CONTROL OF CONVERTERS IN WIND TURBINES

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- Raising fear of climate changes -> bigger use of renewable energy sources
- These sources are more or less stochastic -> necessary to use power converters in order to adopt their volatility
- Converters were not efficient enough – huge improvements have been made in recent period
- Today, power converters perform all the necessary functions with minimal response time and energy consumption

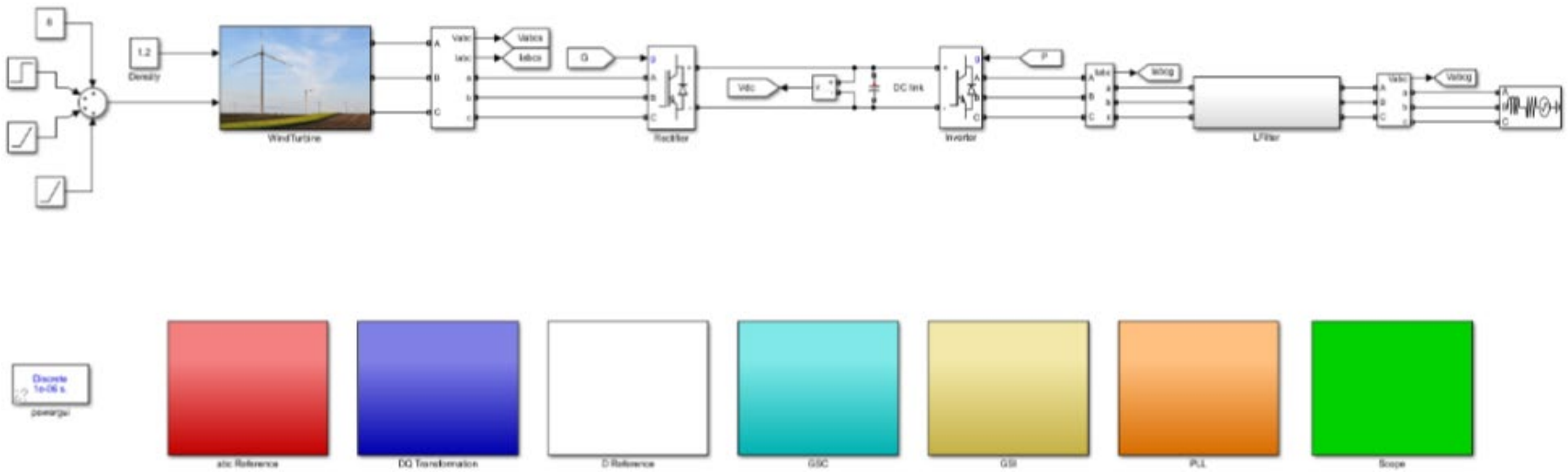
- The converter consists of several parts

- On the machine-turbine side, we use a rectifier based on IGBT transistors, controlled using pulse-width modulation

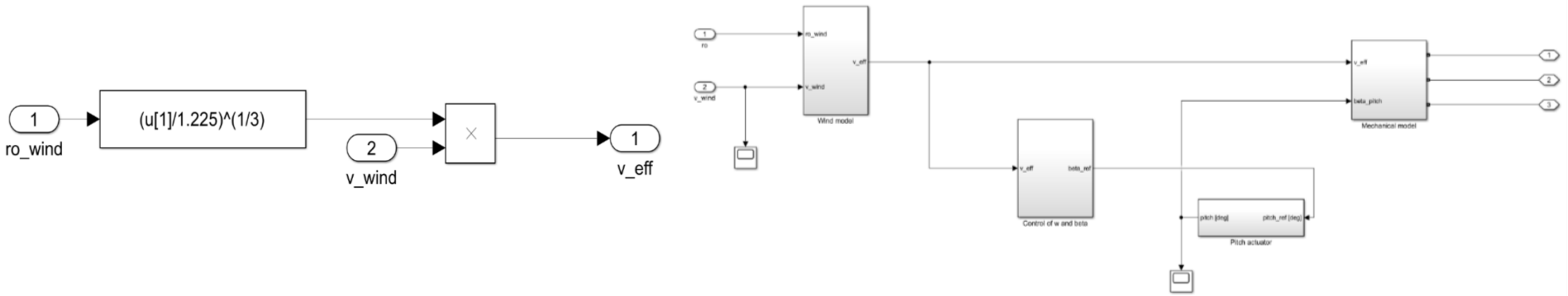
- The machine we use in this simulation is an induction generator, as it is easiest to place in a wind turbine and it is connected to the wind turbine via a gearbox

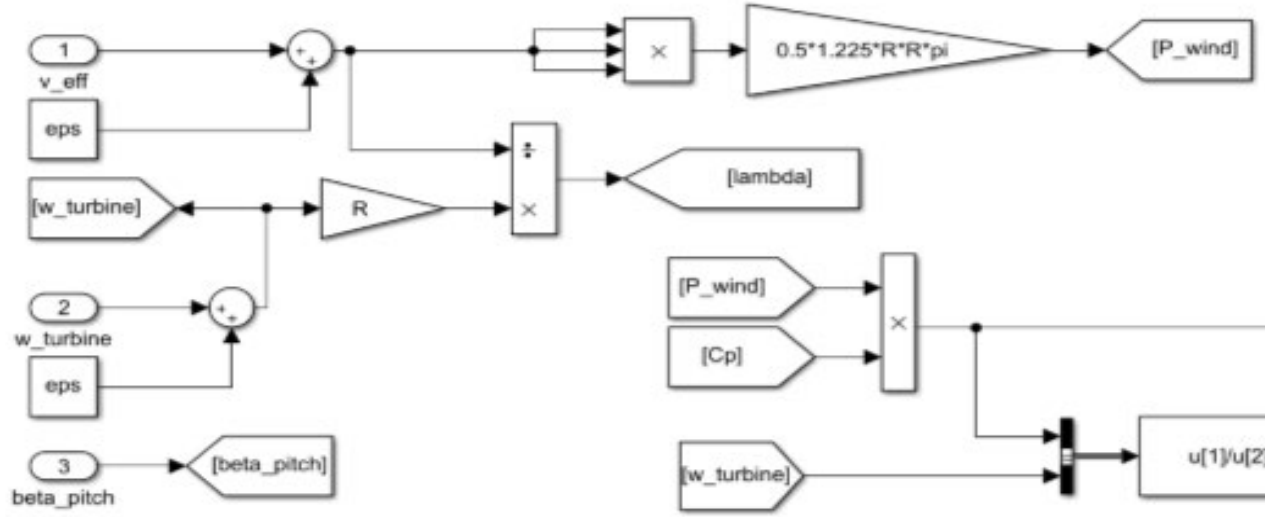
- Further, the converter contains a single capacitor (DC link)

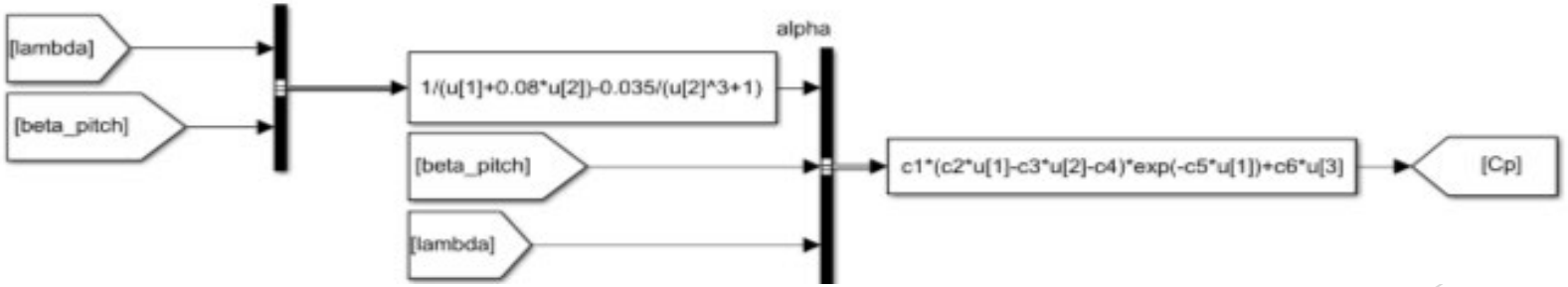
- Finally, we use an inverter based on IGBT transistors, controlled by pulse-width modulation

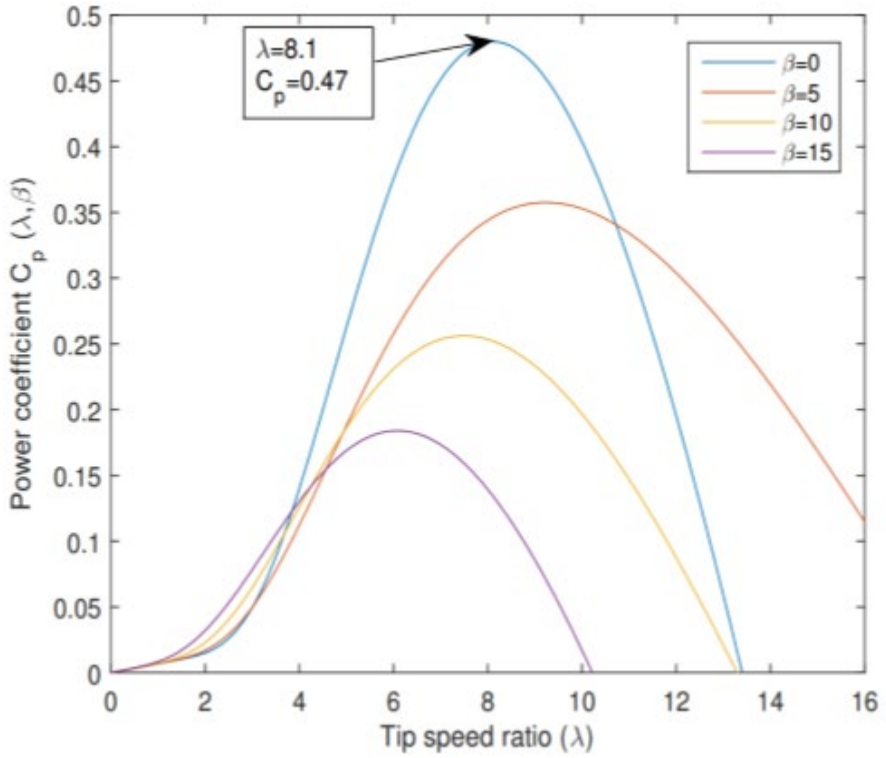


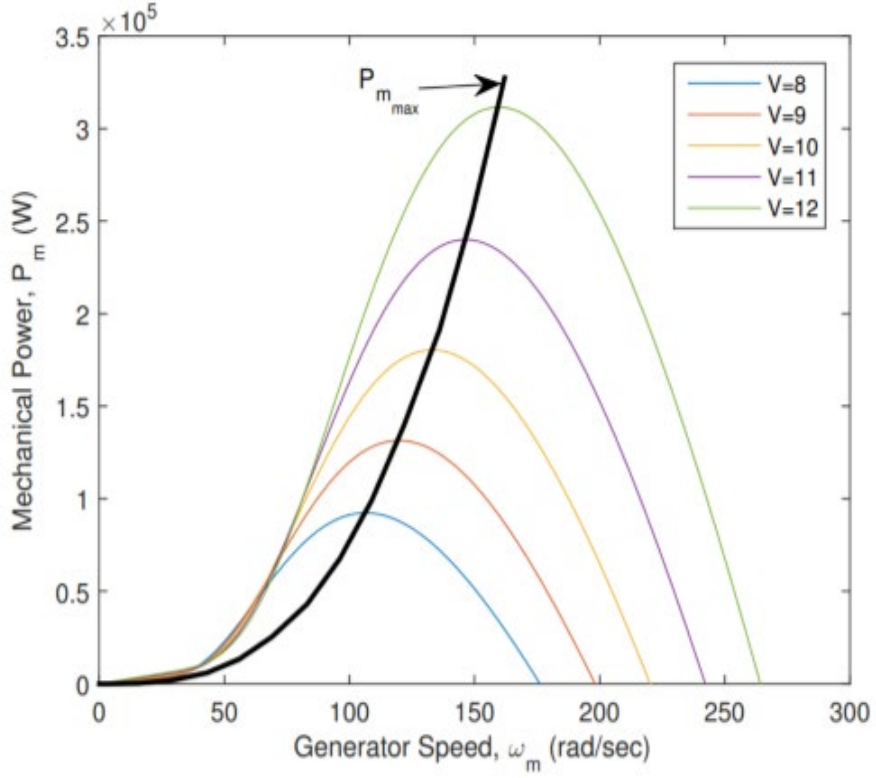
Windturbine Model











- The mechanical power is $Pm = 0.5 * Cp(\lambda, \beta) * \rho * A * v^3$

where Cp is the power coefficient of wind turbine that can be expressed as

$$Cp(\lambda, \beta) = a1 * \left(\frac{a2}{\lambda} - a3 * \beta - a4\right) * e^{\frac{(-a5)}{\lambda}} + a6 * \lambda$$

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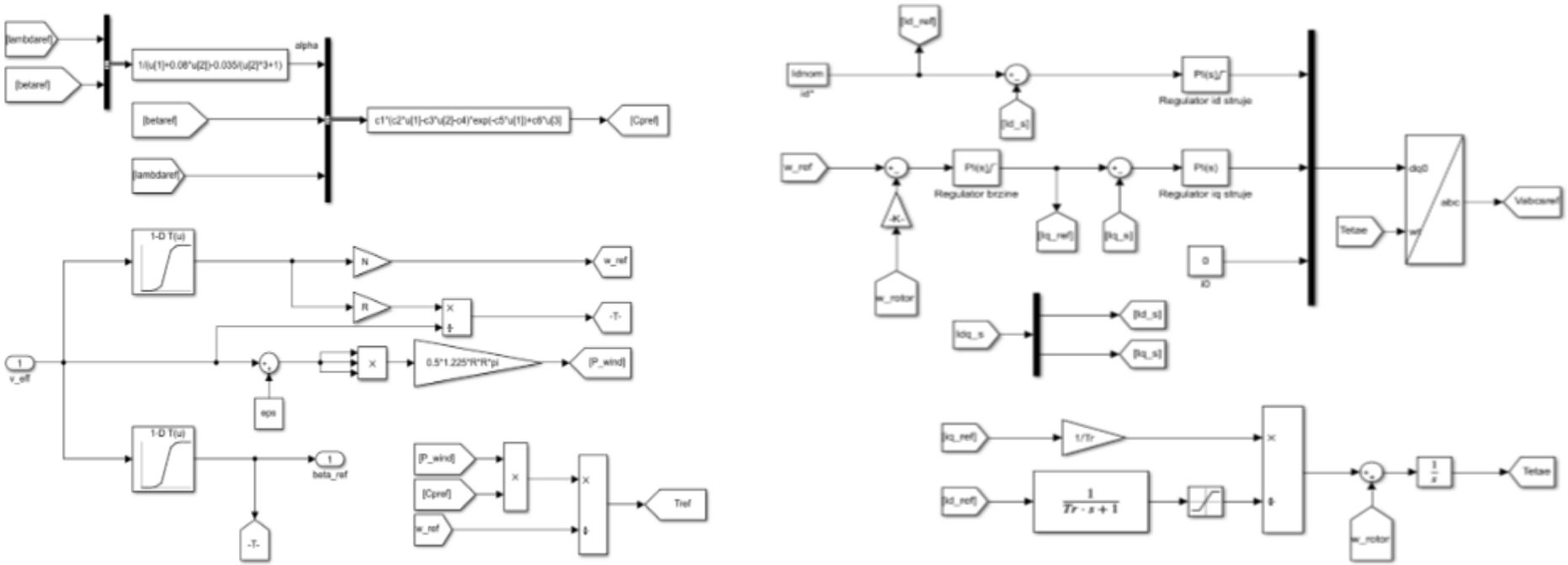
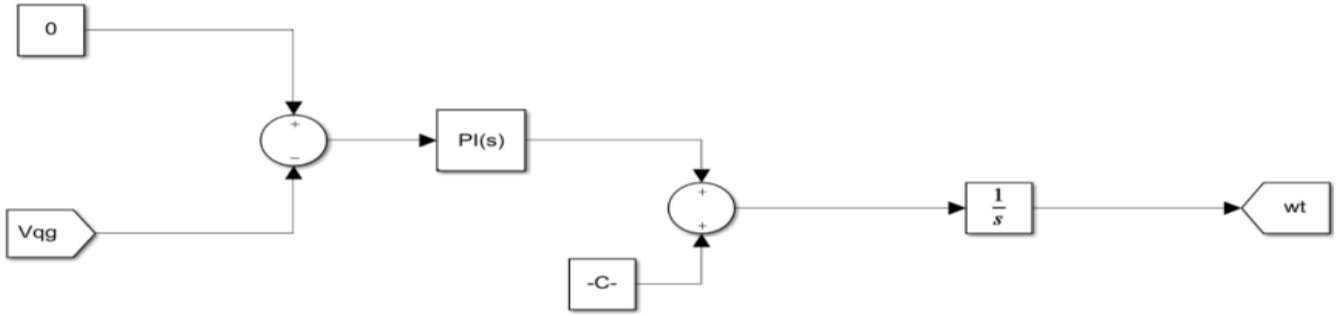
Control of induction generator

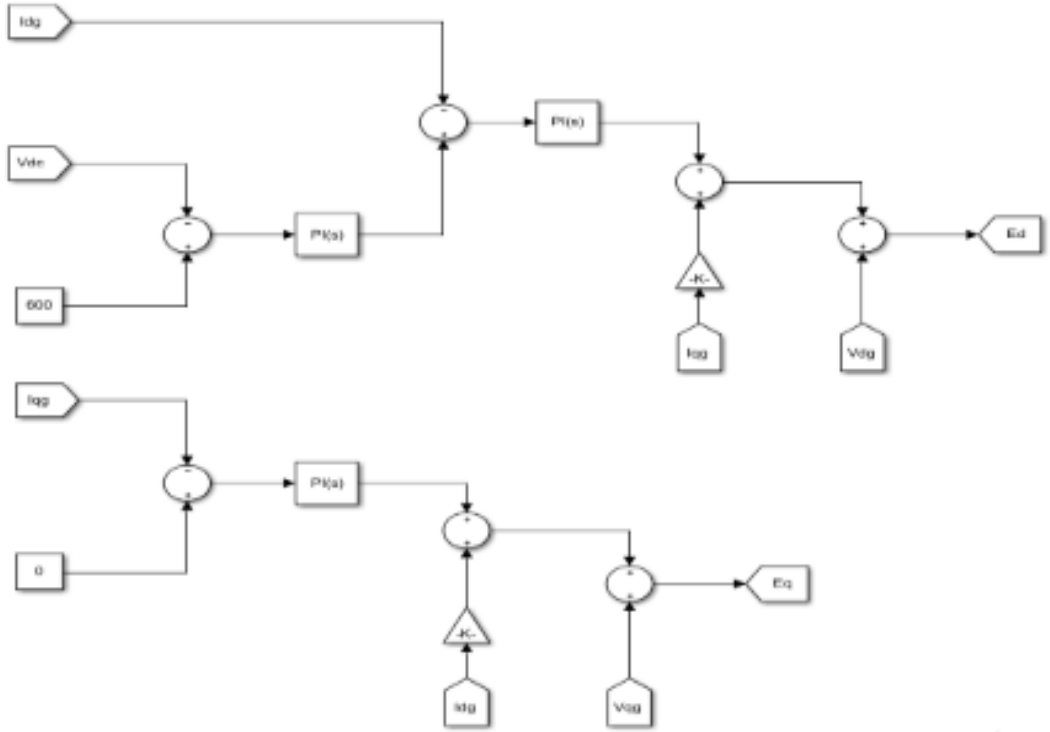


- Biggest challenge is to control an induction generator
- The method of indirect vector control, with Clarke and Park(dq) transformation is used
- By setting the value of the stator current in the d axis, we control the flux in the machine
- By using the value of the stator current in the q axis, we control the torque of the machine

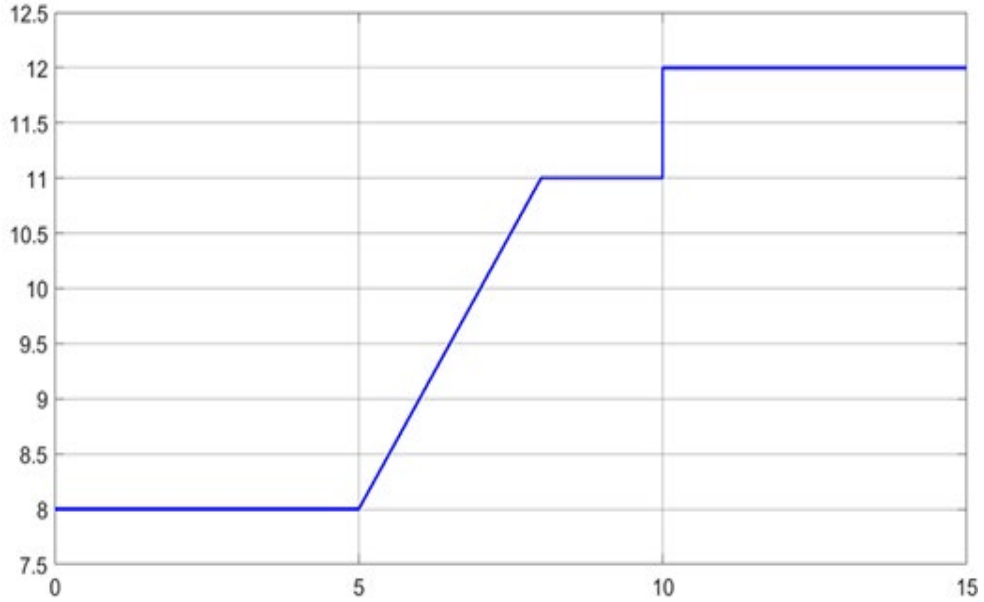
PLL

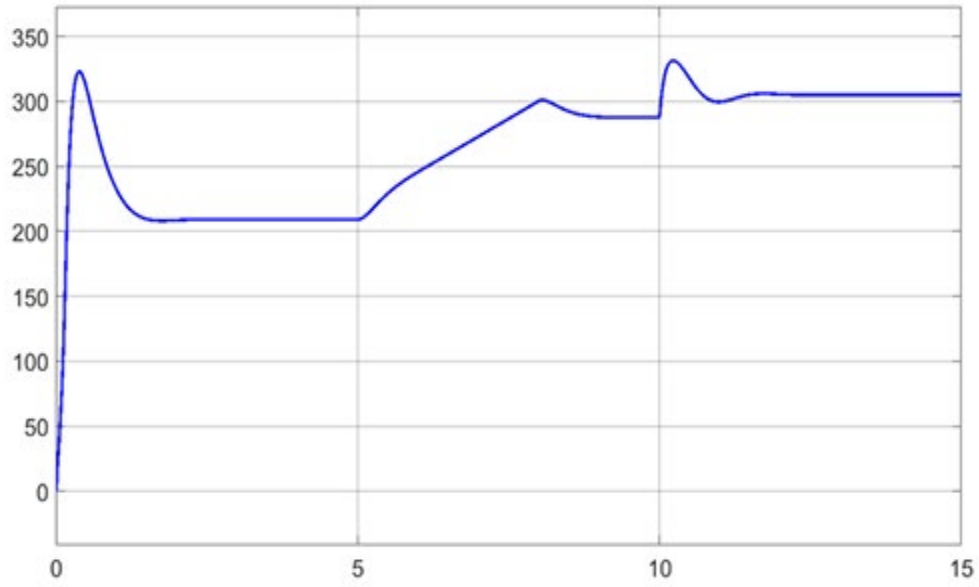


PI control in dq reference frame

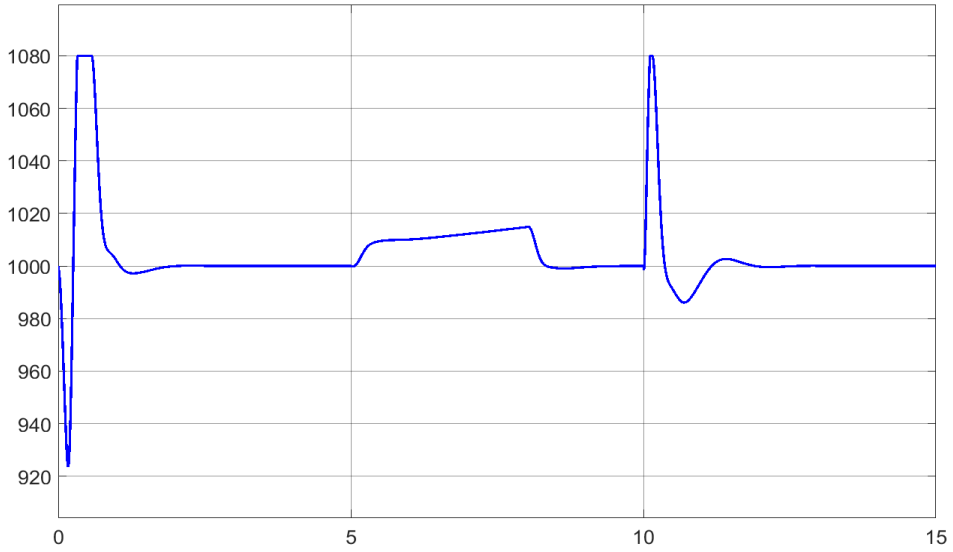


Results of simulation

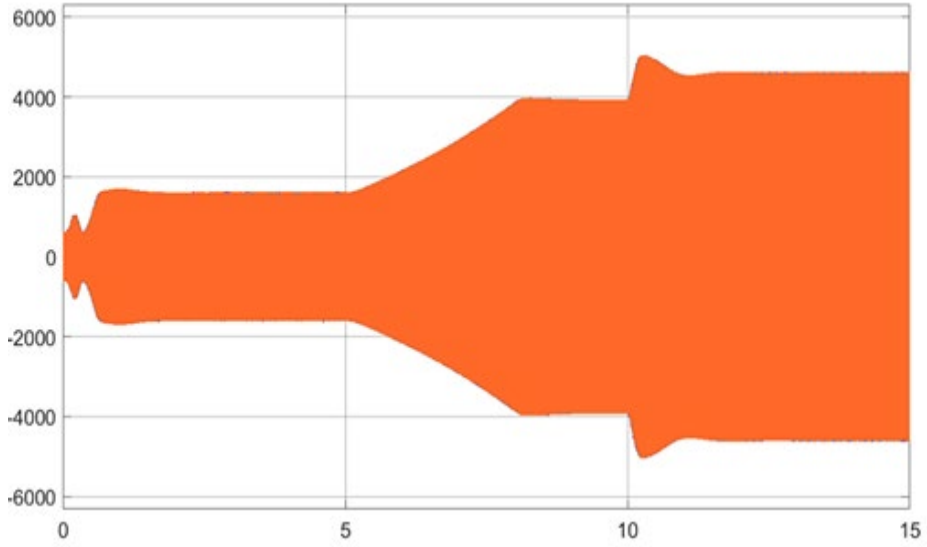




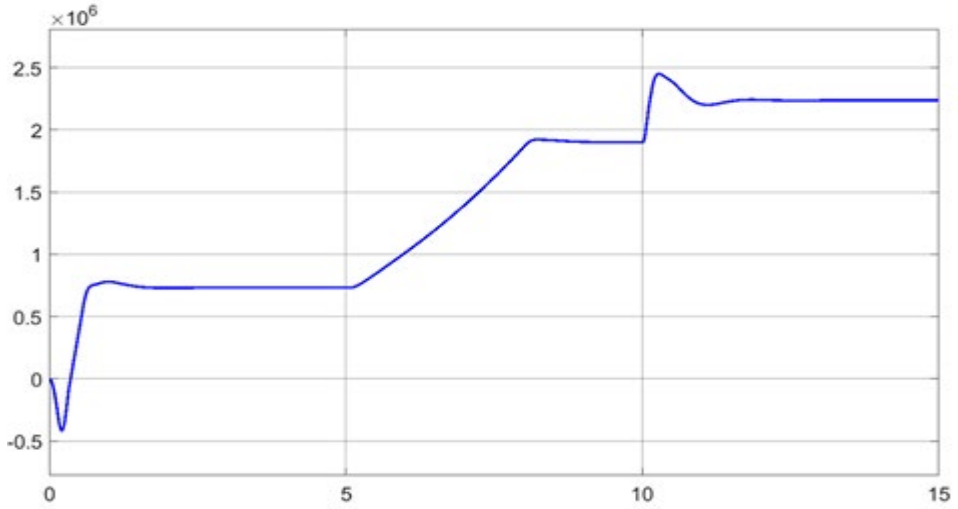
- In the pictures above, we can observe the system input wind speed and the consequential induction generator rotor speed
- Clearly, the system output shows signs of fast response, low overshoot and high overall performance



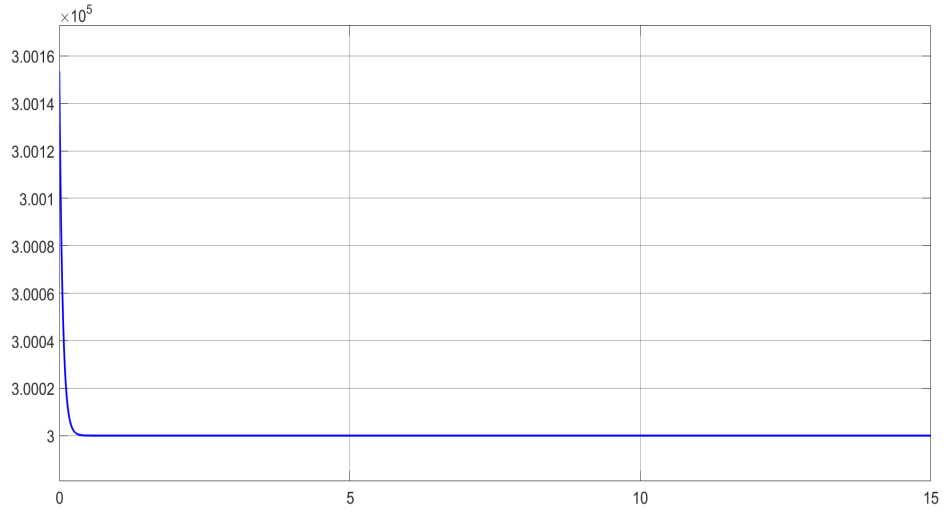
- DC link voltage is represented at the upper figure
- It follows the desired value of the capacitor voltage in a fast and smooth manner



- Current injected to the grid is represented at the lower figure
- First part is distorted due to the starting acceleration of the induction generator
- Its response to sudden changes are smooth



- Active power transferred to the grid is represented in the upper figure
- References are constant values at constant wind speed -> easy tracking with PI controller
- Low overshoot and fast response



- Reactive power transferred to the grid is represented in the upper figure
- References are constant values at constant wind speed -> easy tracking with PI controller
- Low overshoot and fast response

Thank you for your attention!