Answers to reports on wes-2022-109

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Answer to anonymous referee 1

1. **Comparison about ROSCO platform pitch controller strategy and the proposed platform pitch controller strategy**: The main difference in the two approaches can be remarked at lines $305-310$. As it can be remarked, the two ways to define the platform pitch compensation k_β. ROSCO derives the parameter imposing the rotor dynamics and the platform pitch dynamics to be decoupled at the first order. In other words, the effect of relative wind generated by the platform pitch dynamics is, at first order, compensated by feathering. The strategy proposed in this new paper aims at taking advantage of the blade pitch control influence on the platform pitch dynamics in order to introduce an extra term in the second order dynamics equation of the platform pitch. Thus the second order dynamics equation has an explicit form involving a damping ratio ζ_{plt} whose value one can explicitly define.

   On can, then, notice that the two formulas to define k_β for ROSCO strategy and the proposed strategy are different. Also numerically, they lead to values that are opposite in sign.

   Indeed, $\frac{\partial F_a}{\partial \beta} < 0$ (for an above-rated operating point) and therefore using inequality (51), we find that

   $$k_\beta = \frac{1}{h_t \frac{\partial F_a}{\partial \beta}} \left(2\sqrt{K_t J_t}\zeta_{plt} - D_t - h_t^2 \frac{\partial F_a}{\partial v} \right) < 0$$

   On the other hand, ROSCO strategy, as it is defined in (Abbas, 2022) or (Sotckhouse, 2021) derives from the equation $A_{2,4} = 0$ where A is the matrix defined in (17) ((Abbas, 2022) introduces that same matrix) and expresses the platform pitch control coefficient as

   $$k_\beta = -h_t \frac{\partial \tau_a}{\partial v} / \frac{\partial \tau_a}{\partial \beta} > 0$$

   It is negative since $\frac{\partial \tau_a}{\partial v} > 0$ and $\frac{\partial \tau_a}{\partial \beta} < 0$ (for an above-rated operating point). Notice that in (Abbas, 2022), β_{comp} is defined as in (Stockhouse, 2021) but with the convention $\beta_{comp} = k_{float}\dot{\phi}$ so that $k_{float} = -k_\beta = h_t \frac{\partial \tau_a}{\partial v} / \frac{\partial \tau_a}{\partial \beta}$ is negative, but this is just a question of conventions. If one takes the same convention, the sign is actually switched in our formula.

   About the comparison on the numerical tests, we tried to compare to ROSCO during the work in two ways: by using the ROSCO controller as downloaded from github and also by implementing the equations explained in Abbas2022. In both cases, the obtained results not in line with the ones found in Abbas2022. Hence, we concluded that we missed some other parameters for those simulations. It is much better to compare to a strategy with $k_{beta} = 0$. This term of comparison has not been well presented in the paper, but it corresponds to a "detuning strategy". In fact, to find the right ν_{rot} and ζ_{rot} of equations (36) at line $274-279$, a lot of simulations have been tested in order to find the best values for this platform and this wind turbine generator. However, if necessary one can compare the strategies by looking at the article Abbas2022 which considers the same numerical test as the one considered in this article.

2. line 50: comment accepted and introduced in the next paper version.

3. line 64: Lenfest2020 linearizes the k_β (called k_px in his article) and the authors calibrate a scheduling of the values of k_β by testing many numerical values, instead of making an analytical studies on the platform damping to define the parameter. The proposed strategy has an explicit form involving a damping ratio ζ_{plt} whose value one can explicitly define to obtain the right parameter.
4. Line 75, the hinge point of the platform is the COG of the platform. An image will be added to make it clear.
5. 91, comment accepted and introduced in the next paper version (τ_w replaced by τ_{wave}).
6. Line 96: comment accepted and introduced in the next paper version.
7. Line 102, comment accepted: the sentence is removed in the next paper. It does not add any information.
8. Line 121, comment accepted and introduced in the next paper version.
9. Line 125, "relative speed" replaced by "infinitesimal speed" $\omega = \Omega - \Omega_r$.
10. Line 125, Yes, it is indeed the onshore standard blade pitch control.
11. Figure 1: we'll modify the scheme to remove $\dot{\Phi}_r = 0$.
12. Line 153: "closed loop" will be added to the sentence.
13. Line 155: this is the *Laplace* domain. It will be clarified in the next version.
14. Line 161: the size of the equations with matrix is too big to write it in the article. It could be done in an Annex, if necessary.
15. Line 166: corrected
16. Line 174: corrected
17. Line 174: corrected
18. Line 167: corrected
19. Line 185: "the amplitude" will be replaced by "the importance" to make it clear
20. Line 191: "with respect to the platform pitch at the operating point" will be added
21. Line 193: we propose to replace the sentence by "When the equation is verified, it means that: τ_a is more sensitive to blade pitch than rotational speed and F_a is more sensitive to omega than blade pitch. Therefore, by increasing blade pitch ω increases and, then, occasions F_a to decrease. Then, ϕ increases."
22. Line 200 Table 1. the values are determines arbitrarily as examples, to ensure the appearance of NMPZs. This is done in the purpose of a pedagogic example to show the effects of the NMPZs. The values are purely numerical. There are not so far from the coefficients related to the IEA15MW wind turbine because we started from those physical values and we found the right coefficients, in the order of 10% or 20%, to make the system unstable. The numerical section focuses on more realistic FOWT tests.
23. Line 200. Caption clarified by: "Platform pitch (ϕ) and rotor speed (ω) responses to a blade pitch (β)-step input ..."
24. Line 220. A graphic visualization of the roots of G(s) will be added. We'll show how those roots move when m_{τ_g} varies, and that will explain its utility. (Stockhouse, 2021) introduces m_{τ_g} and explains that the choice of $m_{\tau_g} = 1$ avoids any eventual NMPZ, but is not always possible because of τ_g saturation. The stability margin will be discussed.

25. 232: for the NMPZ $\omega --> \phi$ a solution is proposed by (Stockhouse, 2020) with the introduction of the m_{τ_g}. For the NMPZ $\beta --> \phi$, at our knowledge it is the first time to be analysed. This paper does not investigate a solution.

26. Line 259: the coupled system is 4x4 fully populated. It is very hard to be diagonalized. We tried to solve it by using symbolic software languages. However, it didn't come to an outcome, it didn't give anything usable in practice. It has been chosen to continue on 2x2 simplified systems. In this case, damping expressions are explicit. Modal dampings could be expressed but they they should be very similar to the one already expressed because the system has only 2 dofs.

27. Line 273: Indeed, this is the same equation as for a rotor with a fixed nacelle.

28. Line 283: Actually here we are not in open-loop condition. The hypothesis $Kp = Ki = 0$ is to arrive to a 2x2 system and the control is ensured by $k_\beta \neq 0$

29. Line 322: in text we'll add "disturbance and open-loop" input.

30. Line 352: $k_{\tau_g} = 0$ has already been studied by "Stockhouse" and it was not interesting to repeat the same study

31. Line 360: Quality factor is defined by

$$Q = \frac{1}{2\zeta}$$

    As some readers might be more used to work with quality factors instead of damping ratios, we thought it was a good thing to give the quality factors corresponding to the damping ratios. It is not mandatory for the comprehension of the paper.

32. Line 366: We'll add in the text: "corresponding to Table 4" as suggested.

33. Line 367: When the platform pitch rate is compensated, the Thrust changes because of the change in the blade pitch (induced by k_β) and the mean platform rotational position change. In fact the system slightly shifts to another operating point.

34. Line 367 (Figure 6): When comparing results from section 3. with Figure 5, one should keep in mind that in in section 3, the system is way more complex: Figure 5 corresponds to a 2-dimensional state-space model. Moreover, what is underlined by Figures 6 and 7 is the comparison between the damping of an input of period 11s and an input of period 28.75s. In figure 6, the gain is much lower than in figure 7 and we can, then, see a similar trend to the one of Figure 5. When comparing Figures 6 and 7, one should also keep in mind that the chosen wave conditions have same height, but this does not mean that the input's amplitude is the same. We'll try to make this clearer in the paper.

35. Line 370: Figures 8 and 9 will be better explained.

36. Line 374: section 2.5 will be replaced by equation (50)

37. Line 399: Yes, k_β changes with time. A filter is also applied to change it smoothly since it focuses on low frequencies and it is useless to have high frequency changes.

38. Line 401: "section" added in the text.

39. Line 406: The mean value of the blade pitch changes because the increase in blade pitch variations makes the rotational speed increase. Hence in order to have this variations of the rotational speed, the mean value has to slightly decrease in order to not overpass the rated rotational speed.

40. Line 415. We correct the text by removing sentence "It is interesting .."

41. Line 424 (Table 7). This question is related to the one at Line 406. Please, refer to the previous answer.

42. Line 439. We'll explain variables in the caption.

43. Line 446. We'll replace in the text "those tendencies ..." by "they keep converging to the right solution".