Passive Electronic Damping

Passive electronic damping using piezoelectric ceramics is a less temperature-sensitive and more tunable alternative to viscoelastic damping treatments. In this damping technique, the mechanical energy of the structure is converted to electrical energy using piezoelectric material. High mechanical stiffness of piezo ceramics enables efficient energy transfer to the piezo damper. The electrical energy, in turn is dissipated, as heat, in an electrical shunt circuit allowing for specific vibration frequencies to be targeted and damped electronically.

The piezoceramic mounted on the structure, can be viewed as a capacitor (its electrical properties is dominantly capacitive). Putting this capacitor *C* in series with a shunt circuit consisting of a resistor R allows for the electrical energy produced by the capacitor to be dissipated in that resistor. This *RC* passive electronic damping system has relatively broadband performance.

Adding an inductor *L* to the shunt circuit and tuning the resulting capacitor/inductor combination to one of the resonances of the structure results in a narrow-band damping system adding a great amount of damping to the resonance it is tuned for. This is because at resonance, the reactive components between the inductor and capacitor cancel each other making the phase angle between the current and voltage zero. As a result the power factor at resonance becomes one, causing the resistor to dissipate energy very efficiently. This results in a very effective tuned damping. Figure 1 shows the schematic of both resistive and resistive-inductive circuits shunted with a piezo damper.

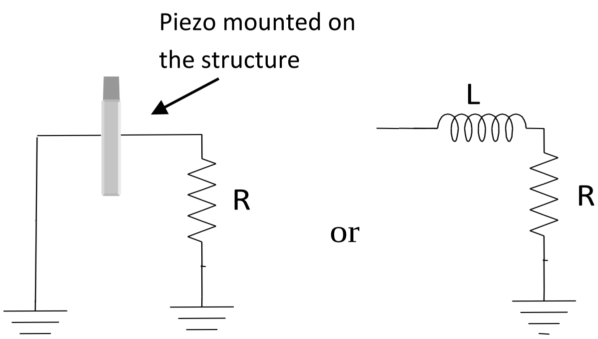

Figure 1 The schematic of a shunted piezo damper

Based on testing or finite element analysis, the frequencies of the major vibration modes and their corresponding areas of highest strain on the structure are determined.

The vibration reduction efforts are focused on those modes which are most harmful to the application. Since strain energy is the cause of vibrations, to have the greatest impact on vibration reduction of a single (or a cluster of) mode(s), the piezo(s) will be placed in the area(s) of highest strain of that mode (mode cluster).

The performance of passive electronic damping is demonstrated by adding significant amount of damping to a sheet metal structure. Two small 1 by 2 inch piezoelectric patches are bonded to the sheet metal; see Figure 2. The peizos are shunted with *RL* circuits, tuned to the first resonant frequency of the structure at 38 Hz.

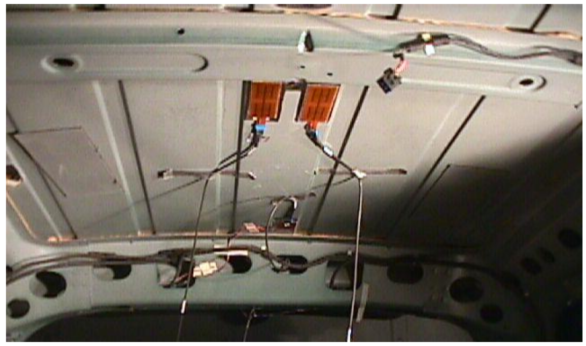

Figure 2 The image of the piezo patches installed on the plate structure

With the structure being perturbed with bandlimited white noise, the acceleration at the center of the sheet metal with and without the damping treatment was measured. Figure 3 shows the low-frequency power spectra of these measurements. Clear from this figure, the shunt piezo damping has added an appreciable amount of damping to the first mode of vibration.

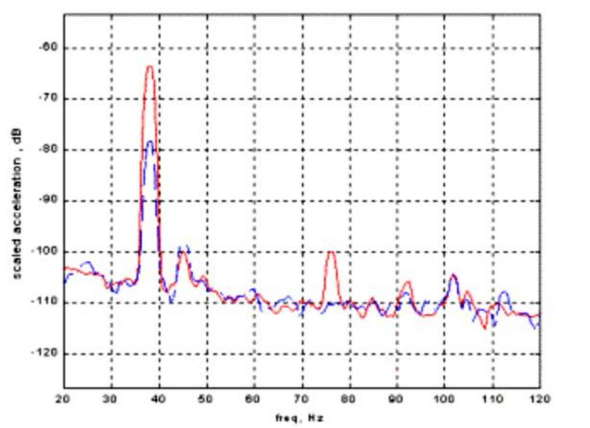

Figure 3 Power spectra of acceleration without (red) and with (blue) shunt piezo damping