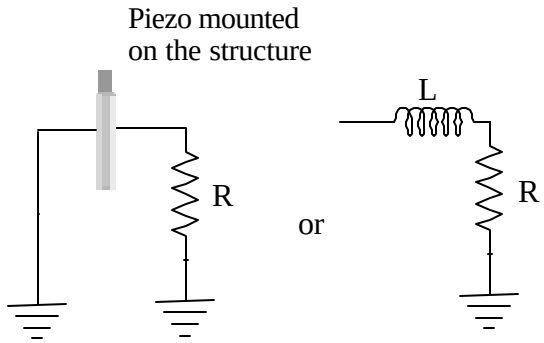
Passive Electronic Damping

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 piezos 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 systems 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 and the phase between the current and voltage is zero. As a result the power factor at resonance becomes one, causing the resistor to dissipate energy very efficiently. This results in very effective damping at the tuned resonance.

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 of cluster of modes, 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 plate structure. A small 1 by 2 in piezoelectric patch is bounded to the plate. The peizo is shunted to an RL circuit, tuned to the first resonance frequency of the plate. As seen in the graph, passive electronic damper adds significant amount of damping to the plate; solid line presents the frequency response function of the untreated and the dashed line presents that of the treated plate.