风能作为可再生能源之一，正发挥着不可替代的作用，为新电能的生成提供支持。最近，全球风电场的安装量显著增加。在澳大利亚，首座海上风电场——Star of the South，也在建设中。该风电场位于维多利亚州吉普斯兰的南海岸。将建设250台涡轮机，预计总成本为80亿美元。建成后，它将为大约120万家庭供电，并提供占维多利亚当前电力约20%的电力。

海上风力涡轮机由大叶片和细长的塔构成，以有效地提取风能资源。这些柔性结构容易受到风、海浪和甚至地震等外部振动源的影响。过度的振动会降低风能转换效率，导致结构疲劳损伤，甚至在恶劣环境条件下可能会导致风力涡轮机的灾难性完全失效。因此，控制海上风力涡轮机的有害振动至关重要。

研究状态：

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研究状态：
Various methods by respectively utilizing the passive, active, hybrid and semi-active mechanisms have been proposed and used to mitigate the vibrations of wind turbines, and to ensure their safeties and serviceability. Among these methods, the passive control devices such as tuned mass dampers (TMDs), tuned liquid column dampers (TLCs) and tuned liquid dampers (TLDs) were most widely used since these methods have simple configurations and do not need external power source. However, to achieve obvious and robust control effectiveness, large oscillating mass is needed, which impedes their applications in practices since the space in the nacelle, where it is installed, is relatively small.

A parallel direction to the TMD approaches is introducing negative stiffness elements for vibration control. The central concept of this approach is to reduce the stiffness of the damper by introducing negative stiffness into the system. The natural frequency of the system is thus significantly reduced, and the transmissibility of the system for all frequencies above the natural frequency can be reduced, which in turn enhances the control effectiveness. However, the negative stiffness in the damper may significantly reduce the static load capacity of the system, and therefore make the system unstable.

**Research aim:**

In this project, a novel negative-stiffness based TMD will be developed and used to control the vibration of offshore wind turbine subjected to wind loads. This novel system will combine the benefits of both the TMD and negative stiffness dampers while overcome their limitations. On the one hand, the damper will be designed to have the overall static stiffness of the conventional TMD, so that it will be stable under both the static and dynamic loads. On the other hand, due to the incorporation of negative stiffness, extraordinary damping will be added to the structure, and the vibration of the wind turbine can be therefore reduced evidently.

**Methodology:**

The damper will be developed in the Structural Dynamics Lab in Curtin University. In particular, disc springs will be used to achieve the negative stiffness due to its small size and high robustness. The developed damper will be tested by using the universal testing machine in the lab, and the mechanical behaviours of the damper will be examined. The damper will be further applied to a scaled wind turbine model, and shake table tests (which are available in the lab) will be performed to examine the performances of the wind turbine with and without the damper by equating the wind loads along the tower to the input at the base. Moreover, extensive parametric studies will also be carried out based on numerical analyses. In particular, the numerical models of the damper and the wind turbine will be calibrated by the experimental study, and the influences of the key parameters of the damper including the stiffness and damping will be systematically investigated.

**Benefits:**

This cutting-edge project builds directly on the research strength of Dr Kaiming Bi. His ARC DECRA (2015-2018) and DP (2019-2021) projects are on the vibration control of offshore structures (offshore pipeline and floating platform respectively). This project will be co-supervised by the ARC Laureate Fellow Prof. Hong Hao. All the selection criteria are met. The successful completion of the project will extend the service life of offshore wind turbines, which will significantly benefit the economy of Australia. It will also develop connections with offshore industry with the possibility of applying for competitive research grants such as ARC Linkage and CRC projects in the future.

**FEASIBILITY AND RESOURCING – DESCRIPTION OF THE SUPPORT THIS PROJECT WILL RECEIVE:**

The project will be supervised by Dr Kaiming Bi and ARC Laureate Fellow Prof. Hong Hao. Both have tremendous research and supervising experiences in the related fields. Dr Bi’s ARC DECRA and DP projects both work on the related area, and he has successfully supervised four PhD students to finish.
All the equipment required in the project (universal testing machine and shaking table) are available in the Structural Dynamics Lab in Curtin University. The licences of the software for the numerical analysis are also available. This project will be funded by Dr Kaiming Bi’s ARC DP Grant.

**WHAT MINIMAL ATTRIBUTES AND SKILLS EXPECTED BY THE CANDIDATE BE COMPETITIVE:**
The candidate should have research experience on Structural Dynamics. In particular, the one with the experiences in the following fields will be preferred:

1. Structural vibration control
2. Random vibration
3. Wind engineering

The candidate is also expected to be familiar with commonly used finite element software such as ANSYS or ABAQUS.

**THE SIGNIFICANCE OF THE PROJECT/ PROGRAM FOR THE ENROLLING SCHOOL OR INSTITUTION:**
The successful completion of the project will extend the service life of offshore wind turbines, which will significantly benefit the economy of Australia. The project will also demonstrate the ability of Curtin University to carry out cutting-edge research, which will contribute to Curtin’s leading position in science and research. Moreover, the developed negative-stiffness based damper has great commercialization potentials, it will attract industry partners to jointly apply for the competitive grants such as ARC Linkage and CRC projects, which will also significantly benefit the school and university.

Students are advised to contact the Project Lead listed below prior to submission of their scholarship application to discuss their suitability to be involved in this strategic project.

**PROJECT LEAD CONTACT**

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**EMAIL:** kaiming.bi@curtin.edu.au  
**CONTACT NUMBER:** +61 8 9266 5139

**CO-SUPERVISOR**

**NAME:** Professor Hong Hao  
**EMAIL:** hong.hao@curtin.edu.au