WHITE PAPER

INSIGHTS FROM TRANSPORTATION SOLUTIONS

MOLEX ROAD NOISE CANCELLING SENSORS: A MORE CAPABLE AND COST-EFFECTIVE METHOD TO OPTIMIZE THE DRIVER/PASSENGER EXPERIENCE

molex

INSIGHTS FROM TRANSPORTATION SOLUTIONS

Molex Road Noise Cancelling Sensors: A More Capable and Cost-Effective Method to Optimize the Driver/Passenger Experience

Authors

KURT DEKOSKI
Molex Business Development Engineer

INTRODUCTION

Modern family cars are complicated machines. They incorporate technology that was originally introduced in jet fighters, including features ranging from headup displays to fly-by-wire controls. Modern cars have little in common with those from a generation ago.

The result is that, as consumers, we are becoming increasingly demanding. Our expectation is that the car will be a safe haven from the world, a comfortable cocoon in which we can enjoy our enhanced technology whilst listening to concert-quality music or holding a telephone conversation with someone on the other side of the globe — hands free, of course.

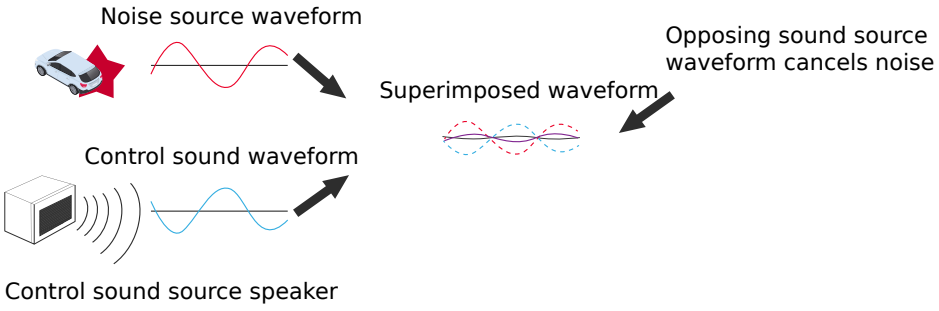
Vehicle manufacturers are developing new and innovative techniques to reduce or even eliminate unwanted noise in the cabin of cars. This has led to an increase in the use of active methods to combat unwanted noise, vibration and harshness (NVH) in automotive design.

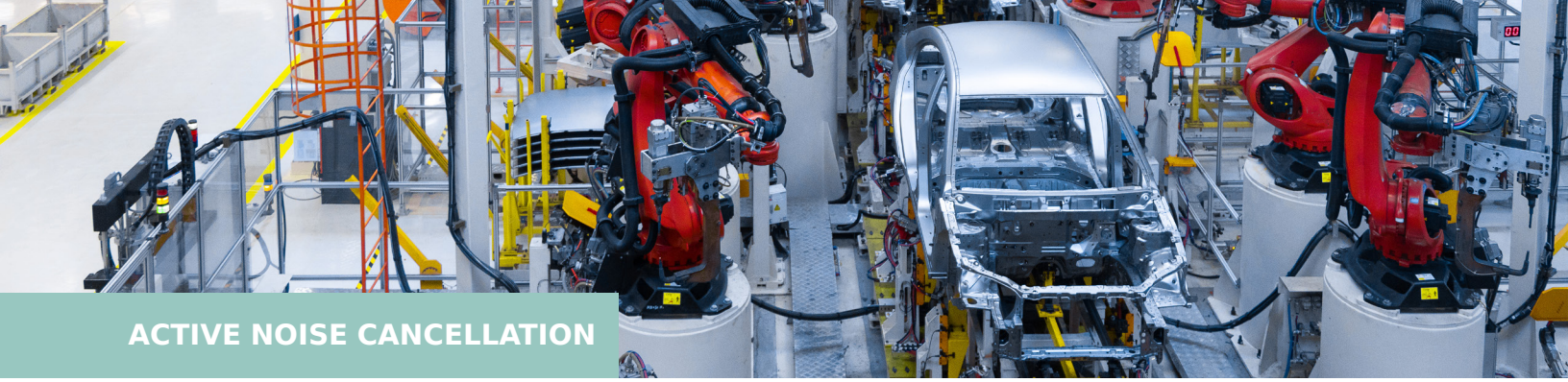
Molex has extensive experience in the design, manufacture and supply of connectivity solutions for automotive applications. This expertise has been applied to the Molex range of road noise cancellation (RNC) sensors.

Sound

Sound is a pressure wave, caused by mechanical vibration, that the human ear receives and processes. The frequency of vibrations that can generally be perceived by the human ear is between 20 and 20,000 Hz. NVH is unwanted sound that can cause inconvenience, discomfort and possibly even physical harm. In many industries, considerable effort is applied to reducing NVH to protect users and prevent noise pollution.

Traditional noise reduction uses passive methods. These range from energyabsorbing materials such as foam or rubber to the use of air gaps to attenuate acoustic energy. In all cases, the intention is to dissipate energy – vibration – before it reaches the human ear. This is not an inconsiderable challenge, as alternative techniques of noise reduction work better with different frequencies of sound, and no one method can be totally effective.





ACTIVE NOISE CANCELLATION

In contrast to passive techniques, active noise cancellation (ANC) works by measuring the waveform of the unwanted sound and generating an equivalent inverted signal. This signal is then transmitted alongside the original. The two waveforms, being inverted images of each other, combine and are weakened by the effect of phase cancellation. This then reduces the amplitude of the original signal and thereby reduces the volume of the unwanted noise.

ANC is now becoming commonplace as a result of the advances in the world of electronics. Sensors and signal processors have become quicker and more accurate, and it has become easier to analyze unwanted sounds and generate the corresponding noise-cancelling signal. As the technology becomes more accessible, designers are looking for new and innovative ways to apply the solution to real world problems.

Road Noise

Road noise is of particular interest to automotive designers. Advances in internal combustion engine design, and the adoption of electric motors, which are virtually silent, mean that the interior cabins of cars have become quieter. Despite this, the problem of road noise has remained, and has become more important to solve as the performance of cars improves.

As vehicles move faster, noise is generated as they interact with the environment, which usually means wind noise and road noise. Unwanted NVH has a major effect on driver fatigue, so solving the problem of noise is not just a matter of convenience but also potentially of considerable benefit with respect to road safety.

Wind noise can be reduced quite effectively using passive techniques, but compensating for the sound generated by contact with the road is harder. The direct physical contact with the driving surface creates a constant vibration that becomes more prominent as speed increases. The noise is generated by the contact of tires with the road and by the mechanical function of the suspension as it reacts to uneven surfaces beneath it.

Installation and the Automotive Environment

The key to applying noise cancellation techniques most effectively is to place the sensors close to the source of the noise. The noise-cancelling signal needs to match the original sound closely. Therefore, detecting the sound at its source provides signal processors with the time needed to analyze and generate the new waveform.

In the automotive application, this means that the sensors need to be located as close to the road as possible, which means mounting them to the underside of the car. This presents a range of challenges for the design of the components.

The automotive environment is one of the toughest in the world. Cars and other vehicles are designed to function in a broad range of conditions. From the frozen tundra of the Arctic Circle to the searing heat of equatorial deserts, cars are designed to handle ambient temperatures from -40°C to near the boiling point of water.

Automotive components must also be able to withstand chemical contaminants. In countries that expect snow and ice, salt is used to help keep roads clear. Devices mounted to the underside of cars

will be exposed to salt mixed with surface water, in addition to a range of other chemicals, including fuel and lubricants that might be on the road surface.

The physical risks to equipment must also be considered. Automotive manufacturers design vehicles that can, whenever possible, be sold globally. With unprepared roads, tracks and trails so common around the world, designers must be mindful of the damage that can be caused to the underside of vehicles during everyday use. Even family cars that are intended to travel on prepared roads are subject to grit, stones and other debris that can be thrown around when traveling.

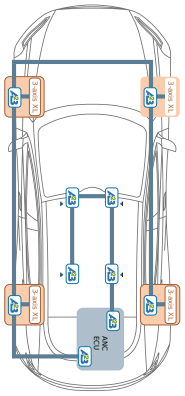
RNC sensors, along with the components that connect them together, must be designed with these extreme conditions in mind. The materials from which these devices are constructed must be selected with care, to provide the best combination of resistance to extreme temperatures and attack from harsh chemicals. They must be designed in order to provide physical strength while keeping mass to a minimum. In addition, they need to be easy to install and yet secure enough to withstand the vibration and shock that vehicles experience.

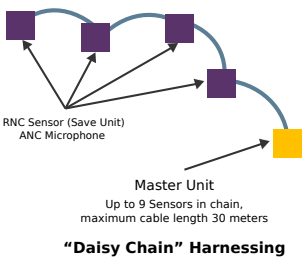
Molex RNC Sensors

Molex designed their wide range of RNC sensors to be installed in exposed locations on the chassis of cars and other vehicles. The housings of the sensors have been created to withstand the harsh automotive environment, and they offer IP6K9K rated protection against water, dust and other contaminants.

The sensors are available in several different housing variants that accommodate different installation locations around the vehicle, including vertical and perpendicular positioning.

The sensors include integral connectors that allow easy interface with the cabling system of the vehicle. The connectors are derived from Molex's own Mini50 Connector family and offer considerable space savings over traditional USCAR 0.64mm connectors. This has enabled the design of the sensors to be kept as small as possible, which allows the mounting of sensors as close as possible to where the noise is generated. As we have seen, this mounting location allows for optimal noise cancellation.





"Daisy Chain" Harnessing

Daisy Chaining

Weight is always a key concern to automotive designers, especially on suspension components. The desire is always to keep the components of the suspension light to allow the quickest response to road conditions. In addition to keeping the mass of the sensors as low as possible, Molex has incorporated daisy-chain cabling.

Traditionally, sensors would each be connected directly to the signal processor by individual cables, referred to as home-run harnessing. The Molex solution is to connect sensors in a daisy chain. Each sensor connects to the next in a sequence of up to 9 units. This reduces the length of cable needed to provide the necessary connections and can reduce the weight of cabling by up to 30%.

The mass of passive-noise-reducing materials in the average car can be as much as 60 lbs, rising to over 100 lbs for luxury brands. This weight has a real impact on the performance of the vehicle, and the cost of the materials and their installation is significant. The use of an RNC system allows savings to be made in traditional techniques, creating a reduction of both weight and installation costs.

SUPERIOR SENSORS

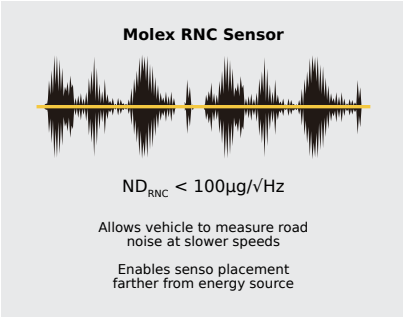
Molex has designed the sensors to provide superior performance in the automotive environment. One of the key criteria of any sensor is latency. This is defined as the time delay between the sensor's reception of a signal (the excitation) and that signal being received by the signal processor. In the active cancellation of noise, it is vital that this time is kept to the minimum.

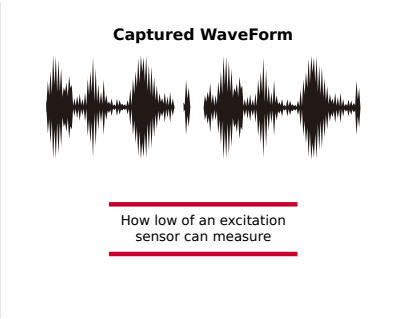
The noise-cancellation system needs to receive and analyze the signal in as short a time as possible in order to generate the inverted signal. A sensor with a low latency will be able to respond quicker and more effectively.

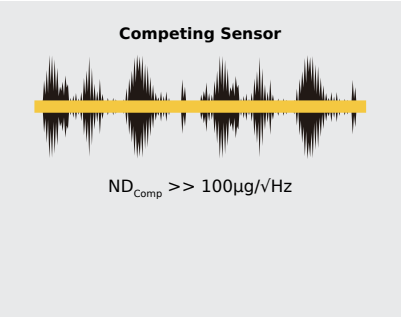
The Molex RNC sensors typically feature a latency of less than 150 µs, which is superior to alternatives available on the market today. This low latency improves the effectiveness of the noise cancellation system as it allows rapid response to road noise conditions.

Another key measure of sensor effectiveness is noise density. While the goal is for a sensor to detect all signals, the reality is that there is a threshold or noise floor. Sensors cannot detect signals below this threshold. In the case of road noise, travelling at lower speeds will cause less noise. A sensor with a high noise floor will not be able to detect the low noise that is generated by slow speeds, rendering noise reduction ineffective.

Molex sensors have been designed with a lower noise floor so that a larger proportion of the original waveform is detected, allowing effective noise cancellation at lower speeds. This extra sensitivity has an additional advantage in that it allows the sensor to be located farther away from the noise source. This enables the designer to install the sensor in a more advantageous position, taking advantage of possible additional protection or shorter cable lengths.







Conclusion

While road noise cancellation may be a feature associated with luxury brands, RNC technology is becoming both more capable and cost effective.

As has happened with other advanced features, this technology will soon enter mainstream car production. With its superior sensor technology, mechanical design and innovative connectivity solutions, Molex can provide a complete RNC sensor package, ready to satisfy the most demanding driver.

Order No. 987652-2361 USA/0K/GF/2021.05