Model Validation of Mostar Hydroelectric Plant Using PMU and Synthetic Data

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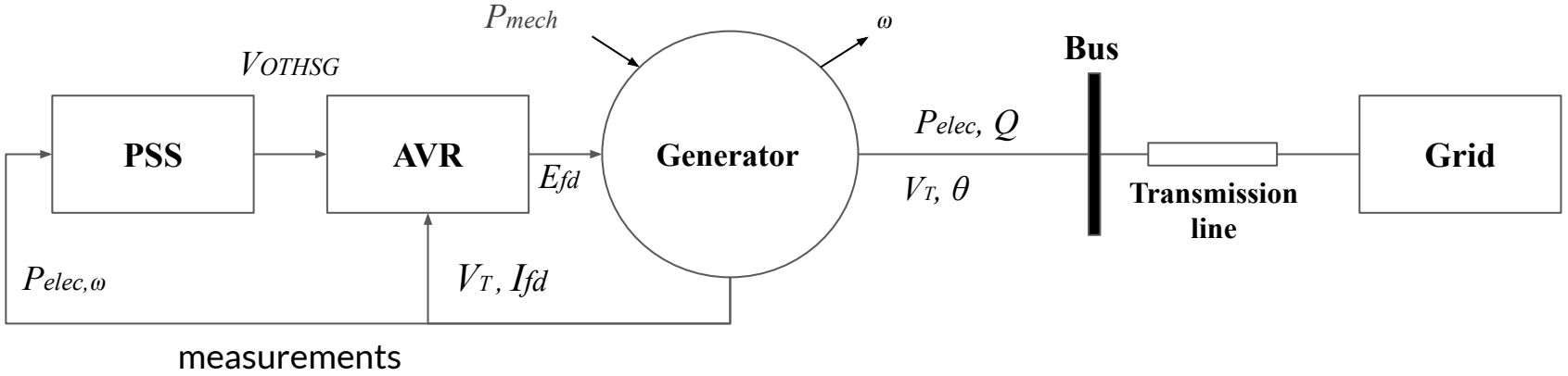
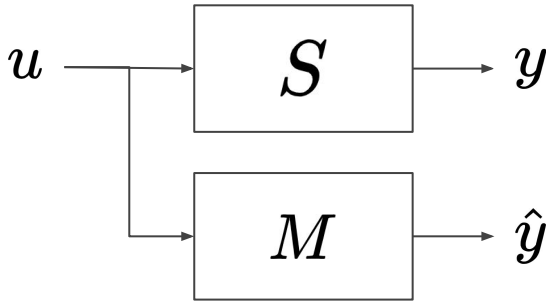
Motivation

- Simulation-based studies are **indispensable** in determining best practices for the power system.
- Verifying models are still correct is crucial for simulation-based studies.
  - Validate model of Mostar hydroelectric power plant.
- Controllers have time-constants and generators have physical parameters that can change over time.
  - Run regular tests to validate the models by applying a step on measurement of V_T to measure the response of the system.



Using data for model validation

- Apply a step to V_T to get a response from the system
- Validate system by looking at the error between y and \yhat to make sure the model matches the system

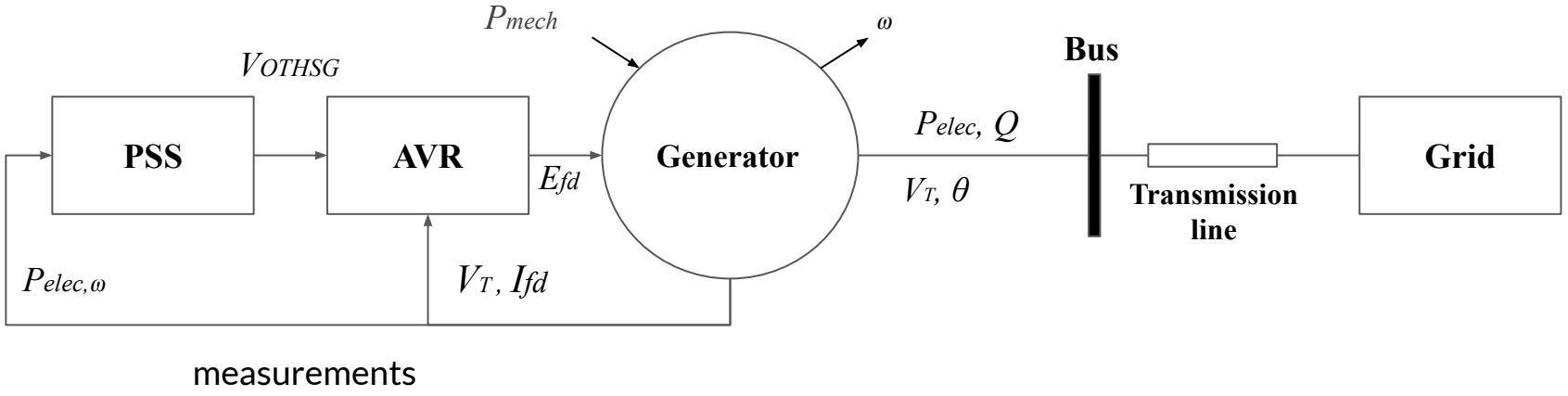


$$\varepsilon = y - \hat{y}$$

- Validate each component in the system individually
  - Generator
  - AVR
  - PSS

Generator, AVR, and PSS Validation

- Validate each component in the system individually
- Need to distinguish inputs and outputs of each component:
  - **Controllers:** inputs and outputs are straightforward based on controller structure
  - In the case we consider, the AVR and PSS are validated
  - **Generator:** inputs and outputs are more difficult to determine



Initial approach for input/output

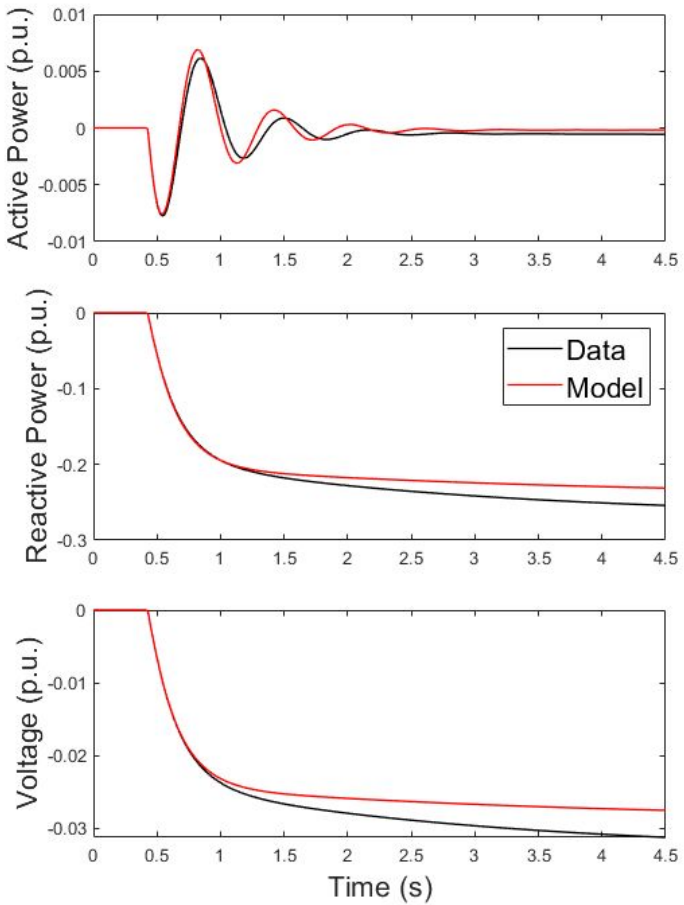
Inputs: Field voltage (*Efd*), mechanical power (*Pmech*)

Outputs: Active power (*Pelec*), reactive power (*Q*), machine voltage (*V*)

- Initial validation approach does not have a good fit for the model

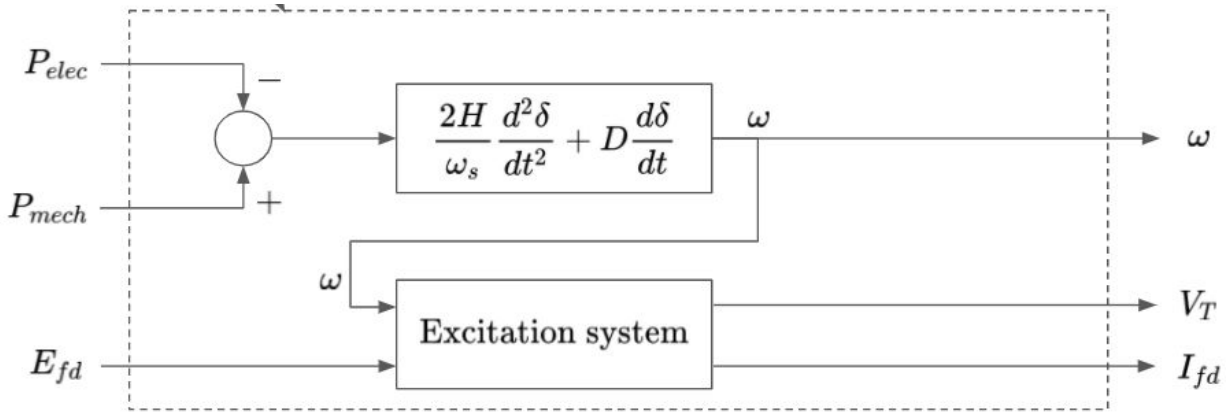
Model fitness			
	P(%)	Q(%)	V(%)
Model	69.29	80.29	75.66

- By selecting these I/Os, the grid and generator are lumped into one model



Choosing new inputs and outputs for generator validation

- To separate the generator model from the grid, we choose the correct inputs and outputs
- Using the swing equation, the mechanical and electrical power can be used as inputs to separate the grid from the system



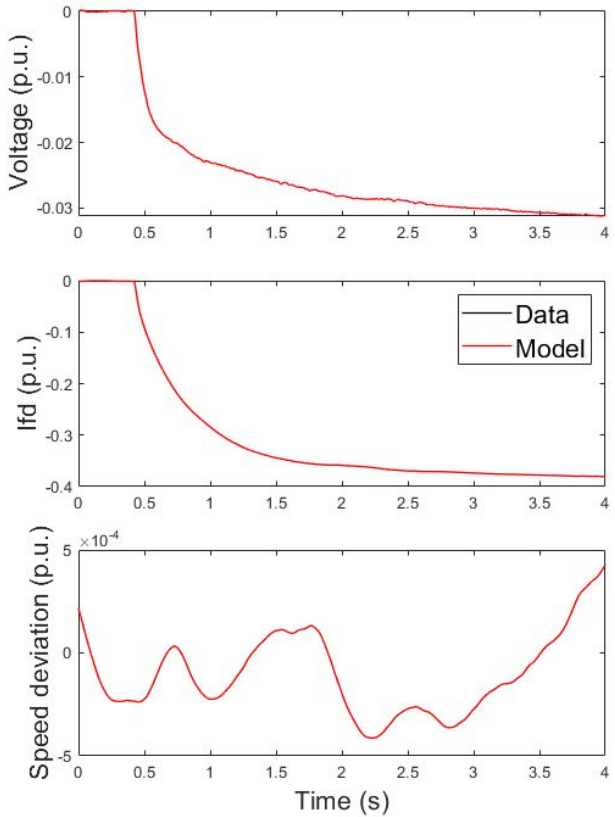
Validation with correct inputs and outputs

Inputs: Field voltage (*Efd*), Active/electrical power (*Pelec*), mechanical power (*Pmech*), reactive power (*Q*)

Outputs: Machine voltage (*V*), Field current (*Ifd*), speed deviation (*Δω*)

- By choosing our inputs and outputs correctly, we can validate that the model is a suitable fit for the data.

Model fitness			
	V(%)	Ifd(%)	Δω(%)
Model	99.6	99.8	99.9



Conclusion and future works

- Distinguished inputs and outputs of the three elements we want to validate in the plant, and that allows a good validation of the three elements.
- By selecting the inputs and outputs of the generator carefully, we can validate the model.
    - Instead of choosing conventional inputs and outputs based on what the generator is physically producing, we can choose them based on the equations of the model.
- In future studies, we will focus on using the data to validate and identify all components in the plant model.
    - Are the experiments rich enough to validate and identify **all parameters** in the plant?
    - What if the experiment is not explained by the model?
    - How can we design experiments for these models to identify all plant parameters?