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STRUCTURAL HEALTH MONITORING AND METHODS FOR MEASURING THE FUNDAMENTAL FREQUENCY OF SATELLITE LAUNCHER IN FLIGHT

Abstract

During flight, the fundamental frequencies and co-acting fundamental vibration mode shapes arise due to external aerodynamic and mechanical loads acting on the launcher. The fundamental frequencies vary in time due to change in rigidity of the structure and significant change in mass due to fuel burn. The flexibility of a launcher is mainly a problem of stability. Control system, which is responsible for guiding the launcher, is sensitive to the dynamics of the structure. If the control system will sense the fundamental frequency of the launcher it may give an unnecessary order, which may result in increased vibration and later on to the destruction of the launcher. Nowadays, the fundamental frequencies and mode shapes are being estimated before flight using algorithms and ground tests and a typical range of frequencies is being filtered. To improve the performance of the control system, the controller must receive the fundamental frequency value continuously during the flight so it will be possible to reduce the notch filter frequency range, which improves launcher's performance as well as by measuring these frequencies there is the ability to monitor its structural health during flight.

An electro-mechanical method for measuring fundamental frequencies in flight was suggested on the basis of cantilever beams deflection at resonance utilizing the restorative amplification and the inherent properties of the beams to sense the launcher fundamental frequencies. The measuring device includes an array of beams. Each beam represents one frequency from the selected frequency range. The change of frequency is obtained by change of the beam's length in a defined resolution. Optimization in attempt to minimize the beam length can be obtained by adding a proof mass on the free edge of the beams. It is also could be used for SHM during storage or transportation by monitoring the structure modal frequencies and comparing them to undamaged structure.

Each beam is used as a switch signaling the controller the current fundamental frequency. The switch is obtained by placing an electrode underneath each beam at a distance such as at resonance the bending of the beam will cause a shortcut circuit or at a distance such as a change in capacity can be measured. The designed measurement device has two possibilities of operating voltage: a. a piezoelectric thin film attached to the body of the launcher, converting the bending to alternate voltage at the bending frequency for shortcut circuit method. The measurement device placement will be according to voltage supply, as for the piezoelectric film it will be placed in the launcher where the list vibration is sensed so the beam excitation will be from the film only, while for the constant voltage the placing will be according to the first mode shape of the launcher where the bending vibration is large enough to assume the launcher and the measurement device vibrate in the same vibration frequency.