Experimental study on the Dynamic Behavior of a Metastructure Possessing Quasi-Zero-Stiffness Characteristics for Vibration Control Application

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Abstract. This work studies the dynamic behavior of a metastructure for vibration control applications in low-frequency ranges. The proposed metastructure works on the principle of high secant and low tangent stiffness, commonly known as Quasi-Zero-Stiffness (QZS). The metastructure consists of four-unit cells arranged parallelly, and each unit cell consists of cosine-beam system and semicircular arches arranged together to possess QZS behavior. The lower dynamic stiffness of the system shifts the natural frequency to a lower range, hence making possible a wide effective isolation region. To analyze the dynamic behavior, a vibration-shaker experiment is performed. The time-domain data is recorded by giving sinusoidal input; further, sine-sweep is performed to study the jump phenomenon. Finally, the obtained transmissibility vs frequency curve suggests a lower peak at resonance as compared to the equivalent linear model and a wider effective isolation region for the proposed metastructure.

Introduction

Low-frequency vibration has been the main cause of concern in industrial applications for almost a decade. Recent research suggests the application of a quasi-zero-stiffness (QZS) system as one of the non-linear passive isolation techniques to reduce the transmission of unwanted waves either to the payload or base. QZS is generally based on the concept of high static stiffness to support large weight, and low-dynamic stiffness to possess low natural frequency, hence, making it better than the linear isolators for the same payload [1, 2]. This work is a further extension of the authors previous work [3] by performing a dynamic experiment on the developed metastructure, which is the combination of a cosine beam system (exhibiting negative stiffness) and semi-circular arches (exhibiting positive stiffness) and then finally combined to possess QZS for a certain range of displacement. In the present work, a QZS payload is kept on the top of the metastructure to compress the system to its zero-stiffness range. The system is excited using a shaker by giving sinusoidal wave input, and the output signals are recorded and measured using the accelerometers and DAQ system, and further these signals are processed using LABVIEW software as sown in figure 1.

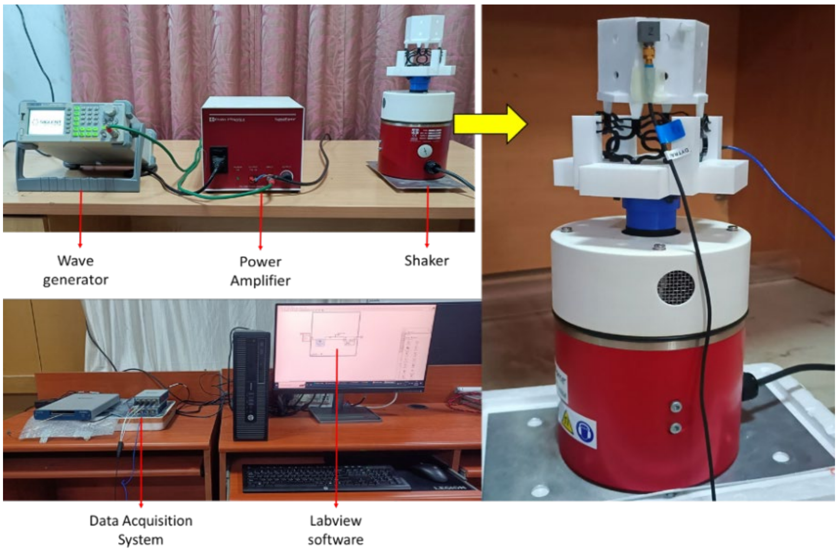

Figure 1: Experimental setup of the vibration experiment specifying all the equipment.

Results and discussion

The forward sine sweep, backward sine sweep and individual sine waves are applied for the frequency range of 1-30Hz, and the results suggests that the effective vibration isolation from low-frequency range. Further the obtained experimental results are compared with the analytical and simulation results.

References

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