DSPs power efficient automotive active noise control

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While energy-saving techniques are contributing to greener vehicles, they are also producing a noisier cabin experience. To reduce the noise, many automotive engineers are utilizing a vehicle’s audio system, in a process called active noise control (ANC). Carmakers are also tapping into active sound design (ASD) technologies to create distinctive engine sounds. This article discusses how a dedicated audio DSP supports the latency, performance, and cost considerations for ANC and ASD systems.

Introduction

Removing vibration reduction materials and allowing higher cylinder engines to operate with fewer cylinders under certain driving conditions are examples of ways to create more energy-efficient vehicles. However, such energy-saving techniques don’t always result in the quietest of cabin experiences. For example, when it comes to smaller engines with lower RPM, the low-frequency turnover noise actually gets louder. That’s why many automotive engineers are relying on ANC.

ANC is based on coherent acoustics and aims to accurately replicate the original sound field at all relevant locations, for all relevant times, in-time and in counter-phase. ANC systems tap into in-vehicle amplifiers and microphones and use signal processing, either in the radio or amplifiers, to create the opposite sound to what the engine emits so to cancel out the noise. Using a small DSP in the audio subsystem makes good sense, allowing you to focus your primary processor on compute-intensive functions.

Figure 1 depicts a typical system design for a passenger car utilizing ANC. The engine noise is in the 30-250Hz range, so the speaker system should counteract the noise by producing the same level of opposing sound. Another example of ANC in action is a hybrid vehicle, where the ANC system helps reduce the noise that is generated when the car’s battery is charging.
It’s also common now for mainstream automotive in-vehicle infotainment systems to adopt active acoustic technologies to influence vehicle sound, which is what ASD is all about. As an example, consider the BMW M5, which features a digital signal processing function that exchanges data with the engine manager to produce sounds that reflect the engine’s revs and torques, as well as the car’s driving speed. When the driver goes into Sport or Sport+ mode, the engine’s responsiveness sharpens, along with the acoustic experience inside the car. Figure 2 illustrates some examples. We’re now seeing more infotainment systems use highly integrated systems on chip (SoCs) with high-performance standard CPUs and software infrastructure to support ASD technology.

Figure 1 Active noise control in a typical passenger car

Figure 2
Figure 2 Decibel levels of various active sound design examples

Today's infotainment systems

Providing a communication hub with multiple (and often wireless) interfaces, modern infotainment systems are highly integrated and boast ever-increasing functionality. Obviously, there are limitations in package space and power and also heat dissipation restrictions. From a design standpoint, infotainment systems typically rely on powerful, standard multi-core processors with an open operating system and middleware. Many system designers are also opting to use cross-functional SoCs; for example, such an SoC might support the vehicle’s radio tuners and audio capabilities.

Supporting active sound technologies with a dedicated DSP

Active sound technologies don’t fit into mainstream audio frameworks, due to their latency requirements. That’s why SoCs developed for infotainment systems must take into account the unique requirements of audio signals for active sound technologies:

- High bandwidth, 48kHz sampling frequency
- High dynamic range, ≥24 bit
- High number of channels (≥20 source channels, 20 target channels)
- Non-synchronous sources and sinks, and different clock domains
- Complex signal processing and block processing
- No interrupts and synchronization capabilities. In application areas such as hands-free voice control and buffering, low latency is a must.

Looking back at the first generation of active sound systems, automotive designers were adding in an extra control unit to the car with a DSP for audio signal control between the power amplifier and the speaker. This approach provided the low latency needed between microphones in the car and the speaker system. In the next generation, we saw designers integrating active noise technology onto very powerful DSP-based amplifiers. This proved to be expensive, and therefore impractical for economy cars.

In today’s economy cars, the power amplifier is typically integrated with the radio component in the head unit. Head units, in turn, run either on large embedded CPUs or multiple CPUs that support navigation, infotainment, and smartphone apps. This configuration provides the computational capabilities needed, but not the low latency that audio demands. The problem stems from the OS—Linux is commonly used and, while it guarantees a latency of 100ms for task switching, this latency level is insufficient for ANC functions.

To meet the low latency and cost requirements for the audio component, consider offloading your primary processor by incorporating a small, dedicated DSP into your SoC for active sound technologies. While the primary processor runs more compute-intensive tasks, the DSP could interface with vehicle, microphone, and loudspeaker data and run the functional software for these applications.
For example, Cadence’s Tensilica HiFi DSP supports 160+ audio, voice, speech recognition, and audio and voice enhancement software packages, and the IP can be included in any SoC design. The DSP also provides enough compute resources to support other audio processing algorithms, such as acoustic echo cancellation, beamforming, and sound-stage widening.

Summary

With audio technologies like ANC and ASD, carmakers can minimize engine noise and also create distinctive engine sounds. Offloading the primary processor with a small, low-power dedicated DSP that runs the ANC and ASD algorithms provides an effective way to satisfy the performance, energy consumption, and cost requirements for an automotive system.

Reference

1. Boeriu, Horatiu. *Active Sound Design brings the M5 engine sound into the cabin*, BMWBlog.

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- Active noise cancellation: Trends, concepts, and technical challenges
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- Design an ANC headset using the AS3415
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