Wind Field Generation

Exercise to Lecture #7
Controller Design for Wind Turbines and Wind Farms

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1 Wind Field Generation

Here, we only consider one point at hub height of 90 m.

a) Calculate the amplitudes of an IEC Kaimal longitudional spectrum [1] at 20 m/s and turbulence class A for following frequencies: 0.001, 0.01, 0.1, and 1 Hz. Use 0.001 Hz for the frequency resolution.
b) Generate a wind time series for IEC Kaimal longitudional spectrum [1] at 20 m/s and turbulence class A, with a length of $T = 4096$ s and a discretization of $\Delta t = 0.25$ s considering frequency up to $f = 2$ Hz. Use the seed 1 for uniformly distributed phase angles between 0 and 2π.
c) Compare the analytic spectrum with an estimated one using `pwelch`. Use first a single block, a rectangular window, and no overlap. Then use at least 8 blocks, a hamming window with the block length, and 50% overlap. Use the second setting for the rest of the exercise.
d) Prove by numerical integration that the standard deviation of the time series is close to the square root of the area below the spectrum.
e) Generate the spectrum of a rotor effective wind speed (grid resolution of 4 m) and a rotor diameter of 126 m and compare it to the single point spectrum.

2 Wind Field Analysis

a) Generate a turbulent wind field with the same grid resolution and spectral properties as above using TurbSim.
b) Read the wind field into Matlab with readBLgrid.m.
c) Compare the analytic spectrum of a single point with an estimated one for the wind at hub height using `pwelch`.
d) Compare the analytic spectrum of the rotor-effective wind speed with the estimated one using `pwelch`.
e) Compare the magnitude squared coherence from [1] (so you have to square "Coh(r,f)") to the estimated one from two points at hub height with a distance of 4 m using `mscohere` with at least 16 blocks. For more details about the bias in coherence calculations see [2].

References

[1] IEC 61400-1. *Wind turbines - Part 1: Design requirements*. International Electrotechnical Commission, 2005.

[2] J. S. Bendat and A. G. Piersol. *Random data; analysis and measurement procedures*. New York, USA: John Wiley & Sons, 1971.