Single-Mode Damping vs. Multi-Mode Damping

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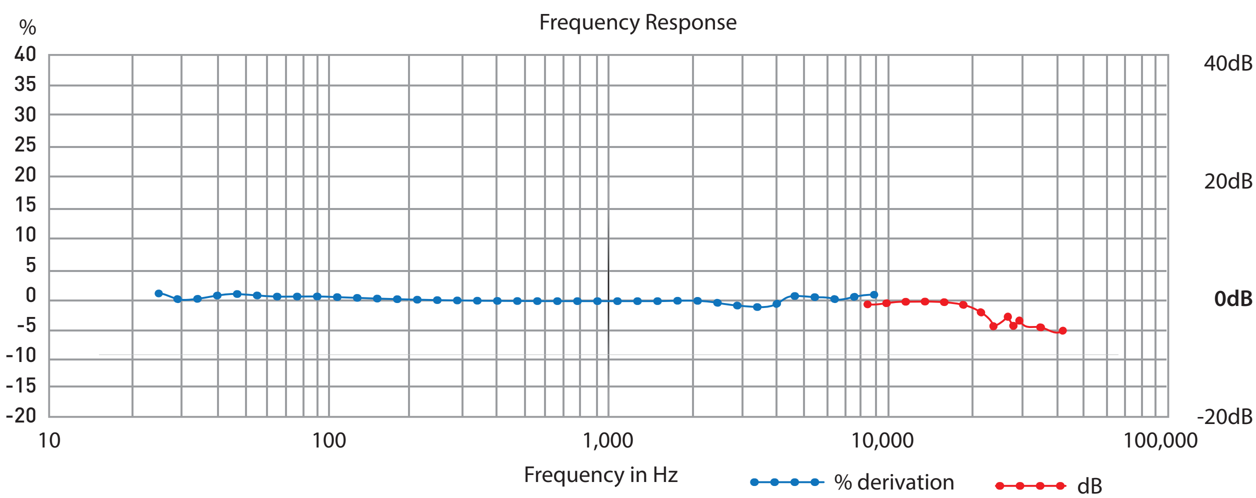
In a traditional single degree of freedom (single mode) model, the primary natural frequency of the accelerometer is used to determine its transfer characteristics. Damping ratio of an accelerometer can range from almost undamped (<0.005 of critical) to over-damped (>0.7 of critical). For approximation, the damping ratio is practically equal to half of the sensitivity of the accelerometer at its reference frequency (typically at 100Hz) divided by the sensitivity of the accelerometer at its natural frequency (= 0.5 x Sens @ fr /Sens @ fn). The term "damping ratio" is used by engineers to assess how much damping is built into the accelerometer. To effectively control the sensor response near its resonance, damping ratio >0.7 is often used. The trade-off in applying over-damping design is that the "flat" amplitude response below the sensor resonance is greatly limited. Endevco has developed a multi-mode damping model in which the mechanism of the MEMS sensing system is tuned to make use of not only the primary resonance mode, but also its secondary resonance. Because the two resonances are designed to be closely spaced, their damping characteristics interact with each other to yield a desirable frequency response. The benefit of this interaction is an extended "flat" response up to a very high frequency that still retains a high degree of damping to control the amplification at its resonances. Since we are dealing with two resonance modes all at once, the typical damping ratio approximation, which is meant to describe the behavior of a single second order system, no longer applies.

In short, the term "damping ratio" typically associated with a single second order system is inadequate in describing the effectiveness of damping in a multi-mode damping design. Instead, one should pay attention to the actual frequency response of the sensor. The figure below shows the frequency response of a multi-mode damped accelerometer with primary resonance (1st mode) at 25kHz and secondary resonance (2nd mode) at 36kHz. Note these resonances are virtually unnoticeable in the calibration sweep because they have been effectively eliminated by careful sensor design tuning. This allows a usable bandwidth up to 40kHz which is unobtainable in previous generations of accelerometer design.



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