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IMPLEMENTATION AND APPLICATION OF DIGITAL-CONTROLLED PIEZOELECTRIC VIBRATION ABSORBERS TO TRUSS STRUCTURES

Abstract

In recent years, accuracy required for artificial satellites has been getting higher, as communication devices become more popular and as data become higher definition. Then, micro vibration caused by a reaction wheel or a refrigerator becomes a problem, because the vibration transmits to the observation equipment and affects high-definition observation. Dynamic Vibration Absorber (DVA) is difficult to downsize and to adjust the vibration characteristics, although being a representative way of passive vibration control. Therefore Piezoelectric Vibration Absorber (PVA) with a piezoelectric transducer and a shunt circuit has been paid attention. Existing PVAs, however, are difficult to realize desired natural frequencies and damping ratios of PVAs, because they consist of analog variable resistors. Furthermore, there has been a problem of performance deterioration in vibration control, because temperature dependency or aged deterioration of the piezoelectric element changes the vibration characteristics. It is necessary to keep superior performance in vibration control, although flexible structures or PVAs change their characteristics in orbit. Thus, this study aims to implement the adaptive PVAs adjusting their characteristics in orbit. Especially, this paper presents the results of the study, focusing on implementation of digital-controlled PVAs and demonstration of performance in vibration control. By using digital potentiometers, we made the PVA easier to tune the characteristics. We derived empirical formulas to estimate the characteristics of PVAs, and implemented PVAs of which natural frequency and the damping ratio are designated in the microcomputer. The formulas corresponded well to the theoretical values. Also we simulated the transmission of vibration to the observation equipment with the truss structure, and demonstrated experiments of vibration control. The truss structure is composed of 5 bays. The two electromagnets fixed on the uppermost nodes excited the truss structure with swept sine wave. Four PVAs were equipped on the lowermost nodes for vibration. We measured the mode shapes and got natural frequency 16Hz of the fundamental mode such as beam bending. Based on this result, we conducted experiments of vibration control under the condition of natural frequency 16Hz and optimum damping ratio 0.04395 obtained in the previous research. As a result, we confirmed that PVAs were possible to reduce peak value of frequency response at least by half. Moreover, we derived the transfer function from the mode and natural frequency, and compared this function with the experimental results. These results made it clear that digital-controlled PVA worked effectively and it could suppress the vibration of truss structures.