the power balance.



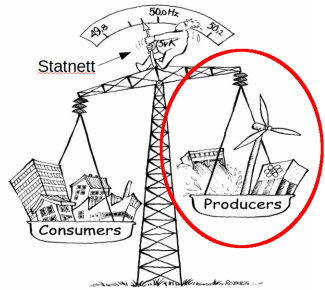
# Load and production balancing

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



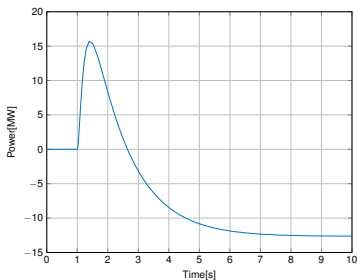
# Load and production balancing

- 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

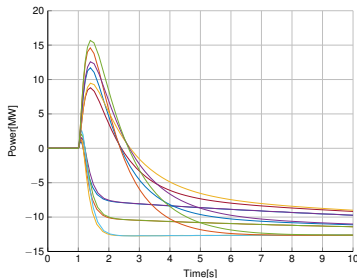
- Statnett pays all power plant owners to provide frequency control.



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

# Buying frequency control

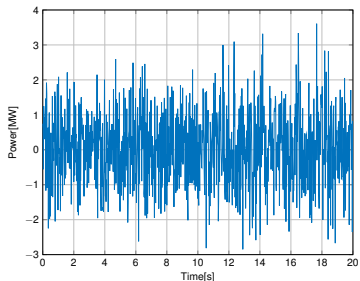
- Statnett pays all power plant owners to provide frequency control.
- However, they don't provide the same quality of service.



**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



# 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.

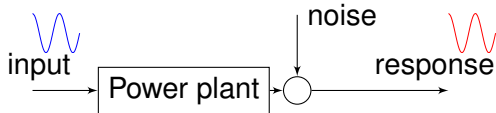


Figure: Test of power plant

# Tests proposed by the industry

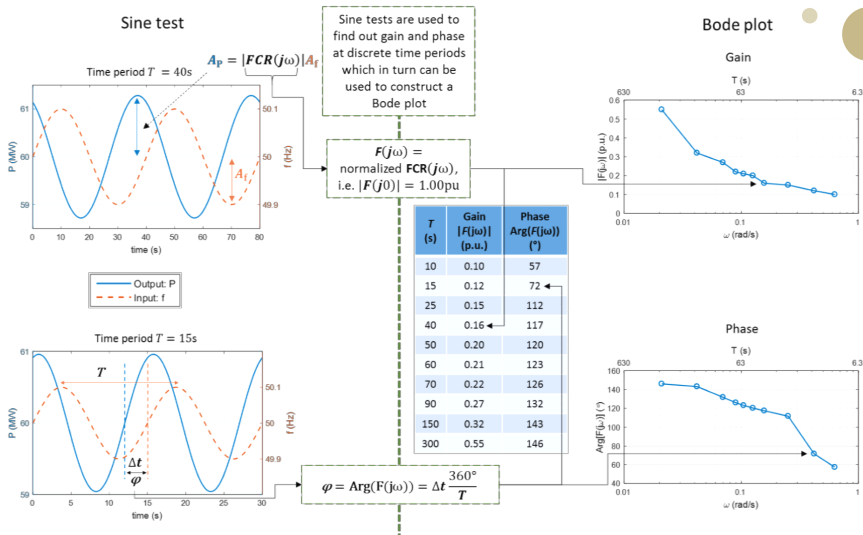
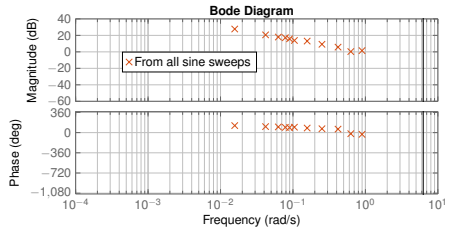
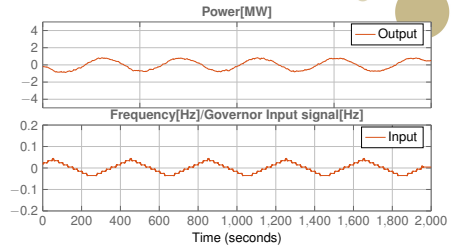


Figure: Testing procedure [source:ENTSO-E]

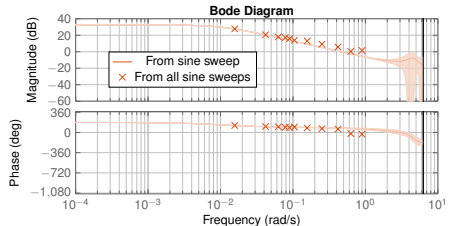
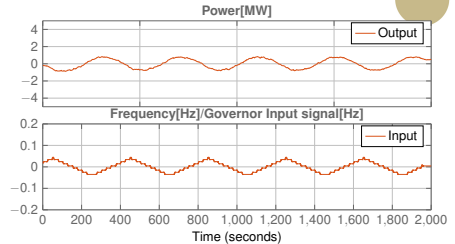
# Example from real tests

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



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



# Outline

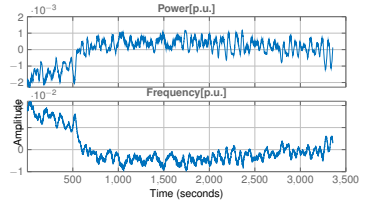


Problem

Solution

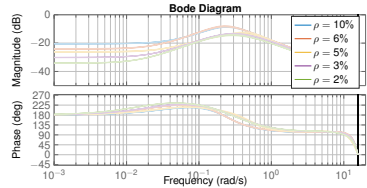
# Idea

- Can power plants be tested without testing?



# Idea

- Can power plants be tested without testing?
- Yes!



## Product

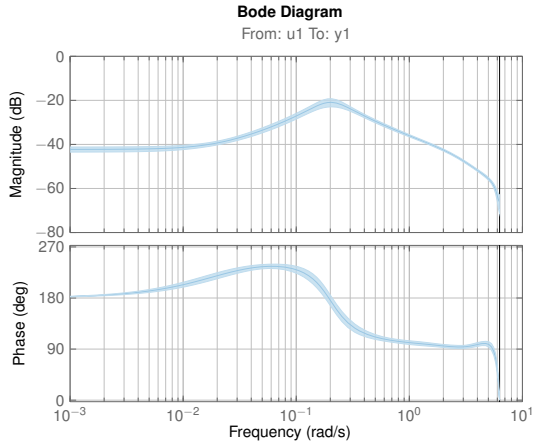


- A small pc with analog and digital input and output.
- Software for interfacing with turbine control systems and TSO measurements.
- Software for performing model learning and analysing results.



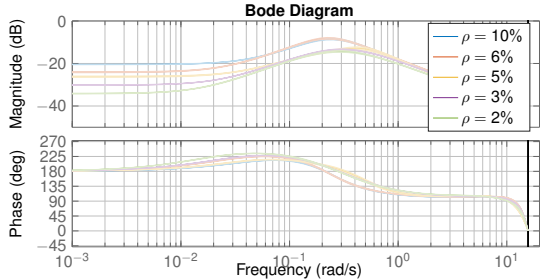
# Use cases

- Statnett can check plants using their own data.



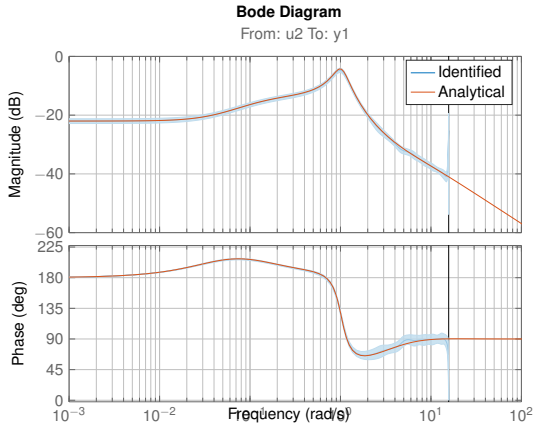
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- Power plant owners can test their plants continuously.



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- Statnett can check plants using their own data.
- Power plant owners can test their plants continuously.
- Testing with defined accuracy.



# Competition

- DNV GL offer a product according to the industry proposal.
- It requires disconnection of the plant.
- It takes very long time.



## ENERGY

# VERIFICATION OF FREQUENCY CONTROL SERVICES

DNV GL has developed new streamlined test equipment for the verification of frequency control services, designed to meet the new comprehensive requirements in the Nordics for frequency containment reserves, FCR-N, FCR-D and FFR. In the future, all units providing frequency control services in the Nordics must fulfil the new requirements.

DNV GL's new test and verification equipment has been developed to meet the new FCR requirements in the synchronized Nordic power system. The equipment meets the new verification requirements by breaking up the frequency feedback loop to the turbine governor, and replacing the feedback frequency signal with a synthetic frequency signal. The test equipment is significantly smaller than traditional test equipment making it portable and easy to place in control rooms or cabinets. It can also be connected when the production unit is running and synchronized to the grid, reducing the stand still costs.

- Frequency quality deterioration in the Nordics
- Reduced system inertia in the Nordics due to closing of nuclear power plants and large-scale implementation of renewables
- Fewer frequency dependent loads
- Market based solutions for FCR resulting in increased costs for the TSOs
- A need to optimize the frequency control to meet the power system needs of stability and performance

Therefore, a mandatory qualification process is now applied in the Nordics for production units selling FCR services.

The test equipment is highly flexible and can be adapted to

## Future work



- Map the market and business potential.
- Develop a prototype.
- Demonstrate the prototype.
- Start a company for testing power plants or sell the idea.



Thanks for listening!