

Voice and Acoustic Signal Processing

ADI LISTN—Hear What Matters

Analog Devices understands that an immersive, in-cabin, audio experience is one of the primary differentiators in purchasing a car.

From infotainment to hands-free communication, with a person or with a machine (think Siri, Alexa, or OK Google), ADI has utilized its sophisticated IP to develop ADI LISTN™—a portfolio of high performance, microphone audio signal processing software solutions that fulfill the highest automotive industry standards.



With a matured IP equipped on millions of cars on the road, this dependable software solution is easy to integrate and tune, and thus gets you to market faster.

We are continually expanding our portfolio of audio signal processing software solutions immensely. All ADI *LISTN* microphone audio signal processing software solutions are available as building blocks in SigmaStudio® and as libraries for integration with CrossCore® Embedded Studio (CCES), on ADI SHARC® DSPs, or any tool chain as required for compiling on a third-party CPU or SoC.

ADI *LISTN* High Performance Benefits Include:

- **Industry-leading software that is flexible**, customizable, and supports any hardware platform.
- **Enabling hardware implementations that are resource efficient and optimized**, resulting in high quality audio signal processing and deterministic performance with low latency.
- **Enabling compliance with the highest quality automotive standards** (ITU-T p.1100/1110/1120/1140) that pass multiple Apple CarPlay and Google Android Auto certifications.
- **Simple-to-use tuning tool that cuts the evaluation time** compared to other existing solutions, for a fast time-to-market schedule.
- **Over 20 patents filed**—ADI *LISTN* is uniquely positioned to provide exceptional performance not only in human communication but also when processing audio before the recognition engine receives it to minimize error rate and deliver a great in-cabin experience.

Voice Recognition

All aspects of voice recognition require high quality audio processing for satisfactory performance in all use cases (high velocity, music playback, passenger conversations, etc.). ADI's state-of-the-art solutions, in conjunction with the audio preprocessing (AEC/NR/BF) algorithm, deliver the perfect product for all range of automotive customers.

ADI's wake-up word solution for voice recognition is part of ADI *LISTN* and supports the latest industry standards for automotive infotainment systems.



In-Car Communication (ICC)

One direct benefit of ADI's sophisticated IP is In-Car Communication. ICC is a voice-band, audio use case where the processed microphone signal is not sent to a distant receiving entity but is output on loudspeakers within the vehicle. This requires very low latency signal processing, otherwise the loudspeaker output would be perceived as an echo of the speaker's own voice.

The closed-loop situation bears the risk of feedback problems known as howling or ringing, which must be kept under control by the ICC algorithm. ICC is most important in front-to-rear (unidirectional) communication, so the driver can easily speak to rear passengers without turning their head. But it can also be implemented in a bidirectional manner adding rear-to-front support.

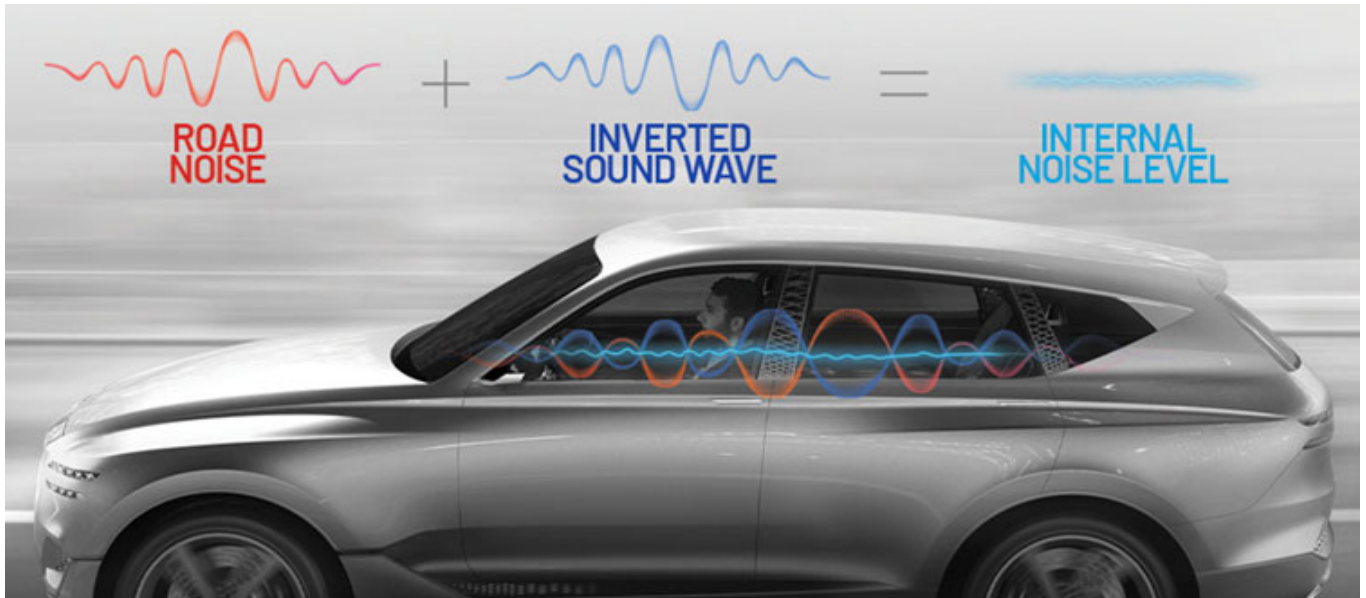


ICC is essential for a driver to easily speak to rear passengers without turning her head, but can also be implemented in a bidirectional manner adding rear-to-front support.

A derivative of ICC is in-car karaoke, which can be understood as front-to-front ICC (because the driver wants to hear themselves singing!). In-car karaoke is usually preferred louder than ICC, as ideal ICC is barely noticed by passengers but missed when turned off.

Active Noise Cancellation (ANC)

Active noise cancellation (ANC) is rapidly evolving as a technology area that enables car manufacturers to differentiate their vehicles while enhancing the overall passenger experience. Multiple types of ANC are currently being developed, from simple engine order cancellation (EOC) to more advanced road noise cancellation (RNC). Regardless of the implementation or architecture, Analog Devices delivers efficient and cost-optimized signal chain solutions that leverage our core technology competencies, including DSP, automotive audio bus (A²B®), MEMs XL, and associated software.



The ANC application “listens” for unwanted external engine noise, then plays a sound that is 180 degrees out of phase, so the noise is “removed” by the time it reaches your ear.

A²B-connected digital microphones are quickly becoming the industry standard due to improved audio quality and speech recognition rates compared to their analog counterparts. OEMs are increasingly adopting A²B technology for voice and acoustics applications, as it provides low and deterministic latency critical for optimized system performance. Furthermore, A²B's daisy-chain architecture greatly simplifies wiring complexity in typical RNC applications, reducing wiring costs and weight by up to 75%.





Ken Waurin explains how A²B[®] delivers lowest latency digital audio, control, and power in a simple design to enable revolutionary architectures for voice and audio.

Audio Signal Processing Software Algorithms

Acoustic Echo Cancelling (AEC), Noise Reduction, and Beamforming are the main algorithmic components of the ADI *LISTN* audio signal processing software suite. These technologies are the foundation of ADI's voice processing solutions, which manufacturers require in a truly immersive, in-cabin experience.

Acoustic Echo Cancelling (AEC)/Noise Reduction Technologies

Different disturbances interfere with the speaker's voice signal and without elaborate signal processing, communication would not be possible, neither between humans nor with a machine.

AEC and NR control the two disturbing signal components in a vehicle: loudspeaker-output and driving-noise. Since the source signals of loudspeaker outputs are known, these disturbances can be completely removed from the microphone signal via a two-step process.

Linear echo cancelling is an adaptive algorithm that calculates the impulse responses between loudspeakers and microphones, and estimated echoes are calculated that are then subtracted from the microphone signals.

Nonlinear residual echo suppression removes the echoes that remain after linear cancelling, as the human ear is extremely sensitive to echoes of one's own voice.

For other **omnipresent disturbances** (driving noise), it can be assumed that this changes slowly over time in a running car and an adaptively calculated noise estimation serves as internal representation of the actual, current noise that is then reduced by the NR algorithm by up to 20 dB.

Beamforming Technology

Beamforming starts with two or more microphones arranged as an array. Spatial information of the sound in the vehicle is considered and it is thus possible to distinguish different directions of sound impact.

With beamforming, you can focus on a certain seat position and reduce other voices in the car. This helps with voice recognition because other interfering voices can substantially degrade voice recognition performance. For human communication, beamforming is useful as an add-on to noise reduction because it can reduce non-

stationary noise components if they come from off-beam directions.



Listen to a demonstration of our voice processing technology.

ADI LISTN runs not only on ADI SHARC and SigmaDSP processors, but also on third parties' SoCs—giving customers the freedom to choose their preferred system architecture.

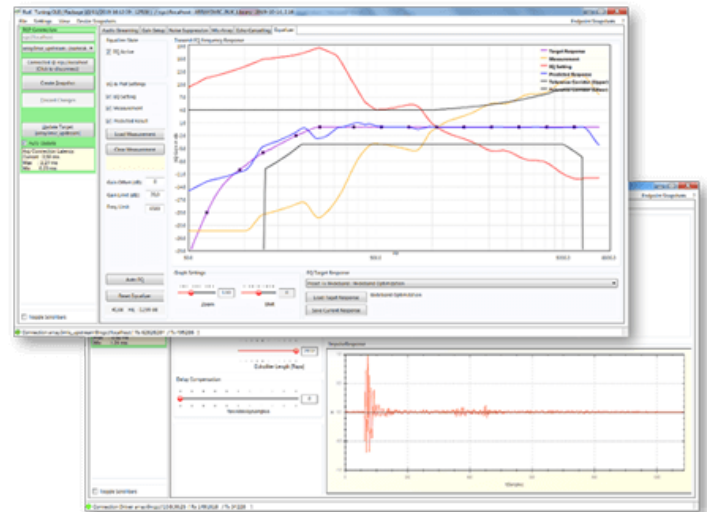
When used in combination with ADI's A²B[®] technology, ADI LISTN leverages time synchronicity by eliminating signal clock regeneration through the daisy chain—ultimately reducing overall BOM cost and simplifying microphone wiring schemes to enable a full turn-key solution.

Audio Signal Processing Software Tools

ADI LISTN Tuning Tool

The ADI *LISTN* tuning tool is a graphical user interface (GUI) that connects to the target via Ethernet, UART, or SPI. With the ADI *LISTN* automotive audio signal processing suite and its tuning capabilities, it is easy to create a system that passes the relevant automotive specifications such as ITU-T p.1100/1110/1120/1140 and Apple CarPlay.

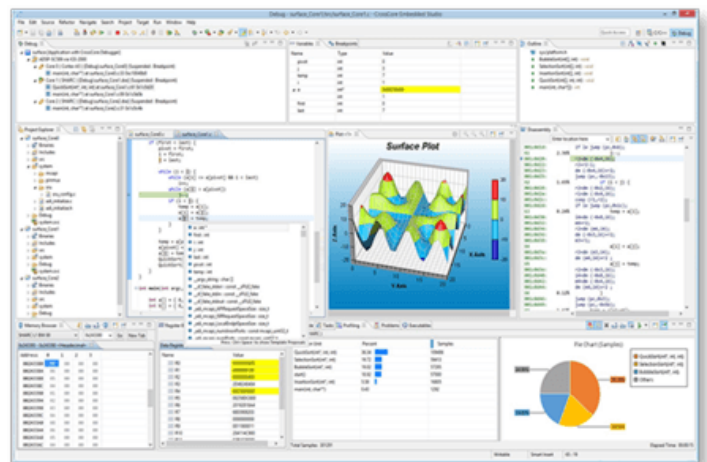
[Download the ADI *LISTN* Tuning Tool](#)



ADI LISTN EZ-AUDIO System Tuning Tool

The ADI LISTN EZ-Audio System (EV-21562-AUTO) enables rapid tuning and deployment of a pre-configured 4-channel in/12-channel out audio flow from DSP Concepts running on the ADSP-21562 SHARC audio processor. This custom tuning tool (AWE Tune) allows customers to quickly tailor the audio output for any automotive cabin. Reduce your time to audio using this turnkey hardware/software automotive audio solution jointly developed by Analog Devices and DSP Concepts.

[Download the ADI *LISTN* EZ-AUDIO System Tuning Tool](#)



SigmaStudio

The SigmaStudio® graphical development tool is the programming, development, and tuning software for the SigmaDSP® and SHARC audio processors and A²B transceivers. Familiar audio processing blocks can be wired together as in a schematic, and the compiler generates DSP-ready code and a control surface for setting and tuning parameters.

[Get SigmaStudio](#)

CrossCore® Embedded Studio (CCES)

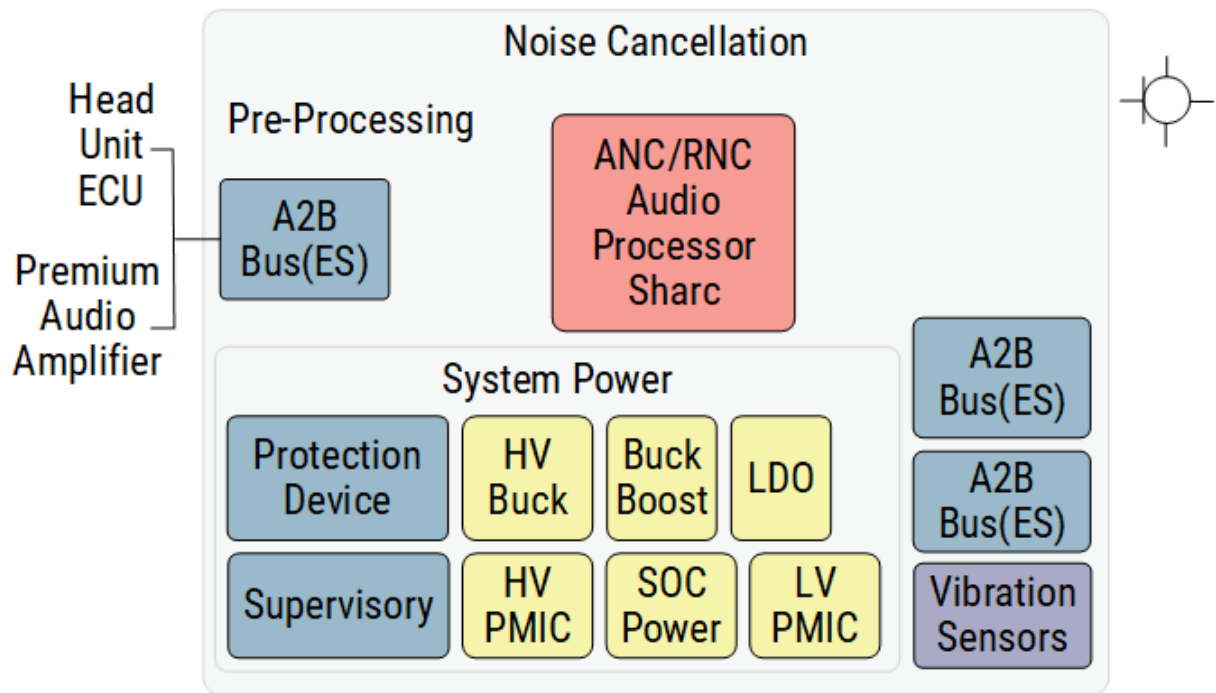
CrossCore Embedded Studio is a world-class integrated development environment (IDE) for the ADI Blackfin®, SHARC, and Arm® processor families. CCES also offers Blackfin and SHARC developers highly integrated add-in support for drivers, services, and algorithmic software modules.

[Get CrossCore Embedded Studio](#)

Signal Chains (1)

Advanced Acoustic Systems

Click on a part in the diagram below



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