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Model Reduction of Wind Turbine Generator Models for Control Performance Evaluation

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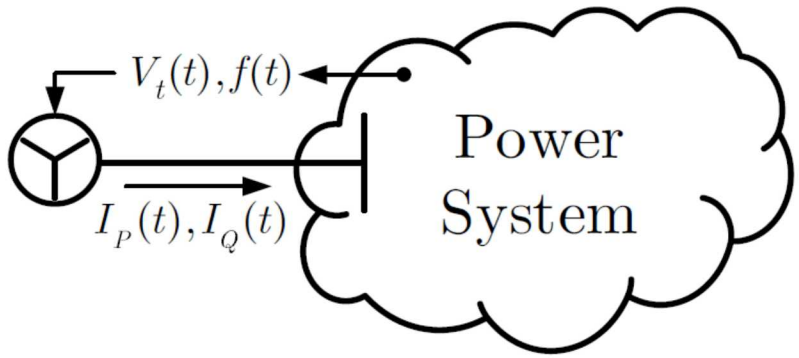
Background

- Power systems are changing due to high integration of converter interfaced renewable resources such as Wind
- In the future wind turbine generators will be expected to provide voltage and frequency regulation
- This work presents a reduced order model of a WTG. The model was obtained from
  - Linearization
  - Model reduction
- Model can be used to evaluate the control performance (active and reactive power) of WTG from measurements (using system identification)

WTG Model and Linearization

- Identify response of the WTG *decoupled* from the rest of the system

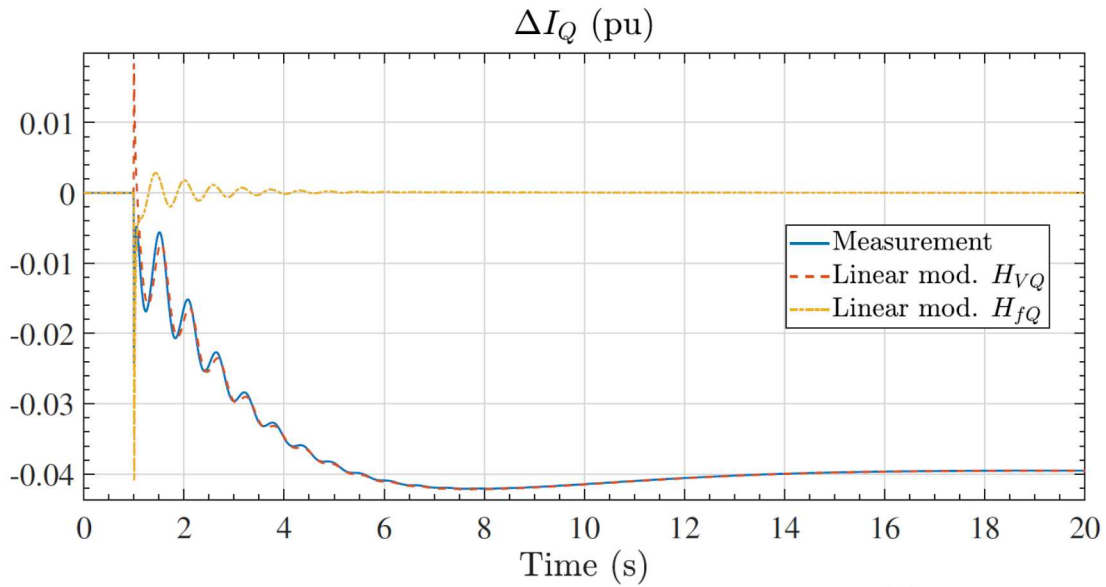


- Develop a standalone WTG model that receives voltages and frequencies as inputs and compute the active and reactive power current injections

- Develop a linearized version of the model such that

$$\begin{bmatrix} \Delta I_Q \\ \Delta I_P \end{bmatrix} = \begin{bmatrix} H_{VQ}(s) & H_{fQ}(s) \\ H_{VP}(s) & H_{fP}(s) \end{bmatrix} \begin{bmatrix} \Delta V_T \\ \Delta f_T \end{bmatrix}$$

- Validate individual components

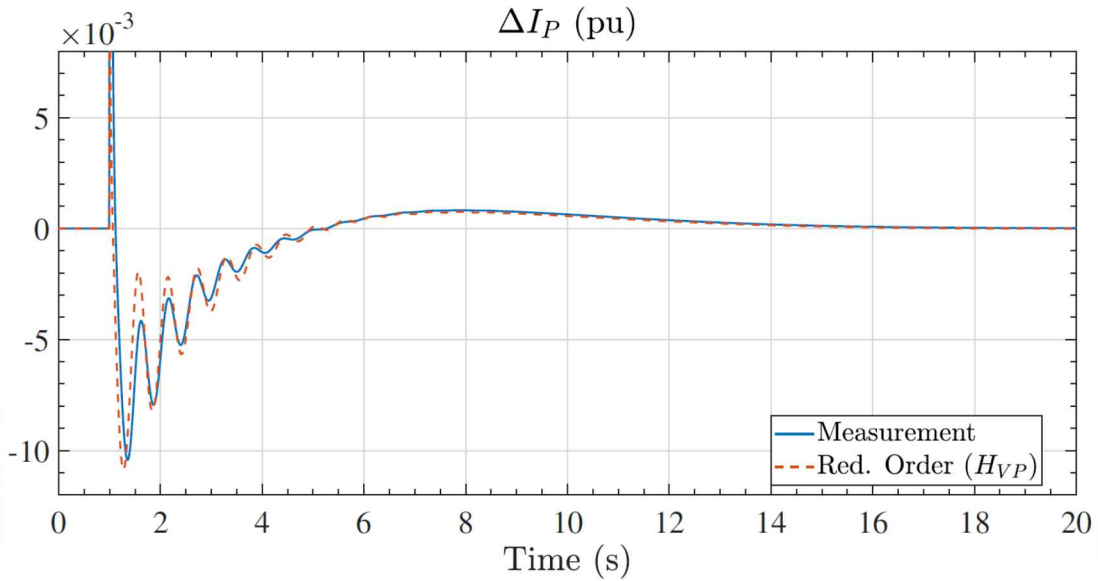


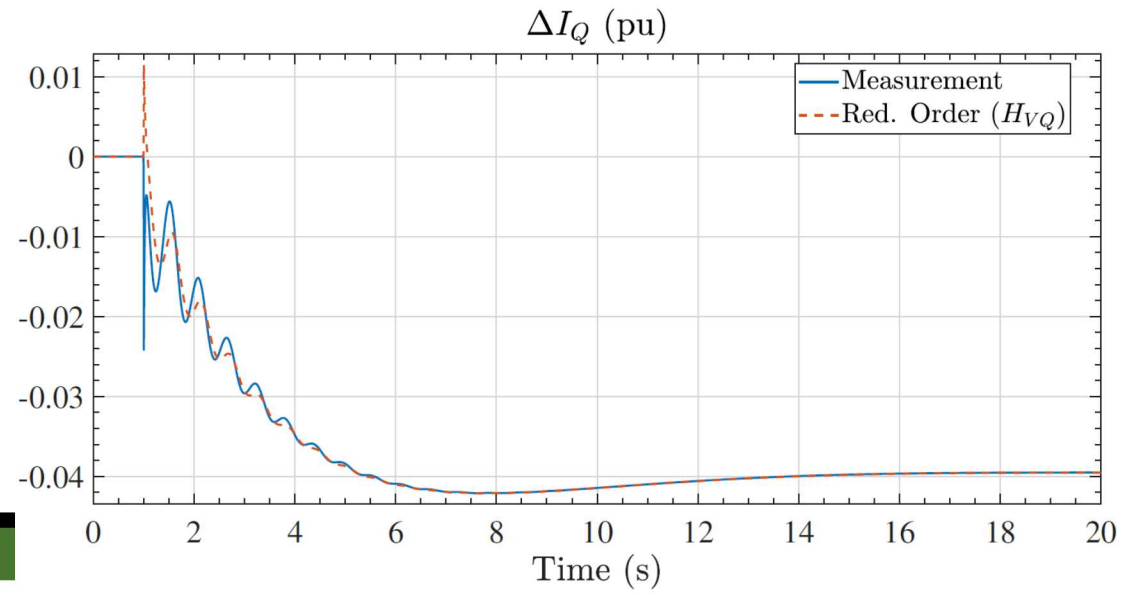
WTG Model reduction

- The linear model had order 17. However several approximations can be done. Time-domain analysis and frequency domain (Bode plots) confirms that active and reactive power contributions can be treated separately.
- The reduced order transfer functions:

$$\hat{H}_{VQ}(s) = \frac{-K_{VQ}(s+z_1)(s+z_2)}{s(s+p_1)} \qquad \hat{H}_{VP}(s) = -K_{VP}$$

  - The 3rd order reduced order model





Conclusions

- The approach is based in to main components:
  - Linearization
  - Model reduction
- Results show that active and reactive power components can be treated separately
- The results also show that voltage is the main driver or the transfer function (not frequency even for the real power component)
- A third order model can capture well enough the dynamics of the WTG model
- Models can be used to evaluate performance of WTG