

**Authors' response:
Assessing lidar-assisted feedforward and
multivariable feedback controls for large
floating wind turbines**

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First of all, we would like to sincerely thank all the reviewers for their interest in our manuscript and for taking their valuable time to carefully read our manuscript. Undoubtedly, the reviewers' comments have played a crucial role in improving the quality of our paper. We have carefully read and considered all the comments in detail and have revised our paper accordingly.

Please find below our response to the reviewers' comments. The reviewers' comments are repeated in black text, our response should be given in blue text, and if necessary, the corresponding corrections are provided in red text.

Response to comments of Anonymous Referee #1

Overall comments

The work is interesting and the manuscript is well written. It could be further improved by:

- (1) Adding a nomenclature section at the beginning of the document.
- (2) Adding a block diagram of the control structure.
- (3) Providing some information on the baseline feedback control. Maybe some step simulations or the frequency response of the open loop and closed loop system.
- (4) Providing some more data about the numerical optimization. How did you choose the total amount of simulations, the step in the different values, etc?

Some other corrections on typos and grammar are attached in the pdf.

We would like to thank the referee for the interest in reviewing this research and the positive feedback on the manuscript. We have went through the paper again and corrected the typos and grammatical errors according to the comments in the attached PDF. Please see the “Specific comments” below for the detailed response to these points.

Specific comments

1. Adding a nomenclature section at the beginning of the document.

Thanks for the your comments. We have added the nomenclature at Section 1.

2. Adding a block diagram of the control structure.

Thanks for the your suggestions. We have modified Figure 3 to include the detailed control block diagram of the pitch controller.

3. Providing some information on the baseline feedback control. Maybe some step simulations or the frequency response of the open loop and closed loop system. Thanks for your comments. Actually, we have mentioned that the baseline feedback controller is the ROSCO controller by NREL, whos source code and detailed descriptions have been published. We added a sentence in Section 3.1 to emphasize this. We also added a figure to show the responses of the baseline feedback controllers to a extreme operating wind gust, as shown by Figure 4.

4. Providing some more data about the numerical optimization. How did you choose the total amount of simulations, the step in the different values, etc?

Thanks for the your comments. We have added the discussion in Section 4.1 as We have selected the variation ranges of these gains following the studies by Lemmer et al. (2020) and Zalkind et al. (2022). As for the step size selection, we consider the time consumption of simulation and make some compromises. The overall number of simulation cases and, hence, the time required, will rise dramatically if a smaller

step size is chosen. However, Figure 7 shows that the step size we chose clearly indicates trends in tower loads.

Response to comments of Anonymous Referee #2

Overall comments

The authors presented several implementations of controllers on a large scale floating offshore wind turbines, a baseline controller from the NREL, a slight modification of the baseline controller on the floating feedback with a fine tuning/optimization of the feedback gains called MVFB, and the MVFB controller in combination with a feedforward LiDAR assisted controller. From what I have understood, most of the innovation lies in the combination of existing blocks from the literature, the slight modification on the floating feedback, the implementation on a large scale floating offshore wind turbine and the optimization/fine tuning of the parameters. If there is more innovation than this, it seems unclear to me.

The authors successfully implemented these controllers and the MVFB controller in combination with the feedforward LiDAR assisted controller performs better than the MVFB controller alone, which performs better than the baseline controller.

The paper is quite well written, understandable and the presentation of the results is good.

We would like to thank the referee for the interest in this paper, the valuable time spent reviewing it, and the overall positive feedback on the manuscript. We have went through the comments and updated the manuscript accordingly.

Specific comments

1. The authors say throughout the paper that they are optimizing parameters of the orientation of the LiDAR beams and of the controllers, but I did not understand what optimization they were performing, as I did not spot any cost function, constraints or optimization algorithm. Therefore, I understand it more as a sequential fine tuning of parameters illustrated by the figures in the paper, and if it is, I guess a scheme summarizing in what order are the parameters optimized/tuned and how would be of great help for the clarity of the paper.

Thanks for the reviewer's comments. Indeed, the optimization problem was not clearly defined in the manuscript. We have added mathematical expressions as Equation 8 and added explanations after this equation.

2. In line 123, the authors say that they choose a time step of 0.293 seconds, it is a very precise number, and I wonder how did you chose it?

Thanks for the your comments. We added one sentence before to explain the reason. It is because that we wanted to have a total time steps of 2048 and a total simulation

time of 600s.

3. In lines 267 and 400, the word "overspend" is used, and I was wondering if it was a typo for "overspeed", or if it is not, can you define the word a little bit more, as this word is quite unusual to me.

Thanks for the your comments. Indeed, it was typos. We have corrected them to "overspeed" throughout the revised version.

4. In line 340, the authors state that the use of more advanced control strategies such as model predictive control should improve the performance, could you please develop and justify further your statement?

Thanks for the your comments. We extended the discussions to provide the general principle of MPC and the potentials to avoid the overspeed problem. We also added some literature that state the MPC algorithm with details.

5. In equation (11), the definition of the extended lifetime looks quite akward, first of all you could have written it more concisely as: $EL = 20((DEL_j/DEL_i)^m - 1)$. Moreover, the use of this metric looks quite unusual to me, could you please explain where does it come from or a cite a source first using it? ?

Thanks for the your comments. We have updated the Equation according to the suggestion. Also, we added literature that uses a similar but not totally equal definition. We did not use the definition $\left(\frac{DEL_i}{DEL_j}\right)^{-m}$ because it only shows the ratio of lifetime. With Equation (11), it shows the extended lifetimes that can be brought by LAC. For example, assuming a turbine is operated with the MVFB Baseline control for the designed 20 years and it brings a DEL value of 409.17 MNm (Tower) in Table 5. Considering another turbine with LACPF+MVFB control, this DEL level will be reached after 20+24.25 years. Therefore, the extended lifetime is 24.25 years.

Typos and grammar errors

line 3: "is considered the benchmark" -> "is considered as a benchmark" Thank you, this has been corrected in the revised version.

- line 101: "more large" -> "larger" Thank you, this has been corrected in the revised version.

- line 179: "transnational" -> "translational" Thank you, this has been corrected in the revised version.

- line 209: "butter time" -> "buffer time" Thank you, this has been corrected in the revised version.

- line 247: "values vary from 10 to ..." -> "values varying from 10 to ..." Thank you, this has been corrected in the revised version.

- line 316: "values fullfill the criteria" -> "values fullfilling the criteria" Thank you, this has been corrected in the revised version.

- line 357: "is slight higher than" -> "is slightly higher than" Thank you, this has been corrected in the revised version.

- line 391: "tends underestimate" -> "tends to underestimate" Thank you, this has been corrected in the revised version.

- line 415: "which can potential cause more damage" -> "which can potentially cause more damage" Thank you, this has been corrected in the revised version.

There might be a few others, therefore I strongly recommend the authors to carefully proofread their papers once again. Thank you again, we have proofread the paper once again.