Research engineer in vibration control of a floating substation for wind farms using non-linear dampers (F/M/X)

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France Energies Marines institute

France Energies Marines is the Institute for Energy Transition dedicated to Offshore Wind Energy. Its mission is to provide, enhance and nurture the scientific and technical environment necessary to overcome the obstacles facing this rapidly developing sector. With a multidisciplinary team of nearly 90 employees and a model of public-private collaboration, the Institute has a raison d'être: R&D, whether it is collaborative or carried out as part of a service activity.

Context

France Energies Marines is conducting, together with other partners (ENSTA Bretagne, Ifremer, LMA of Centrale Méditerranée, RTE, SuperGrid, Chantiers de l'Atlantique, TotalEnergies, RWE), the AFOSS-DC project. This project aims to design a first architecture of floating offshore substation for direct current applications needed for future large offshore wind farms. Based on electrical topside defined in preceding work package, two concepts of floaters will be investigated, and basin test will be conducted in order to perform motion and vibration analyses.

This job involves a study of the principle of vibration control of the substation or one of its components using a NES (Nonlinear Energy Sink) type damper to improve service life.

The vibration control of floating systems under various loads (wind, swell, seismic), particularly wind turbines, has been the subject of several studies [1]. For safety reasons, passive devices are preferred, as they require no external energy input. The vast majority of studies focus on linear passive systems such as single or multiple tuned mass absorbers, but also liquid tuned absorbers. These absorbers are designed to operate over a relatively restricted frequency range in the vicinity of the mode to be controlled. Any change, however slight, in the vibration properties of the system to be controlled will severely degrade the attenuation performance of this type of absorber. As floating systems are located in a marine environment, their vibratory properties may change as a result of operating conditions, ageing, or structural damage. As a result, passive linear absorbers, while offering good performance in terms of vibration level reduction, suffer from a lack of robustness.

To overcome this drawback, the use of nonlinear absorbers of the NES type is a promising research approach. Since Gendelman's early work [2], NES-type absorbers have received increasing attention from both the academic and industrial communities [3-5]. An NES-type absorber can be seen as an extension of a tuned-mass damper, correcting both its relatively high mass (10% of the dynamic mass of the system to be controlled) and its lack of robustness against variations in the mechanical properties of the system to be controlled. The absorber's mass is low (1 to 2%) compared with the system to be controlled, and its coupling stiffness is highly nonlinear of the cubic type. These characteristics enable the absorber to enter into resonant capture with the system to be controlled, whatever its resonant frequency, making it an intrinsically broadband device [6], particularly suited to the control of floating TLP-type substations whose considerable mass would imply very heavy and cumbersome linear absorbers.

However, this broadband behavior is accompanied by two parasitic effects that currently limit the performance of these absorbers [7]:

- An activation threshold effect rendering the system inoperative at low vibration levels.
- The presence of detached resonances at high vibratory levels can present a risk to the structure being controlled.
- These two parasitic effects are closely linked, since lowering the activation threshold favours the appearance of detached resonance.
- Preliminary studies have shown that the use of non-linear damping can lead to the reduction or even complete elimination of detached resonance without altering the broadband attenuation characteristics of the NES [8,9].

Job description

In the framework of this position, the successful candidate will be in charge of the following tasks:

- **Phase 1** (1 month): Bibliographic study of existing damping systems in the Oil & Gas and offshore wind industries, including TLP (Tension Leg Platform).
- **Phase 2** (5 months): Development of a simplified 2-degree-of-freedom (dof) model to describe the main motion to be controlled on the platform and the NES with non-linear stiffness and damping.

The deliverables to be produced by the successful candidate during his/her work in the project are the following:

- A state-of-the-art study including a bibliography of the TLP concept, existing absorption solutions and the principles used for the calculations.
- A section of a report describing the simplified model of the 2-dof system (main system and absorber), and the tools used for calculations.
- A numerical test report including the results of the absorber optimization as well as practical implementation ideas for such an absorber.

The chosen person will be supervised by researchers and engineers from LMA and France Energies Marines.

Profile and skills

Initial training

Master/Engineer in Acoustics or in Vibration mechanics ideally completed with a PhD

Specific knowledge and skills

Required:

- Applied mathematics
- Non-linear dynamics
- Programming in advanced numerical and symbolic calculation languages (Matlab, Mathematica or equivalent)

Desirable:

- Structural dynamics
- Acoustics
- Knowledge of NES

Professional assets

- Excellent English skills
- Strict scientific rigor
- Adaptability to new disciplines
- Initiative, scientific curiosity and multi-disciplinary spirit
- Taste for research and teamwork
- At ease in expressing oneself, at convincing others and in communicating in a collaborative context

Practical information

- **Type of contract:** Fixed-term contract (CDD)
- **Duration of the contract:** 6 months
- **Starting date**: 7 October 2024 (flexible)
- **Application deadline**: 1st September 2024
- **Work location:** The position is located in Marseille, mainly at LMA (around 80%) with periods of work at France Energies Marines Marseille (20%).

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The position is open to people with disabilities.

How to apply

- Applications must consist of a **CV** and a **cover letter.**
- In case of a candidate being seconded by a member of France Energies Marines, the application must mention the agreement of the current employer.
- To apply, please go to the France Energies Marines **website** under the **Join Us** section.
- For more information on this position, please contact: contactrh@france-energies-marines.org

Bibliographic References

[1] Zuo, H., K. Bi, and H. Hao (2020). “A state-of-the-art review on the vibration mitigation of wind turbines”. *Renewable and Sustainable Energy Reviews*

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[9] P.-O. Mattei, R. Côte (2022), Optimisation d'un absorbeur dynamique non-linéaire pour le contrôle vibratoire d'une éolienne flottante, *16ème Congrès Français d’Acoustique, Marseille*

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[12] Starosvetsky, Y. and O. V. Gendelman (2009). “Vibration absorption in systems with a nonlinear energy sink: Nonlinear damping”. *Journal of Sound and Vibration*

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