Filter Design

Exercise to Lecture #4
Controller Design for Wind Turbines and Wind Farms

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1 Design of a Low Pass

For the NREL 5MW reference wind turbine a faulty generator speed sensor transmits the power line hum at 50 Hz to the measured generator speed signal.

a) Test the script Exercise04_LowPassTest.m. You should get a plot like in Figure 1. What is the amplitude of the pitch signal due to the power line hum?
b) Please implement in the subsystem `FBNREL/Filter Generator Speed/LowPassOrder1` of the Simulink model NREL5MW_FBNREL_SLOW2DOF_LowPass.mdl a first order low pass filter. Please use the commented out blocks. Use a cut-off frequency at 50 Hz by adjusting the corresponding parameter in NREL5MWDefaultParameter_FBNREL_LowPass.m. How much is the power line hum reduced in the filtered generator speed signal? What is the time shift?
c) Please adjust the cut-off frequency such that the amplitude of the power line hum in the filtered generator speed signal is reduced to 1%. What is the amplitude of the pitch signal now?
d) Which filter type would have been better in this case (frequency of the noise is well known)?

Filtro de Noche

2 Design of a Notch Filter

The rotational sampling of turbulent wind field and other effects result in 3P frequencies in the generator speed signal and due to the proportional part of the pitch controller also in the pitch signal. These frequencies need to be removed to avoid resonance and unnecessary pitch action.

a) Please test the script Exercise04_NotchFilterTest.m. You should get a plot like in Figure 2. What is the standard deviation of the generator speed and pitch rate?
b) Please adjust the cut-off frequency of the low pass filter from the previous exercise in the file NREL5MWDefaultParameter_FBNREL_NotchFilter.m such that the filtered generator speed signal at the 3P frequency is reduced to 10%. How does this impact the control performance (standard deviation of the generator speed) and pitch activity (standard deviation of the pitch rate)? Why is a low pass not a good idea?
c) Please disable the low pass filter again. Please implement a dynamic notch filter in the of the subsystem `FBNREL/Filter Generator Speed` of the Simulink model NREL5MW_FBNREL_SLOW2DOF_NotchFilter.mdl with the available blocks.
d) Please adjust the cut-off frequency of the additional low pass filter of the generator speed to be roughly 4 times slower than the closed-loop frequency.
e) Please adjust the gain, relative bandwidth, and depth of the notch filter to have smooth spectra at the 3P frequency. What is the standard deviation of generator speed and pitch rate?
f) Please adjust the relative bandwidth to 60% and the depth to 0.01, which will result in too much filtering. What is the effect on the standard deviations?

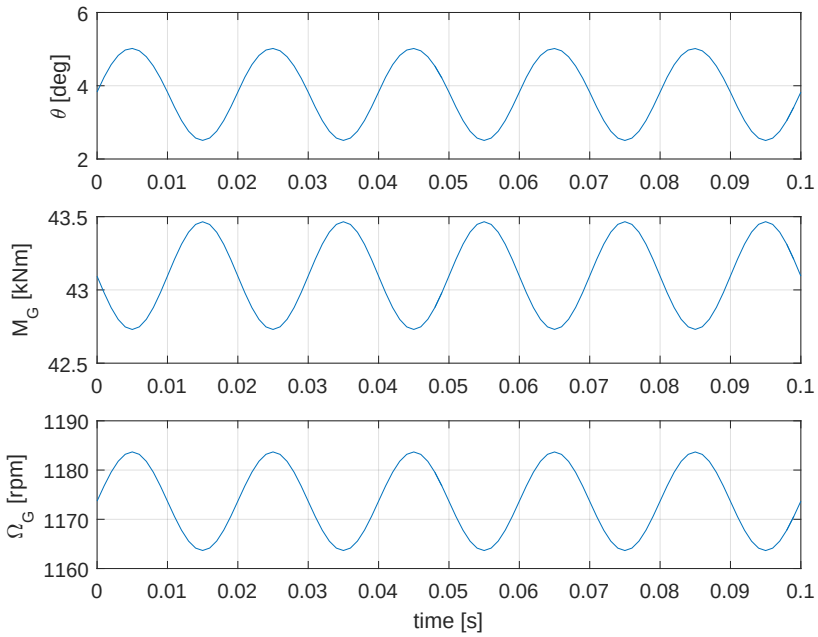

Figure 1: Start of low pass filter design exercise.

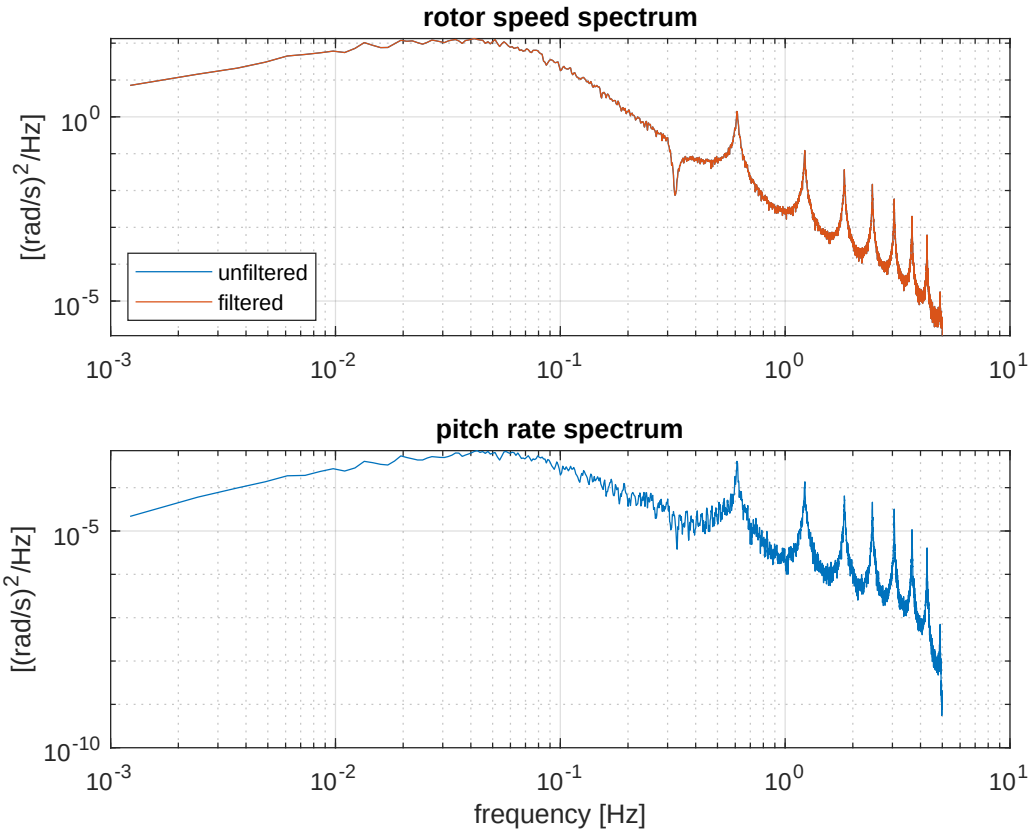

Figure 2: Start of notch filter design exercise.