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The software-defined vehicle is a joint effort

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The AudioAnalyzer is available in various models depending on requirements.
Picture: MCD

How Does the Car Sound?

Audio analysis of in-vehicle infotainment systems

Reliable audio analysis is essential for modern in-vehicle infotainment systems. Objective testing of voice output, control functions, music and component noise helps ensure clear sound, robust communication and reproducible quality in development and production.

At a time when infotainment systems are becoming increasingly important in vehicles — often jokingly referred to as "smartphones on wheels" — the testing of these systems is becoming more critical as well. Voice output and voice control, in particular, can provide valuable support for increasingly complex vehicle functions, making driving easier and safer for the driver. This is because modern infotainment systems integrate car radios, navigation systems, hands-free systems, driver assistance systems and other functions. In addition to audio signals, digital information is constantly exchanged with the vehicle, often via modern cellular communication standards.

In Search of "Pure Sound"

An important aspect is the audio quality itself, but also how it integrates into the vehicle's environment. After all, real-world driving conditions typically don't match the controlled conditions of a living room or concert hall. However, important information must always reach the user clearly and reliably. Even when it comes to purely entertainment-based functions like music or audiobooks/podcasts, listeners' expectations are higher today than they were in the days of crackling and static-filled FM radios. Vehicle manufacturers and their suppliers therefore require test equipment capable of objectively and reproducibly verifying and calibrating the quality of audio transmission. Such testers must be able to capture, analyze and display analog and digital audio signals with the highest possible integrity. This gives rise to various requirements. Among other things, high-quality, precise audio A/D converters are essential. The number of channels can also be critical for capturing as many signals as possible at once. In addition to frequency and various signal level measurements, total harmonic distortion (THD) and FFT spectrum measurements are often required for analyzing audio signals. An integrated signal generator can also be useful in practice, as it allows for the generation of various signal waveforms and modulation types as test signals.

The MCD AudioAnalyzer Toolmonitor

A proven audio analyzer for this application is the AudioAnalyzer from MCD Elektronik in Birkenfeld, which is available directly from MCD Elektronik or through distribution partners such as Meilhaus Electronic. It is

available in various models depending on requirements. At the heart of all variants is the "AudioAnalyzer" software, which centrally bundles all monitoring and analysis functions. This control software operates as a standalone application for controlling the hardware variants. It offers the ability to remotely control or query all functions and measured values from other programs. This remote control can be implemented using various software interfaces such as .Net SDK, Socket, WebAPI, or Command Line. The AudioAnalyzer Toolmonitor features an intuitive graphical user interface and includes functions such as an oscilloscope, FFT spectrum, and measurements of AC, DC, RMS value, THD, FREQ, SINAD, and more. Captured signals, their frequency/phase response, and other results can be visualized directly within the software. The generation of test signals and modulations (AM, FM, PM) is also supported.

AudioAnalyzer Hardware

In terms of hardware, the MCD AudioAnalyzer is available in four configurations designed to meet a variety of audio analysis needs. The Compact USB Edition is a compact, USB 2.0- compatible variant for direct connection to a PC and is ideal for space-saving workstations and quick measurements.

The Rack Edition is designed for installation in standard 19-inch systems and can be conveniently controlled via USB from a host PC. The Standalone Pro Edition operates completely independently with an integrated PC and enables measurements without external control. The SmartModuleS Edition is a flexible module for the MCD SmartModuleS system. In this configuration, up to two balanced stereo inputs and outputs can be configured and additional modules can be integrated into larger enclosures such as an 84 HP SmartModuleS enclosure. All variants are available as standard from MCD Elektronik and offer maximum flexibility for professional audio analysis in research, development and production. All models feature an analog, balanced stereo input (1 mV–50 V rms, two XLR jacks) and an analog, balanced stereo output (1 mV–15 V rms, two XLR connectors). In addition, there is a digital/optical S/PDIF input and output with sample rates of up to 192 kHz (two TOSLINKcompatible connectors) and a digital coaxial S/PDIF input and output (depending on the model, two RCA jacks or two BNC connectors). The sample rates are 44.1 kHz, 48 kHz, 96 kHz, or 192 kHz with 24-bit resolution. The models differ in form factor and whether they include an integrated PC; the core features themselves are identical. In addition to classic audio measurement of signals from sound systems such as amplifiers, radios, TVs and infotainment systems, the AudioAnalyzer also enables noise measurements on a wide variety of components such as switches, gearboxes, mechanical devices, signal generators, switching power supplies, distance sensors or RF modulators, extending to the calibration of tuners, transmission testing of various types of converters of various designs or noise analysis of speed measurements.

While audio analysis in infotainment systems is clearly indispensable, particularly for voice, music and multimedia functions, its applications extend far beyond these areas. For example, the MCD AudioAnalyzer can be used for structure-borne noise measurements, such as analyzing engine and transmission noises from electrically driven components like automotive mirrors, windshield wipers, valves or central locking systems. Through this analysis, users can identify and evaluate issues related to gear ratios, runout, concentricity, or unwanted noise generation. Such noises can be perceived by the driver as both annoying and safety-related - such as the clicking sound of a turn signal - and are therefore examined very closely by manufacturers.



The Compact USB Edition is a compact, USB 2.0- compatible variant for direct connection to a PC and is ideal for space-saving workstations and quick measurements.

Picture: MCD

Modular with the MCD SmartModuleS

The MCD SmartModuleS is a 19-inch module system that condenses an entire test bench into a compact format. The device was specifically designed for small-batch testing, incoming inspections or test station development. Thanks to its standalone design (the base unit contains a fully integrated industrial PC) and compact size, it is also suitable for use as a laboratory or test station device. The currently available module types include a 2-channel oscilloscope featuring the technology of the proven PicoScopes, an industrial, switchable USB hub, a digital control module and the audio analyzer described above. The advantages of the MCD AudioAnalyzer in the SmartModuleS variant lie in the fact that a system with two analyzers can be configured with minimal effort, enabling a total of four mono or two stereoinputs and outputs. This allows even extensive measurement setups to be implemented costeffectively while maintaining the flexibility and precision of audio analysis. This system is available as a preconfigured solution. However, an 8-channel PicoScope or "mixed" configurations can also be implemented in a SmartModuleS system housing.

Summary

Audio analysis is a key factor in vehicle infotainment systems, but also in many other fields when it comes to testing and analyzing sound events. The MCD AudioAnalyzer offers interesting and proven solutions in this area, both in terms of hardware and software. The modular design of the MCD SmartModuleS allows for the cost-effective configuration of an audio analyzer with multiple channels. *(bs)* ■

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SW version, with OTA updates every 14 days.

Additional tools like user management and shared defect tracking improve efficiency across companies involved in the PDP. Simulations and regression testing help identify errors earlier, reduce complexity and speed up development.

Discussions with homologation service providers suggest further efficiency gains are possible. Overall, this leads to a consistent "shift-left" approach, where issues are addressed earlier in the development cycle.

SDV SOP dates are often delayed, mainly due to the complexity of integrating K-matrices / communication matrices.

In the Secor SDV Ecosystem, this complexity is removed. A flexible E/E architecture, combined with a patent-pending Message Broker, manages communication between the central control unit (central.CU) and multiple zonal control units (zonal.CUs).

Similar to how the internet works, each SDV component is assigned to its own IP address. These addresses are managed by the Secor directory service, simplifying communication and reducing integration effort.

OTA updates are available at any time, allowing new features and improvements to be rolled out rapidly. This enables continuous development, integration and testing, as well as the ongoing deployment of SW into vehicles. This results in SW living on beyond the individual vehicle into its successors.

The ecosystem supports both central and zonal E/E architectures, though Secor favours the zonal variant due to its clear advantages for the wiring harness. By dividing the vehicle into zones, wiring harnesses can be standardized and variants significantly reduced. At the same time, the quantity and length of cables decrease, reducing both weight and cost. This lower variance and also increases efficiency in the supply chain and OEM assembly.

A further advantage of the zonal architecture is that SW for uninterrupted applications can be distributed into the zonal. CUs. This reduces the power demand – and the resulting heat dissipation – at the central.CU.

SDV Ecosystem – Further R&D roadmap

The in-vehicle communication networks are being shifted toward full Ethernet. As a transmission technology, Ethernet supports a wide range of protocols, including well-known ones like Internet Protocol (IP) and Time-Sensitive Networking (TSN).

It can run over different media, such as twisted pair, coaxial cables and plastic or glass fiber. Available bandwidths range from 10 and 100 Mbit/s up to 1–10 Gbit/s, which is more than sufficient for future vehicle requirements.

In the Secor SDV PoC 2.0, 10 and 100 Mbit/s bandwidths are currently used.

Plug-and-play

In the current (patent-pending) development, every component becomes plug-and-play. As soon as it connects to the vehicle network, it automatically receives a local address. The component then provides metadata - such as manufacturer, product code, capabilities and control details - which is stored in a directory service. Based on this information, the required SW modules are automatically downloaded, allowing the component to be used immediately. This enables rapid prototyping with flexible combinations of components. In production, components can be replaced without requiring new development. In after-sales, the directory service allows precise identification of installed parts and compatible alternatives, even if they are not identical. Any changes to control parameters can be delivered OTA, similar to driver updates.

Data usage is managed through a central API that handles and distributes all events and data. This data can be logged and sent to the cloud for use in applications like predictive maintenance. During development, it is also possible to record driving cycles with precise timing, which can then be used as input for simulations in development and system integration.

Take an active role in the SDV transformation

The next PoC will be the Bavaria+ SDV 1.0 FPGA at IAA Mobility 2027. Secor is already actively working with a handful of companies on its implementation. You have the opportunity to become part of the new SDV Ecosystem and contribute your components or a concept vehicle. Due to the higher material unit costs for an FPGA-based central.CU and zonal.CU, the Bavaria+ SDV 1.0 targets small-series production.

These vehicles could become the first automobiles of the 21st century that future generations will still cherish as classics. Work is already underway on a silicon-based central.CU and zonal.CU designed for high-volume production, with market readiness planned for IAA Mobility 2029 (Bavaria+ SDV 2.0). *(na)* ■

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