Self-Tuning of Tuned Dampers

The effectiveness of passive tuned dampers depends strongly on how precisely they are tuned. In many applications, the tuning frequency is not quite constant and varies with the operating conditions of the system. For example, the resonant frequencies of an office building floors vary with the number of occupants and the arrangement of the furniture on the floors.

The use of a dynamic absorber (as a tuned damper) in such systems, can only be effective if they are adjustable (semi-active) and continuously retuned to the current resonant frequency of the system. Such dampers require a tuning algorithm that can automatically adjust the adjustable parameter of the tuned damper, e.g., the stiffness of the spring.

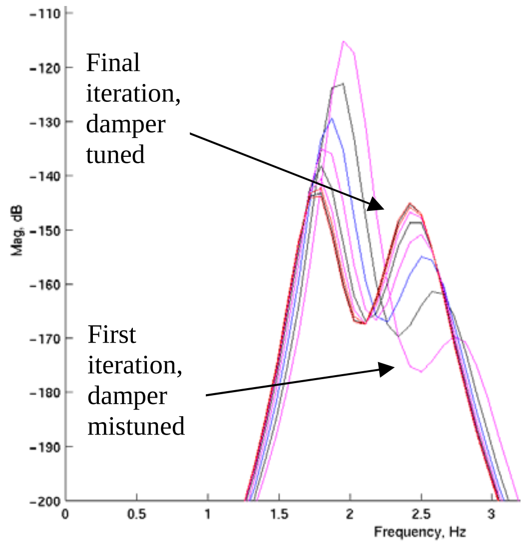

Figure 1 Iterative power spectrums of the measured attribute.

A self-tuning strategy for tuned damping applications is developed which is based on power spectral analysis of a measurement, e.g. acceleration in vibration or pressure in acoustics, at an anti-node location corresponding to the mode targeted for damping. Note that a well-tuned damper splits the mode targeted for damping into two adjacent modes with equal strength. As such, the power spectrum of the sampled measurement of an oscillatory system equipped with a accurately tuned damper exhibits two peaks with equal heights at the vicinity of the resonant frequency of interest. This attribute of a well-tuned absorber is the basis for self-tuning a mistuned absorber. Figure 1 depicts the iterative power spectrums of the vibration or acoustic measurement, as the iteration progresses, starting from the mistuned and ending with the tuned spectrum.

Incremental change in the absorber's resonant frequency, by which the resonant frequency is readjusted in each iteration, is evaluated using an iterative adaptation scheme. The process is repeated until the absorber is retuned. The duration of each iteration depends on the parameters of spectral analysis used in the algorithm. In most settings each iteration will take about 1-1.5 seconds. Besides, it does not take more than just a few iterations for the algorithm to retune the system.

An acoustic enclosure equipped with an adjustable (semi-active) acoustic damper is used to demonstrate the effectiveness of the self-tuning scheme. The tuned acoustic damper in this system was detuned, on purpose, and the self-tuning algorithm was allowed to retune the it. After a few iterations, taking about 10 seconds, the self-tuning system successfully retuned the damper. Figure 2 depicts the scaled power spectrum of pressure measured at an anti-node location in the test subject with the damper detuned, red, and retuned, blue.

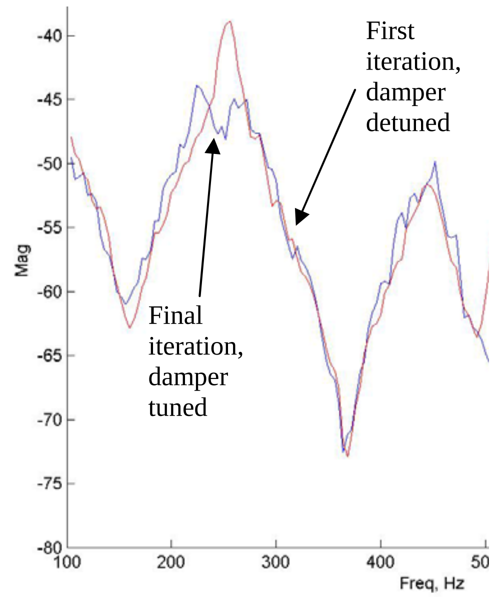

Figure 2 Scaled power spectrums of pressure with a detuned (red) and tuned (blue) acoustic damper.