Collective Pitch Controller

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

David Schlipf

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1 Design of a Collective Pitch Controller

Please download the zip folder 03_Exercise.zip, unpack it, and run Exercise03_TestPitchController.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_EX3, the wind turbine remains again uncontrolled, see Figure 1 (left).

The objective is to have a close 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, some parameters for the pitch controller are missing in the function NREL5MWMWDefaultParameter_FBNREL_EX3 and 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 $\omega = 0.5\,\mathrm{rad/s}$ using the script Exercise03_ClosedLoopShaping.m and the function LinearizeSLOW1DOF_PC.m. The solution needs to be copied to NREL5MWMWDefaultParameter_FBNREL_EX3.m.
d) Please implement the pitch controller in the subsystem `FBNREL/Pitch Controller` in the Simulink model NREL5MW_FBNREL_SLOW1DOF_EX3.mdl without anti-windup but with gain scheduling (via interpolation) to obtain 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_AntiWindup.m. Please test the effect with and without the Anti-Windup. The results should be similar to Figure 2.

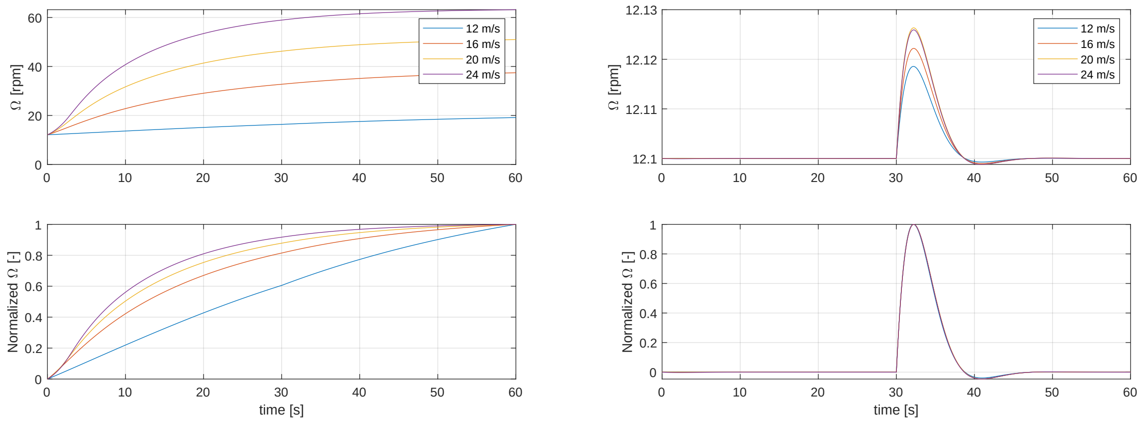

Figure 1: Start (left) and solution (right) of Exercise 3.

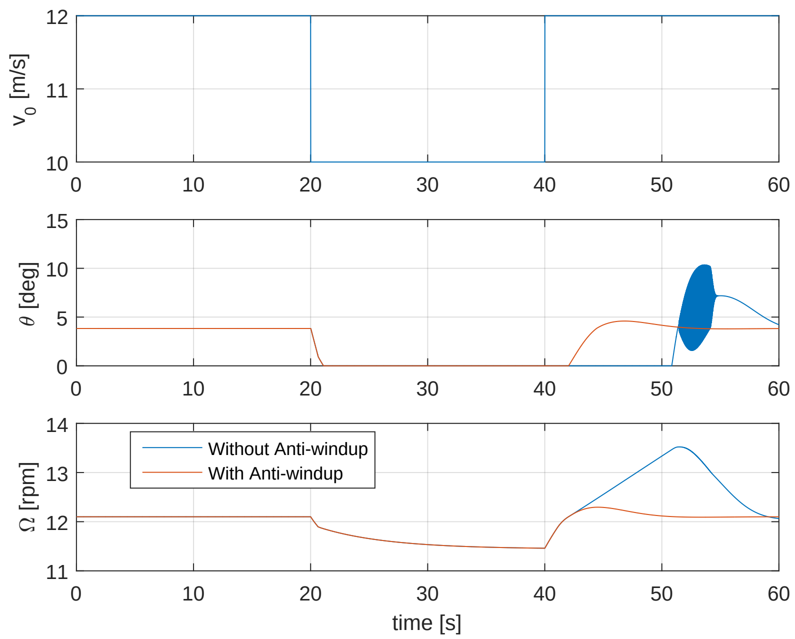

Figure 2: Effect of Anti-Windup.

2 Evaluation of a Collective Pitch Controller

Compare the reaction of the FAST model to a wind step of 0.1 m/s at 20 m/s to the reaction of SLOW by plotting the rotor speed over time. You can use the FAST input files from Exercise 2 and perform the following steps:

- update the initial conditions (pitch angle, tower position and rotor speed is usually enough, you can get them from the SLOW steady states)
- update the controller parameters (in FBNREL_Ex03_discon.in)
- update the wind input to a wind step of 0.1 m/s at 20 m/s
- disable the drive train rotational-flexibility DOF in ElastoDyn to avoide resonances
- adjust the FAST file to produce binary output files to get a higher accuracy and use the ReadFASTbinary.m to read in the results