

Collective Pitch Controller

Exercise to Lecture #3 Controller Design for Wind Turbines and Wind Farms

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1 Design of a Collective Pitch Controller

Please run [Exercise03_PitchControllerTest.m](#). In this first set of simulations, the pitch controller is tested with wind steps of 0.1 m/s at the operation points of 12 m/s, 16 m/s, 20 m/s, and 24 m/s.

With the control parameters in [NREL5MWMWDefaultParameter_FBNREL_PitchController.m](#), the wind turbine remains again uncontrolled, see Figure 1 (left).

The objective is to have a closed-loop transfer function with a damping of 0.7 and a natural angular frequency of 0.5 rad/s at all 4 operation points, see Figure 1 (right).

Similar to the torque controller exercise, in this exercise some parameters for the pitch controller are missing in the function [NREL5MWMWDefaultParameter_FBNREL_PitchController.m](#) and also the Simulink model needs some correction.

- a) What are the poles of the desired closed-loop? Is the closed-loop stable?
- b) How does the step response of the desired closed-loop look like? You can use the Matlab command `tf` to define the transfer function and `step` to simulate the step of the nominal system. The static gain G_0 can be set to 1.
- c) Please determine the PI parameters (proportional gain k_p and time constant of the integrator T_i) for the four operation points with the desired damping of $D = 0.7$ and a angular frequency of $\omega = 0.5$ rad/s using the script [Exercise03_PitchControllerDesign.m](#) and the function [LinearizeSLOW1DOF_PC.m](#). The solution needs to be copied to [NREL5MWMWDefaultParameter_FBNREL_PitchController.m](#).
- d) Please implement the pitch controller in the subsystem `FBNREL/Pitch Controller` in the Simulink model [NREL5MW_FBNREL_SLOW1DOF_PitchController.mdl](#) without anti-windup but with gain scheduling (via interpolation) to obtain with [Exercise03_PitchControllerTest.m](#) the correct results, see Figure 1 (right). You can use the “Saturation Dynamic” block for the saturation and the “1-D Lookup Table” for the gain scheduling.
- e) Please implement an anti-windup and run a simulation with a wind step from 12 m/s to 10 m/s and back to 12 m/s using the script [Exercise03_AntiWindupTest.m](#). Please test the effect with and without the Anti-Windup. The results should be similar to Figure 2.

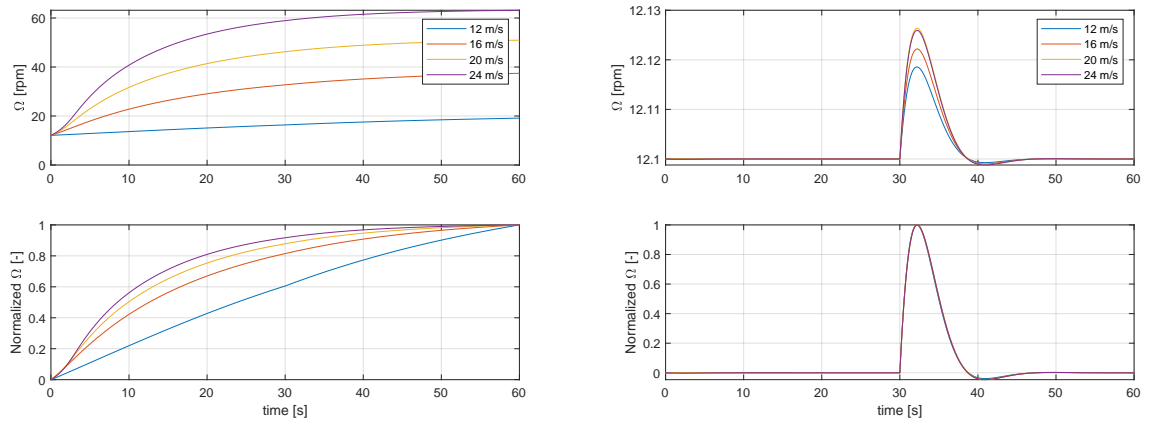


Figure 1: Start (left) and solution (right) of Exercise 3.

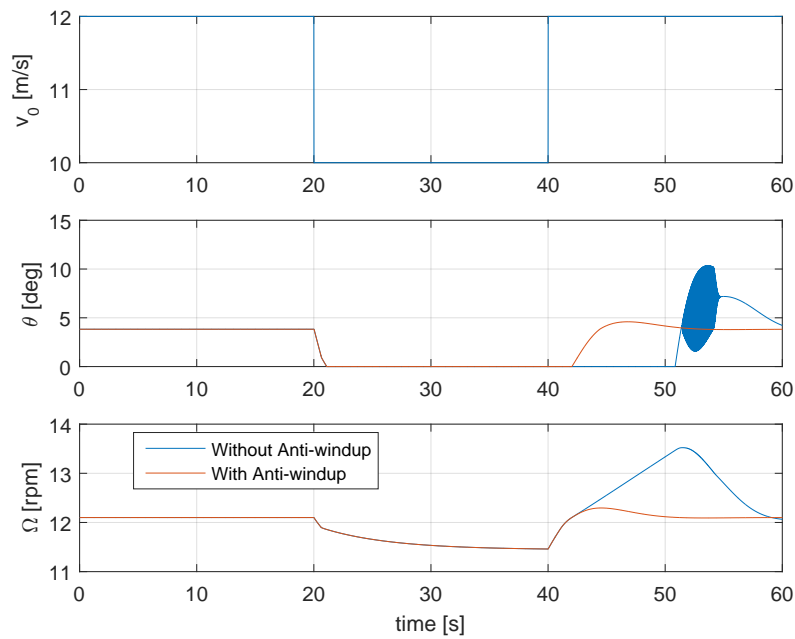


Figure 2: Effect of Anti-Windup.

2 Evaluation of a Collective Pitch Controller

Modify a copy of [Exercise03_PitchControllerTest.m](#) to compare the FAST and the SLOW model to a wind step of 0.1 m/s at 20 m/s by plotting the rotor speed over time. Use the FAST input files from the [FAST](#) folder and perform the following steps:

- Update the controller parameters (proportional gain k_p and time constant of the integrator T_i) in [FBNREL_Ex03_discon.in](#).
- The FAST file is modified to produce binary output files to get a higher accuracy. Use the [ReadFASTbinary.m](#) to read in the results and `strcmp` to extract the signals.
- The results should be quite similar. Why are they not exactly the same?

Note: The edgewise blade mode DOF is disabled to avoid resonances.