Baseline Generator Torque Controller

Exercise to Lecture #2
Controller Design for Wind Turbines and Wind Farms

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1 Design of a Baseline Torque Controller

The baseline torque controller should be designed, implemented and tested with a wind step from 8 m/s to 9 m/s.

With the settings in the case Exercise02.m, the wind turbine remains uncontrolled, see Figure 1, since the implementation (in NREL5MW_FBNREL_SLOW1DOF.mdl) and the parameterization (in NREL5MWDefaultParameter_FBNREL.m) are missing. Based on [1], the region 1.5 of the torque controller should ramp up linearly from 670 rpm and reach the optimal curve at 871 rpm. In region 2, the torque controller should keep the turbine at a tip speed ratio of $\lambda_{\text{opt}} = 7.55$ and the pitch angle should be 0 deg. The region 2.5 should ramp up linearly from 1150.9 rpm and reach the rated value at 1173.7 rpm. Thus, with the corrected files, the turbine should maintain in the initial states at 8 m/s. For 9 m/s the turbine should approach λ_{opt}, see Figure 2.

a) Please make you familiar with the provided files.
b) The function NREL5MWDefaultParameter_FBNREL.m contains the parameters for the torque controller. Please determine following parameters:
   - `Parameter.VSC.k`
   - `Parameter.VSC.M_g_rated`
   - `Parameter.VSC.a_1_5`
   - `Parameter.VSC.b_1_5`
   - `Parameter.VSC.a_2_5`
   - `Parameter.VSC.b_2_5`

   Note: The power coefficient c_{P} over θ and λ is loaded into `Parameter.Turbine.SS`. You can use `interp2(theta,lambda,c_P,theta_opt,lambda_opt)` for interpolation.
c) Which tip speed ratio would have been even better than $\lambda_{\text{opt}} = 7.55$? For that, you can select the line in the c_{P} table corresponding to the pitch angle $\theta = 0$ deg and use the `max` command. How much more power (in percent) could you expect?
d) Please implement the nonlinear state feedback in the function `BaselineVSControl` of the subsystem `FBNREL/FBNREL Torque Controller` in the Simulink model NREL5MW_FBNREL_SLOW1DOF.mdl to obtain the correct results.

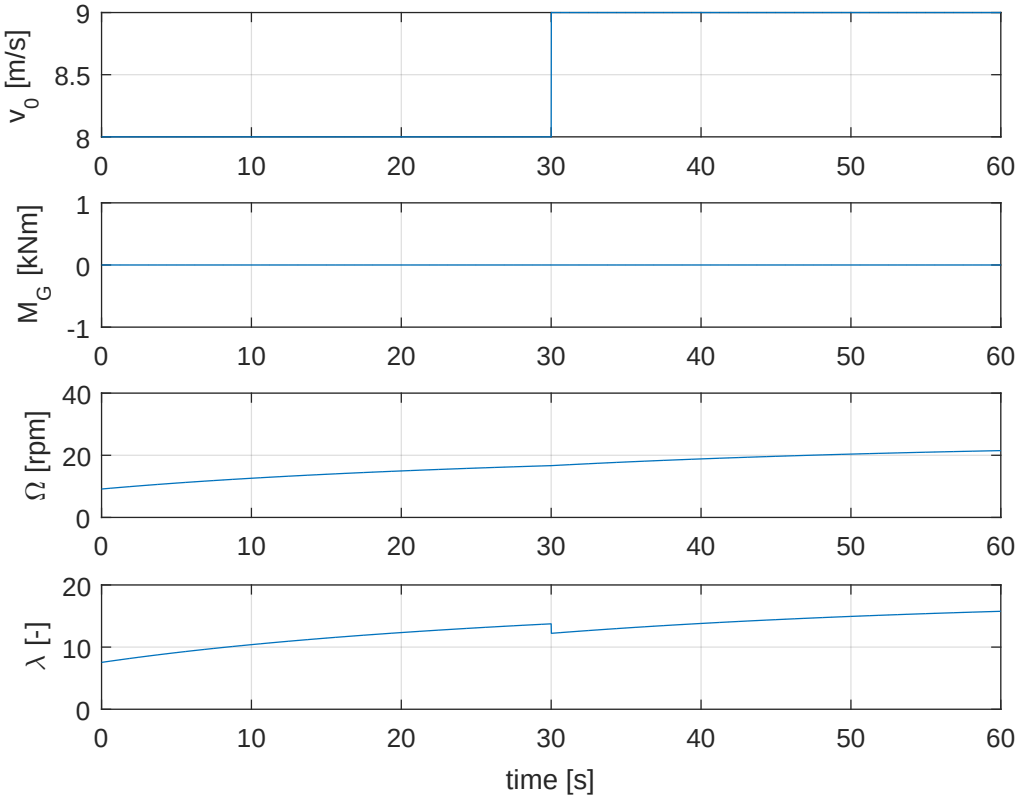

Figure 1: Start of Exercise 2.

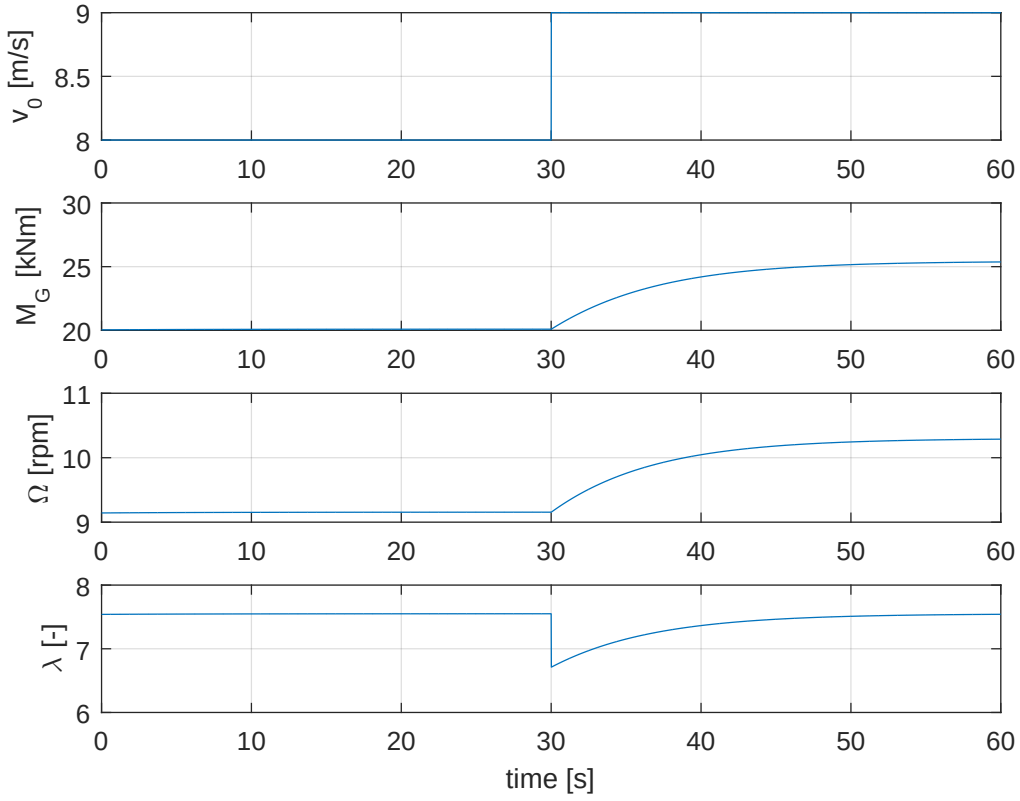

Figure 2: Solution of Exercise 2.

2 Evaluation of a Baseline Torque Controller

a) Please run the FAST simulation with the wind step from 8 m/s to 9 m/s in the FAST folder and compare it to SLOW simulation by adding a processing and postprocessing section to Exercise02.m. Use `dos('FAST_Win32.exe TorqueControllerTest.fst')` to run the code and `fopen`, `textscan`, and `fclose` to load the data into Matlab. You can use code from the previous exercise.

b) Please generate new FAST input files to run the turbine with constant wind speed at 9 m/s.

c) For the operator it is worth to loose 1 % of power by a lower tip speed for reducing the noise. Which tip speed ratio should be used? Which other parameters need to be adjusted? Write an additional script for this investigation. Then add a new FBNREL_Ex02_discon.in and modify the FAST input files accordingly.

d) Check whether the lower rotor speed and the tolerated power loss is reached with FAST. What could be the reason for possible differences?

References

[1] J. Jonkman, S. Butterfield, W. Musial, and G. Scott. *Definition of a 5-MW Reference Wind Turbine for Offshore System Development*. Tech. rep. TP-500-38060. NREL, 2009. DOI: 10.2172/947422.