Master Thesis Work

Control of a wind turbine equipped with a variable rotor resistance

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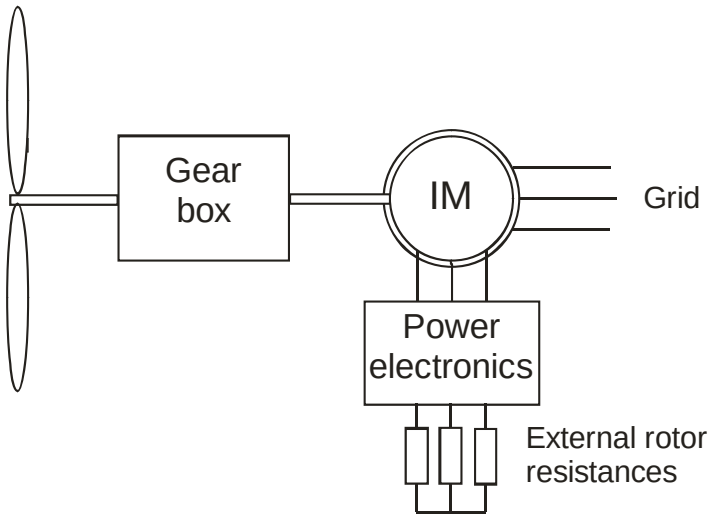
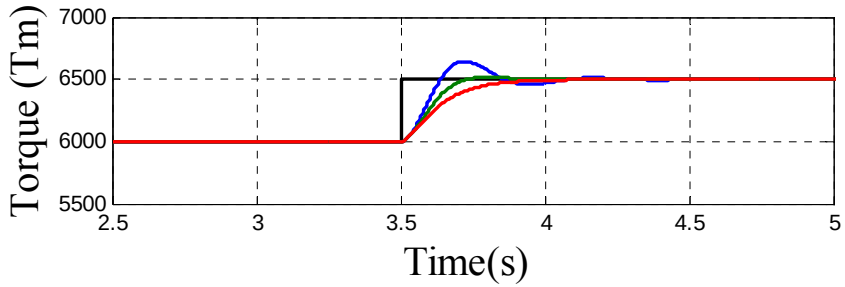
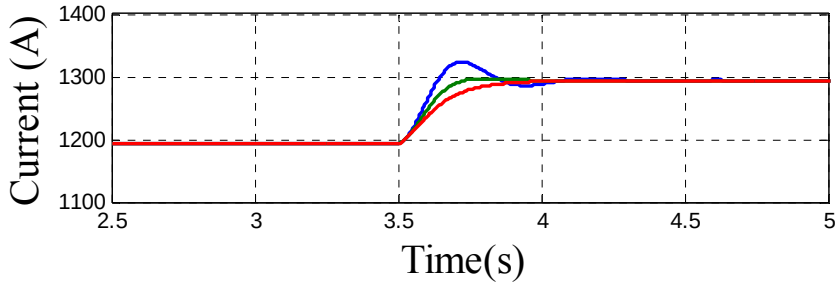
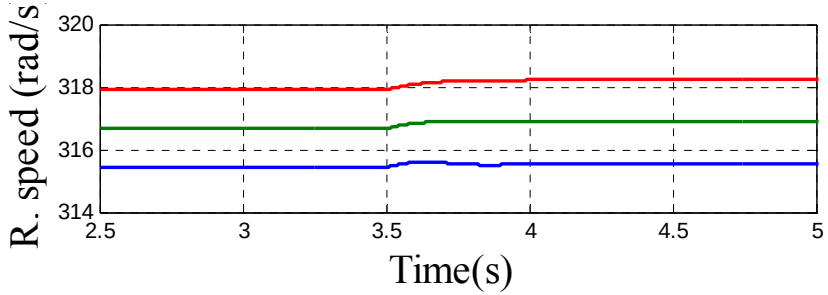
Variable rotor resistance

- What happens when we increase the rotor resistance?



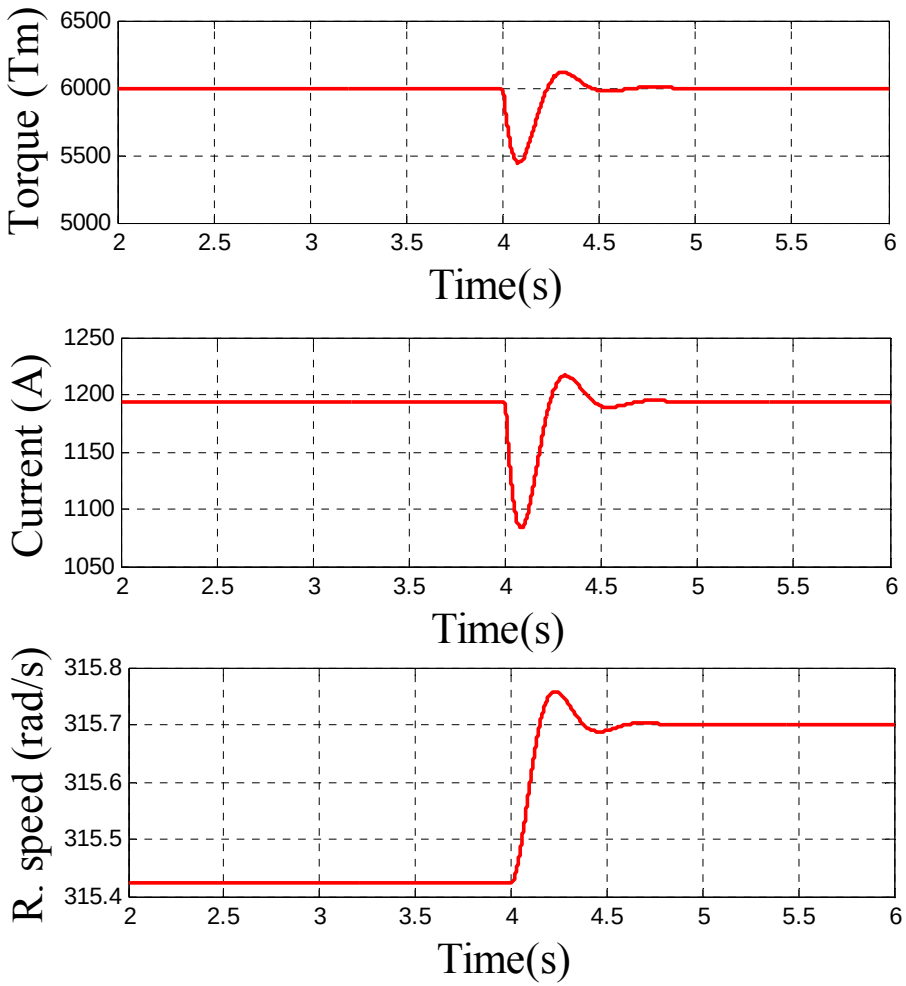




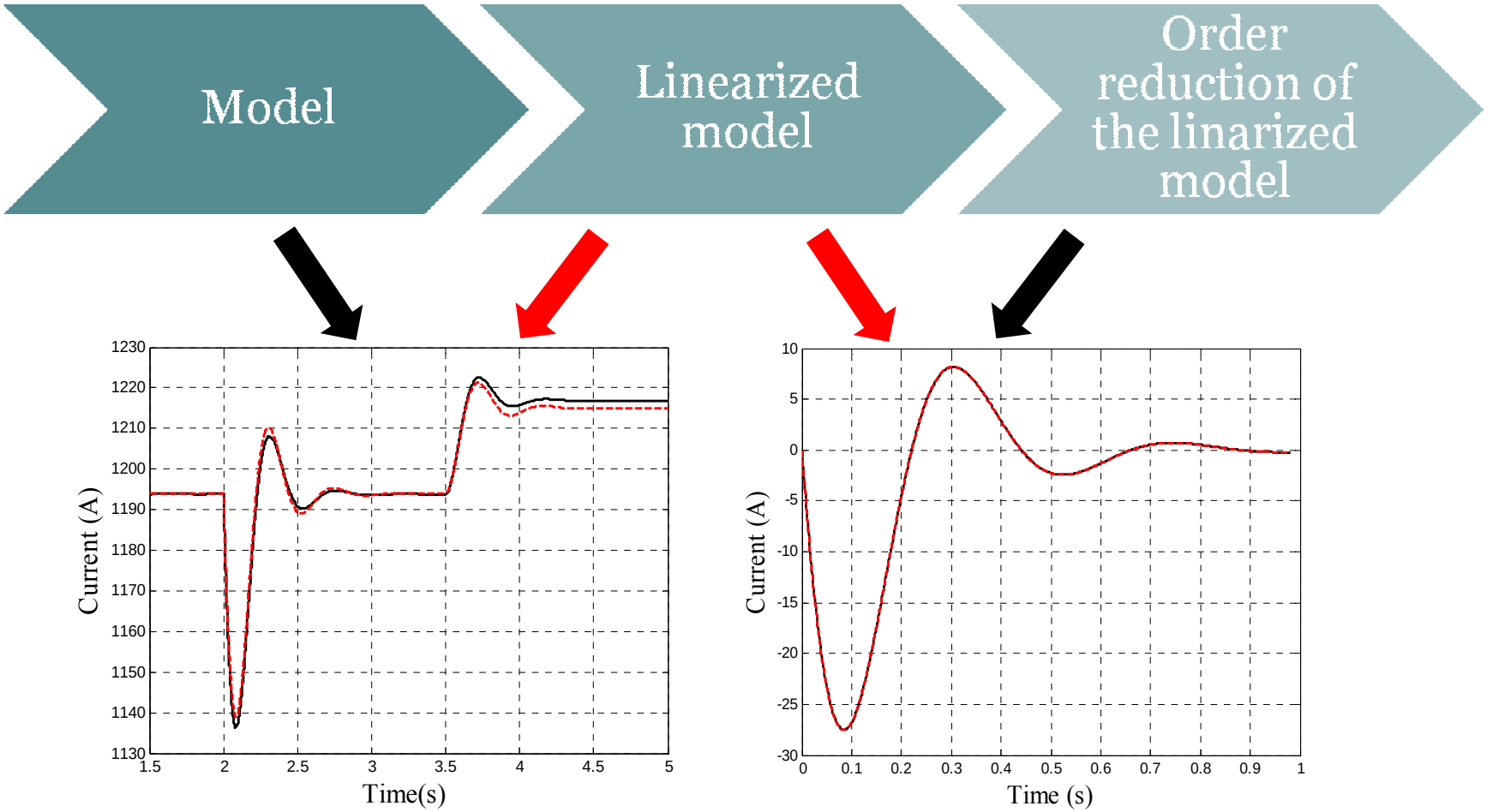


- Nominal rotor resistance
- Rotor resistance fixed to 2 times the nominal value
- Rotor resistance fixed to 3 times the nominal value

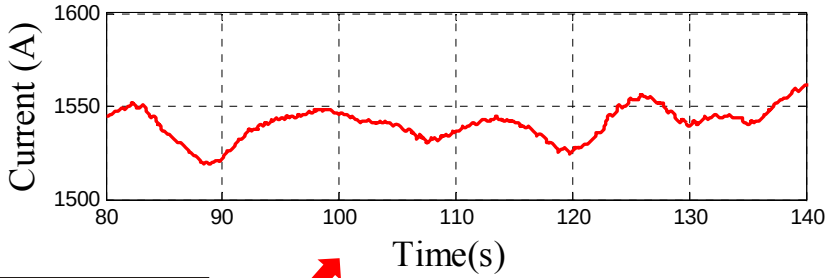
Example of the response of the induction machine due to a step in the rotor resistance

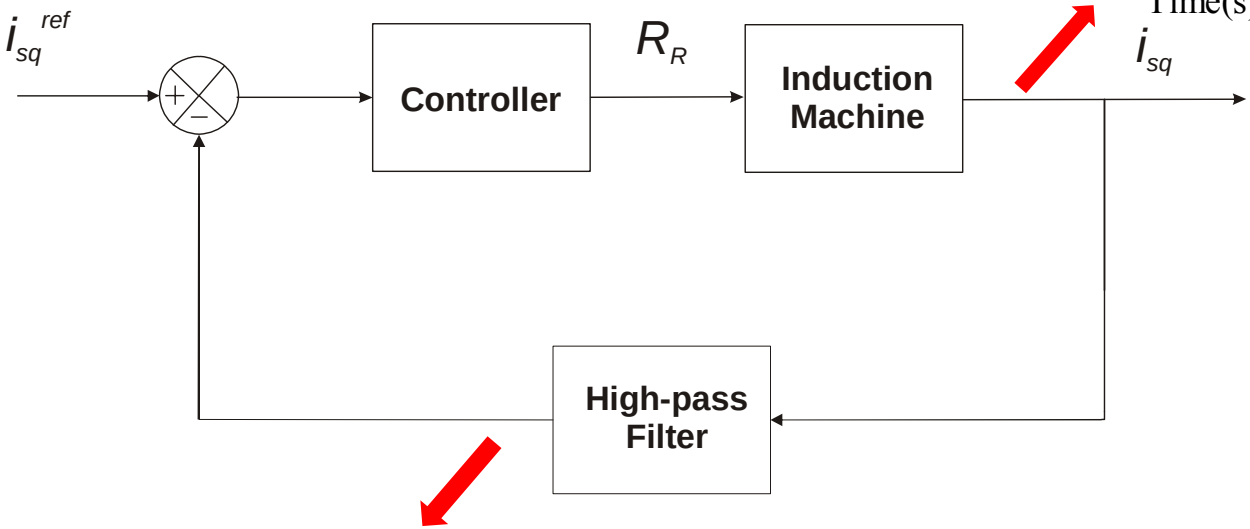


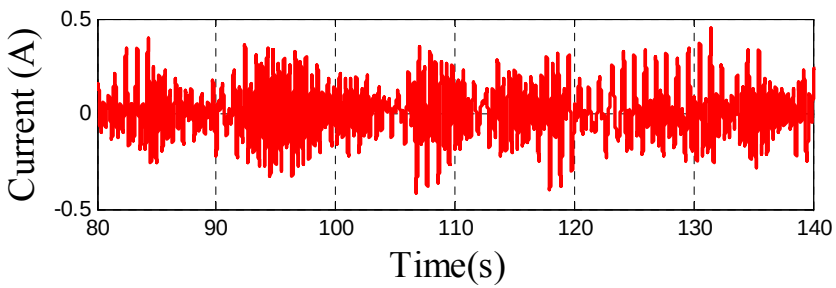
Model and reduced order model



Block diagram of the controller



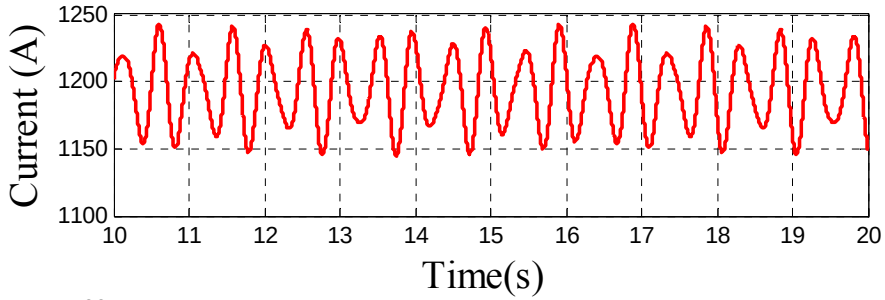


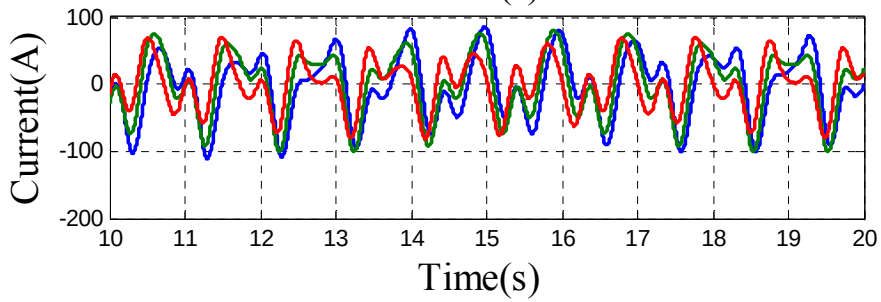


High-pass filter

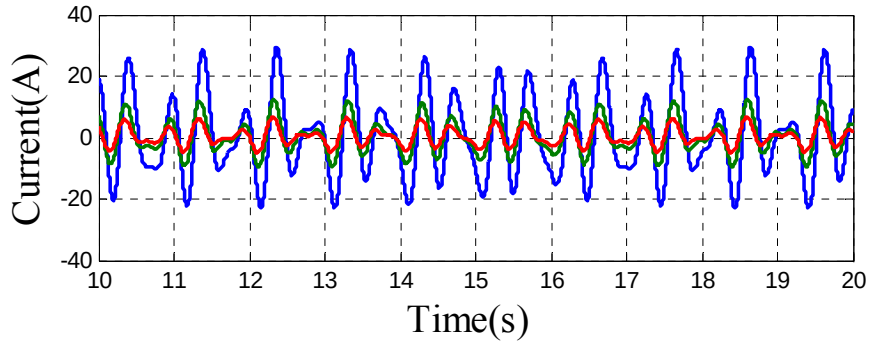
- Cut-off frequency?

- Cut-off frequency 0.1 Hz
- Cut-off frequency 0.5 Hz
- Cut-off frequency 1 Hz

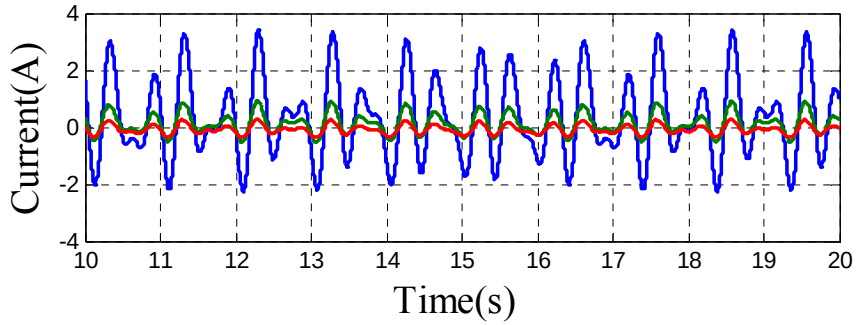




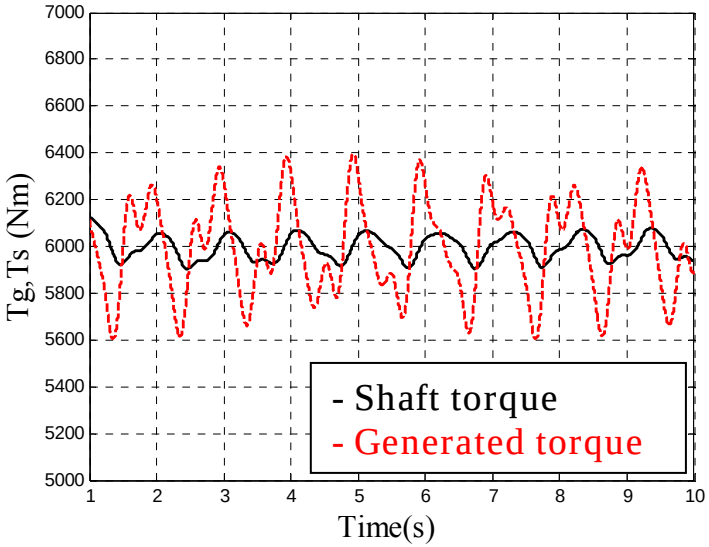
- Cut-off frequency 1 Hz
- Cut-off frequency 3 Hz
- Cut-off frequency 5 Hz

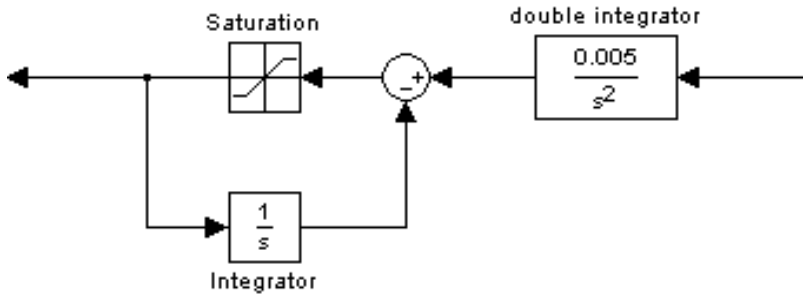


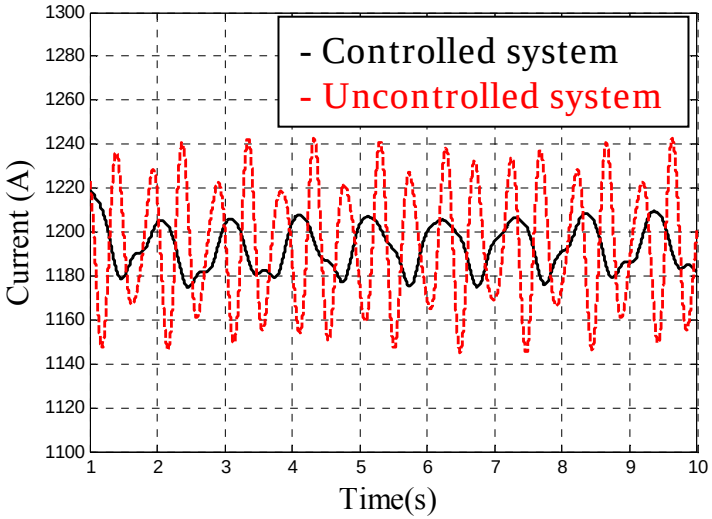
- Cut-off frequency 10 Hz
- Cut-off frequency 20 Hz
- Cut-off frequency 30 Hz

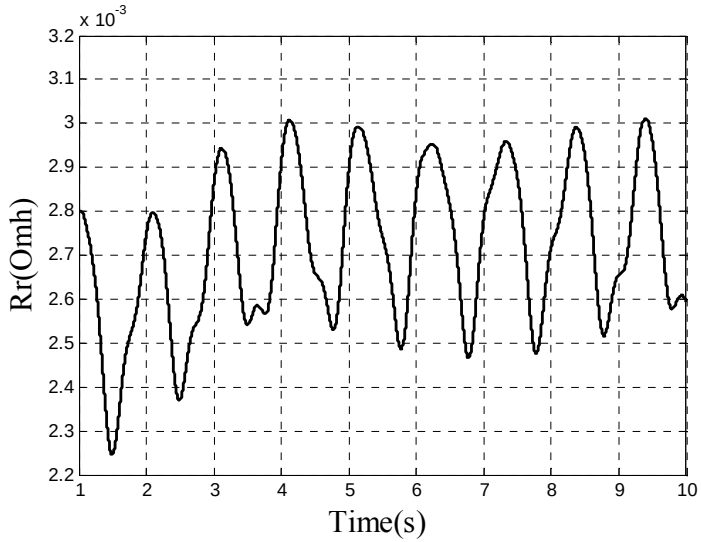


Double integrator

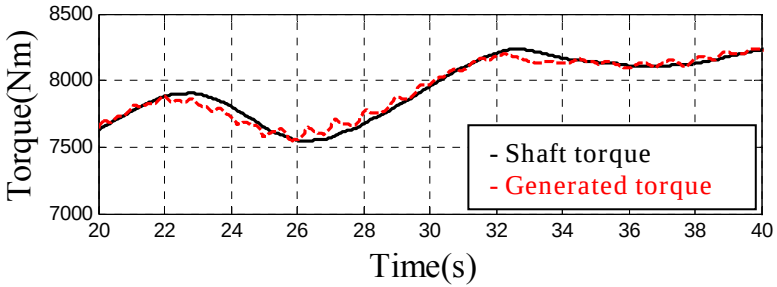


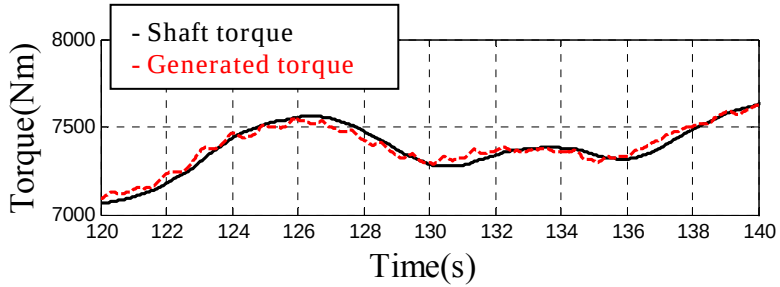


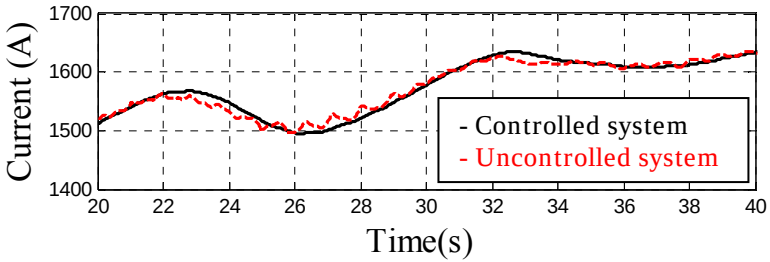


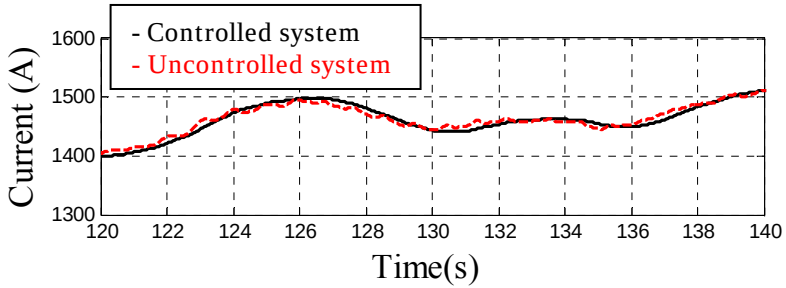


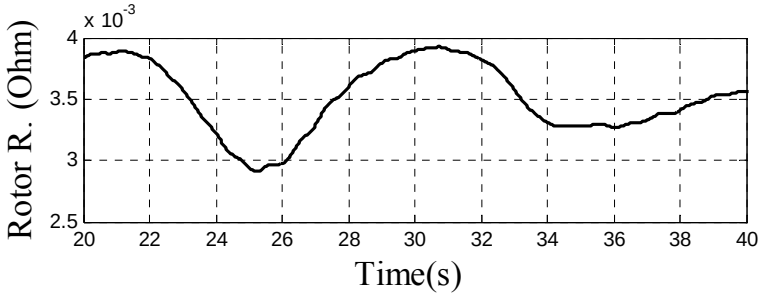
Double integrator (Real shaft torque curves)

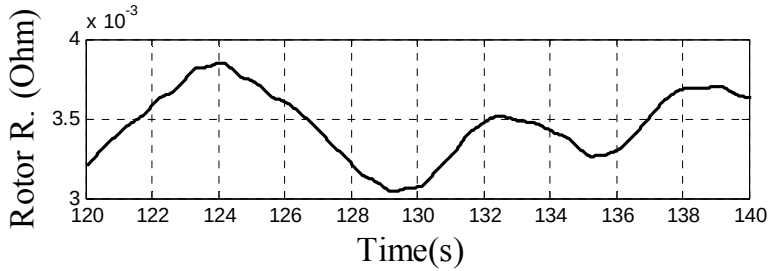












Power quality improvement (flicker emission reduction)

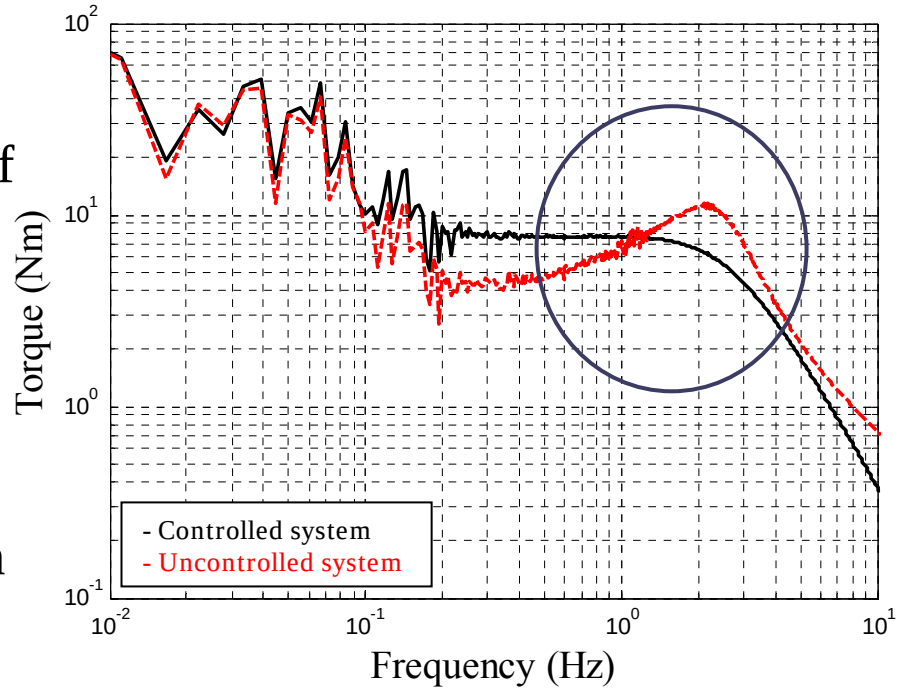
	1st gap	2nd gap	3rd gap	4th gap	5th gap	Average
With variable rotor resistance controller	0,48	0,4	0,41	0,335	0,395	0,404
Without controller	0,895	0,575	0,585	0,52	0,59	0,633
Fixed rotor resistance to 3.6 mΩ	0,69	0,475	0,495	0,415	0,5	0,515
Fixed rotor resistance to 5.4 mΩ	0,61	0,44	0,46	0,385	0,46	0,471

47%

37%

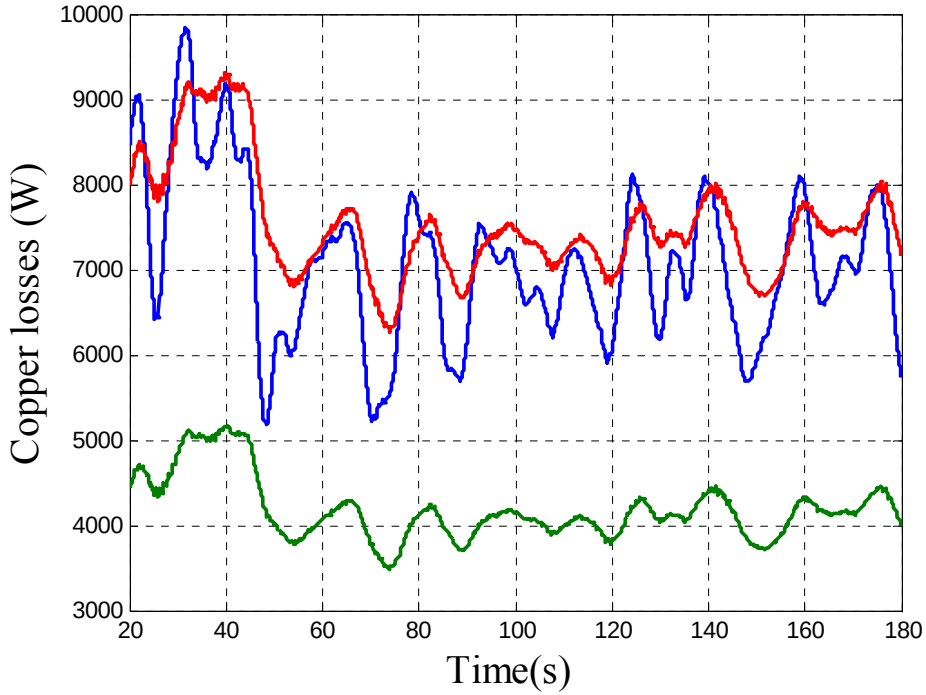
Mechanical stresses reduction

- Lower mechanical stresses means longer lifetime for the turbine
- Reduction in the magnitude of the high- frequency components of the electromechanical torque
- These components where moved to the low frequencies where does not affect so much to the mechanical stresses



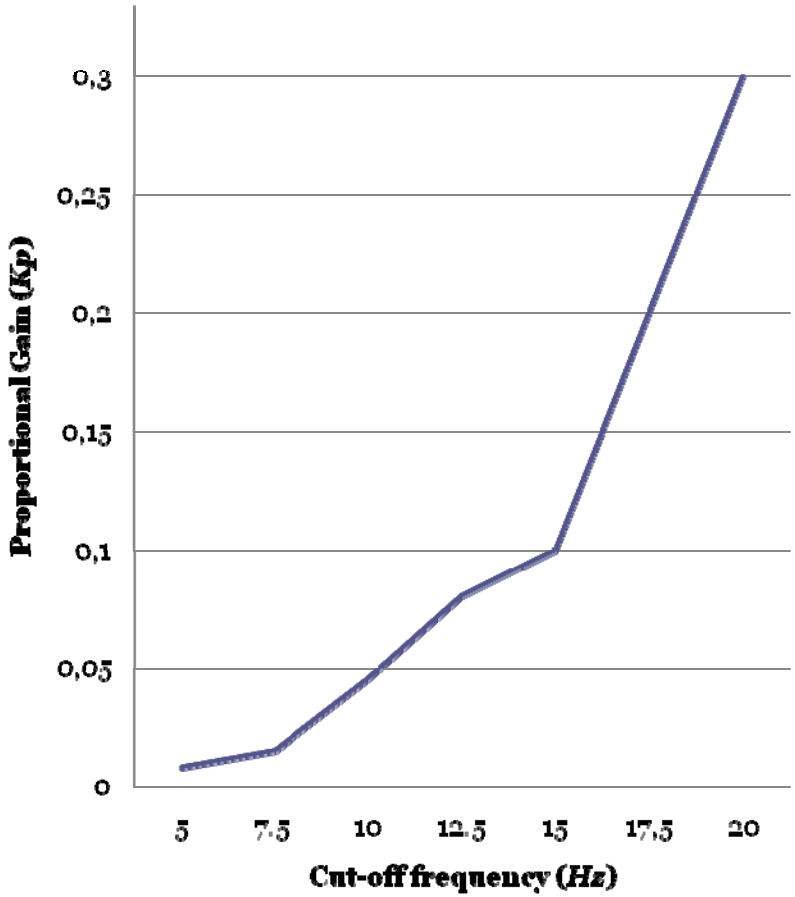
Energy losses in the induction machine

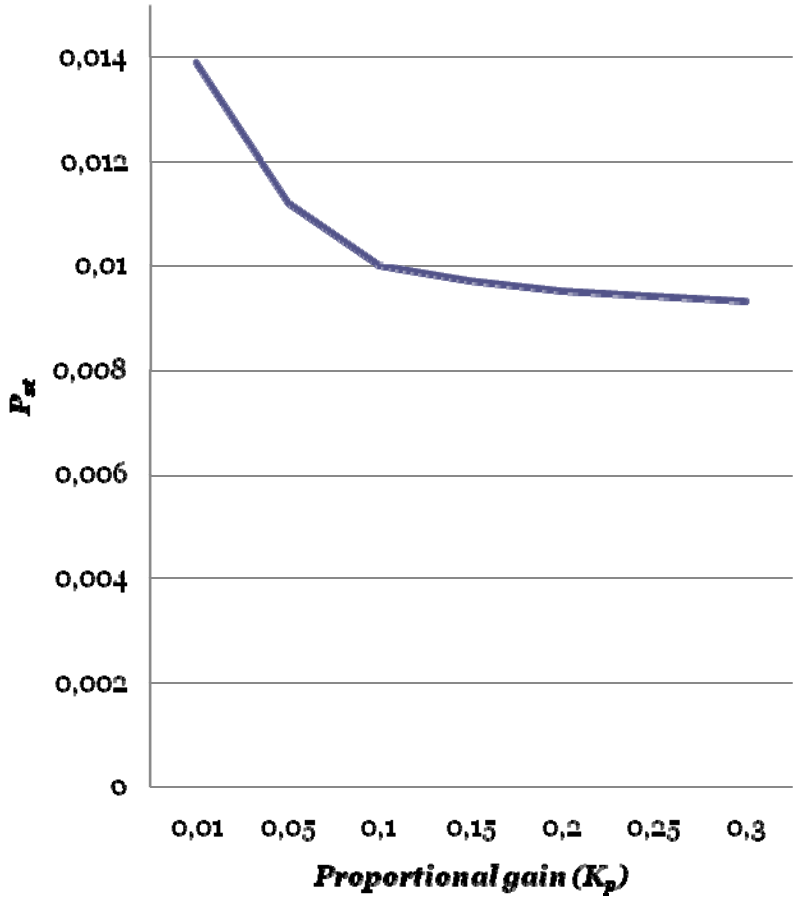
- The higher the average of the variable rotor resistance the higher the losses in the induction machine



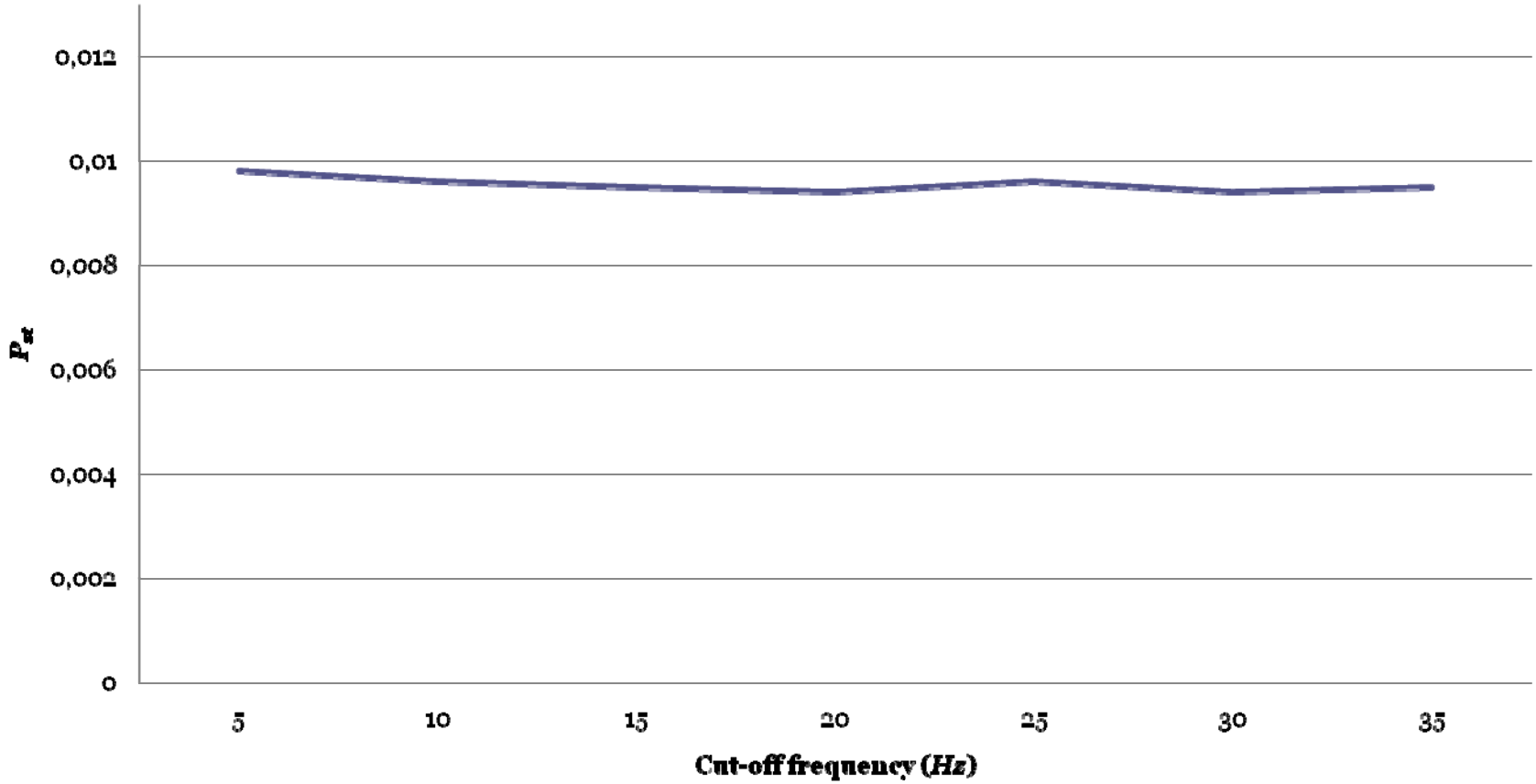
- Variable rotor resistance
- Nominal rotor resistance
- Rotor resistance fixed to 2 times the nominal value

Cut-off frequency and proportional gain

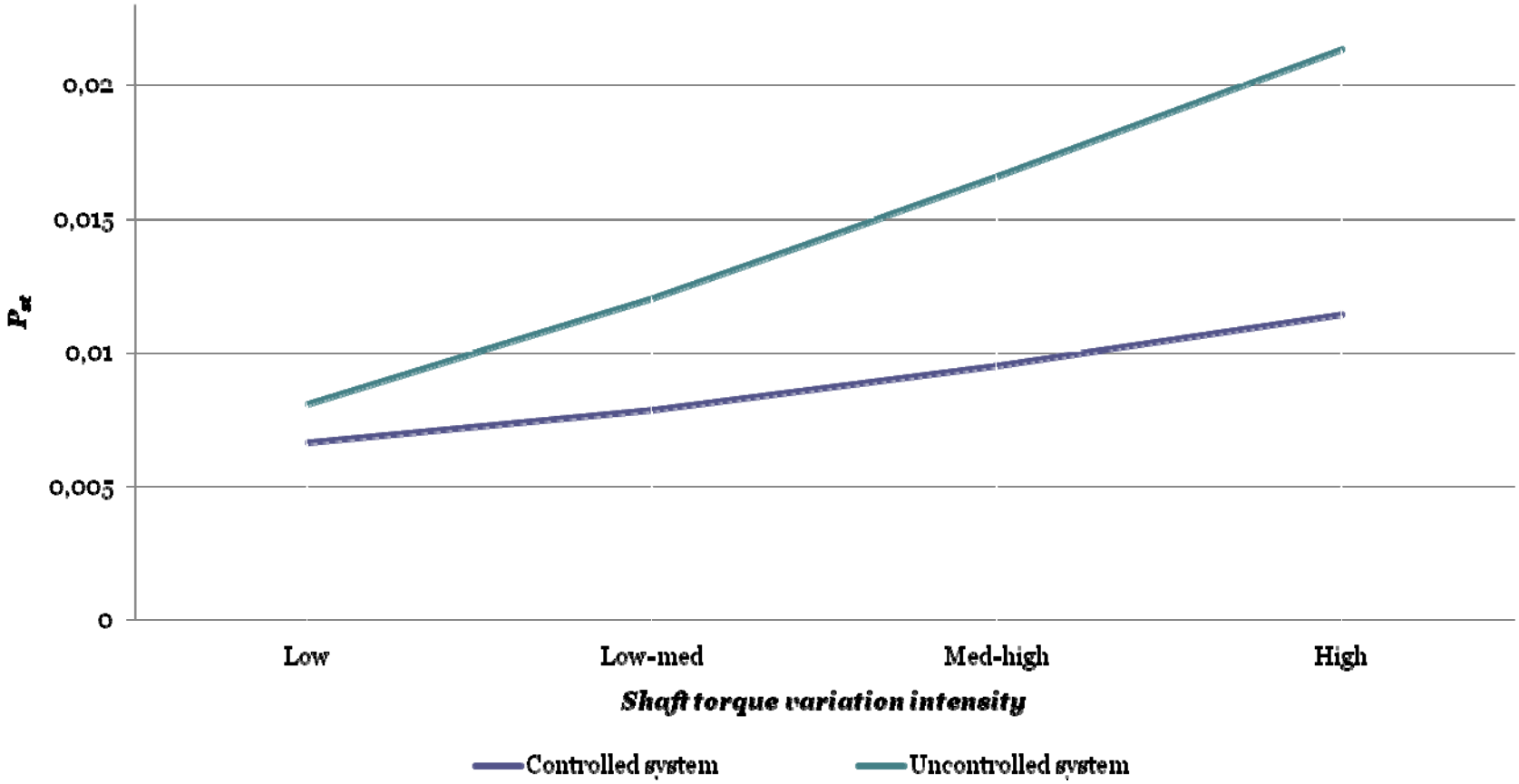




Cut-off frequency vs flicker reduction



Flicker reduction with regard to the uncontrolled system



Final specifications

- *Cut-off frequency = 20 Hz*
- $K_p = 0.3$
- $R_{ro} = 1.8e\text{-}3\ m\Omega$

Conclusions

- Flicker reduction between 35%-60%
- Flicker reduction strongly related with the turbulence intensity of the shaft torque
- Reduction of the mechanical stresses

THANK YOU FOR YOUR ATTENTION!

ANY QUESTION?