Active, Feedback-Controlled Induction Noise Abatement

DEICON's active, low-frequency, '***electronic acoustic absorber***' can be configured to act as an acoustic dynamic absorber, and be used in forced noise control applications such as *induction noise abatement*.

Reactive absorbers, such as Helmholtz resonators (HR) or quarter-wave tubes, are commonly used as the most effective solution for abating the low-frequency noise in many applications including induction systems, particularly in luxury cars. The problem with these low-frequency absorbers is their large size. In addition, reactive absorbers can only be tuned to a single frequency. When absorption at multiple frequencies is required, a number of these absorbers tuned to different frequencies should be used. Accommodating a large number of these resonators under the hood (luxury vehicles may use multiple resonators) is a packaging challenge, not to mention expensive. Active noise control would enable automakers to eliminate the need for resonators. It allows one to deal with multiple frequencies using only a single system.

Active noise control systems normally consist of a microphone, another sensor to identify the targeted frequencies (e.g., the engine rpm sensor), an electronic controller, and a speaker mounted at a vehicle's air induction system. The signals measured by the microphone and the 2nd sensor are processed by the controller (algorithm) creating the control signal which will drive the speaker. The active system is small and does not cause under-hood packaging problems. Most active control systems use feedforward, Least Mean Square (LMS) based adaptive algorithms as their controllers. These complex algorithms need fast, powerful digital signal processors to run. To ensure the convergence of the algorithm, the rate of adaptation should be made slow. This might create the loss of effectiveness of the controller during the transients, e.g., a fast run up of the engine. Although these adaptive feedforward algorithms have been around for more than 20 years, i.e., since the creation of DSPs, but their complexity and cost have prevented them from finding a place in auto industry.

DEICON's cost-effective, feedback-based active noise control scheme, configured as a dynamic absorber, to abate the low frequency induction noise. The controller is realized by a *low-cost, adaptable, op-amp circuit can be tuned to a single or multiple frequencies* abates the sound at that (those) frequencies. A microphone, nearly collocated with the actuator, is used for sensing. *Adaptation* can be done by constant, automatic retuning of the controller to the engine rpm.

The added benefit of all active induction noise control system is that they could enable automotive engineers to shape a vehicle's noise signature to the image of the vehicle, for example powerful, sporty or nostalgic.

In a lab-scale set up, resembling the induction system of a 4 cylinder engine, the effectiveness of the active feedback controlled noise abatement system is evaluated. The set up consists of a short 28 inch plastic tube with the diameter of 4". One end of the tube is equipped with a 4" speaker (noise speaker resembling the engine cylinder) that excites the system. The control speaker (another 4" cone) and microphone are installed in the middle of tube (in the filter box).

Figure 1 shows the frequency response functions mapping the voltage driving the noise speaker to the pressure measured at the tube outlet, with (red/solid line) and without (blue/dashed line) control. The active control system, which is designed to absorb tones at 100, 150, and 200 Hz, is performing effectively. Clear from Figure 1, the transmission of these tones from the noise speaker (cylinder) to the air intake opening is hindered.

This work demonstrates the feasibility of such a cost effective active noise control system.

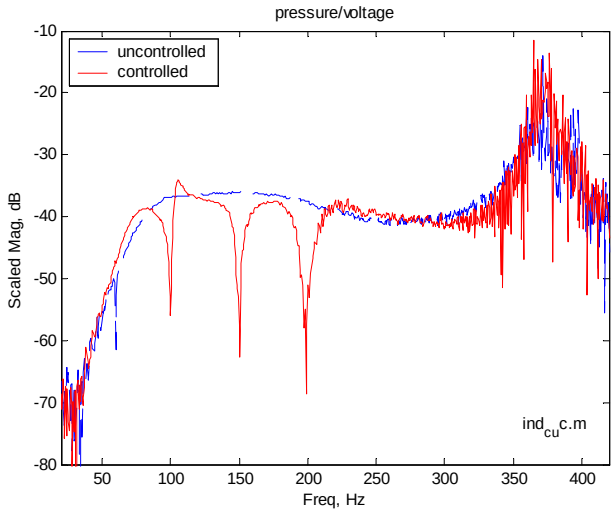

Figure 1 Frequency response functions mapping the pressure at the tube inlet to the voltage driving the noise speaker