CHALLENGES IN AUTOMOTIVE RADIO DESIGN

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In terms of in-car features, customer expectations are driving the integration of more electronic devices. In addition, new technologies and automotive operational requirements create severe design challenges for suppliers.

AUTOMOTIVE INFOTAINMENT SYSTEMS

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Fueled by the growth of new technologies, consumer expectations for automotive entertainment are growing rapidly. Entertainment electronics from the home have found their way into the vehicle, merging with car-specific functions such as navigation, hands-free phone control, and telematics. The new term “infotainment” describes the complete ecosystem of electronic devices for information and entertainment inside the automobile. Audio and video devices, as well as navigation systems and telematics, are merging into single, fully-integrated systems, which naturally creates new challenges for system designers.

Much of the responsibility for the quality of the infotainment system rests with the in-car radio. Along with the reception of real-time audio and video programming, the playback of stored content also adds to the complexity of an in-dash receiver. Bulky CD drives (which require quite a bit of space) have long been considered a standard feature in cars. However, accommodations for flash memory in the form of SD-cards and memory sticks is also becoming quite common, supporting the trend in infotainment to integrate external devices. In addition, customers now expect high-end car entertainment systems to provide interfaces and support for phones, audio/video players and external memory of any kind. The industry-standard USB interface is making great market headway, while a growing number of infotainment systems also integrate Bluetooth® and wireless local area network (WLAN) connections.

Apart from physical connections, the radio head unit also has to offer audio decoding capabilities, drivers, and a suitable user interface for media playback/integration. All of these functions result in complicated car infotainment systems and subsystems that require significant software and hardware effort.

Despite all of these new features, automotive entertainment still centers on the traditional AM/FM receiver. Thanks to technological breakthroughs such as new integrated circuits, filters, amplifiers, and antenna designs, sound quality has improved with each new generation of receiver. Broadcasting technology itself has also been upgraded through the Radio Data System (RDS) extension, which offers specialized features for mobile receivers.

In comparison to analog radio, terrestrial digital broadcasting systems, such as digital audio broadcasting (DAB), HD-Radio™, Digital Radio Mondiale (DRM), and satellite radio, offer a suite of attractive advantages, although they are still striving to achieve mainstream customer awareness and high-volume market success. Each of these digital standards requires very specific hardware to receive and decode the audio data.

Design and Quality Challenges

Traditionally, including more radio functions has required additional hardware. As a result, available space within the automotive radio-head unit has effectively disappeared. The compact nature of the electronics has also caused power consumption and heat dissipation problems. For complex radios, active cooling is mandatory to stay within a safe operating temperature range. Exceeding that limit may result in performance degradation or playback dropouts, as well as increased stress on the entire system.

Because of the expected long lifetime of a car and the rather extreme automotive operating conditions, OEMs are demanding a very high level of quality and reliability for the automotive infotainment system. As a result, the components, especially the integrated circuits, have to demonstrate that they can withstand the changing temperatures, vibrations, and humidity that they will face over the lifetime of a car. For the automotive industry, it is mandatory to qualify a part according to the common AEC-Q100 standard, which was developed by major automotive car manufacturers. Parts that were originally developed for consumer applications often fail to fulfill these requirements, and are typically eliminated early in the selection process.

The close proximity of electronic systems within the radio-head unit can cause interference and electromagnetic compatibility (EMC) issues, which can result in serious performance problems. This is especially true for sensitive analog building blocks such as the receiver front end and signal lines. Designers must work carefully, using shielding and rigorous testing, to verify that the effects of EMC and interference can be controlled.

Cost is also a major design factor, and the need to minimize cost is passed throughout the entire supply chain. OEMs not only need to consider the price of the components when doing economic calculations, but also the development time for the design-in and debugging of the system. It is critical to avoid errors that come up in late project stages, so OEMs typically rely on proven vendors with a history of reliable parts that have already been used in the automotive industry.

RF Challenges for Automotive Receivers

Improvements in car-radio reception over the last decade can be attributed to the introduction of digital signal processing (DSP). However, the fact remains that an analog receiver front end is required to amplify and down convert the radio-frequency (RF) signal and apply basic filtering before the signal is converted to a digital one. Despite the addition of DSP, the efficiency of the entire infotainment system still depends on the quality of the analog receiver. For several reasons, the RF requirements for automotive applications are significantly more demanding than those for stationary radios.

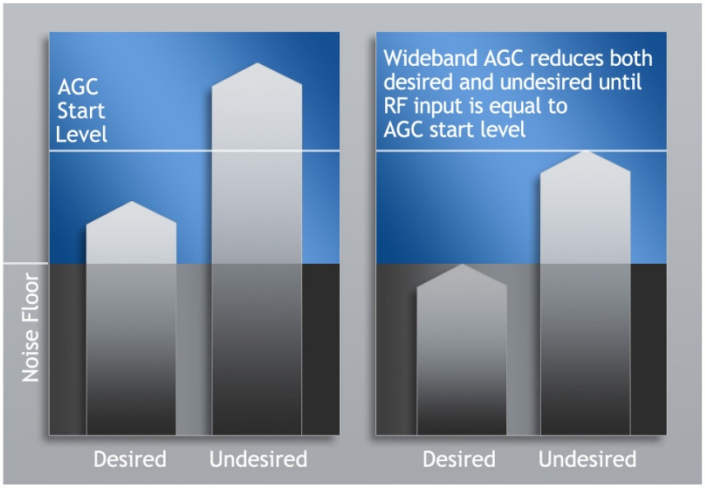
Dynamic Signal Behavior – Automatic Gain Control (AGC)

Receiving conditions for an automotive radio range from extremely low-level signals (such as when passing under a bridge) to absolute maximum peaks (while passing by a roadside transmitter). In the first situation, the sound quality depends heavily on the performance of the antenna as well as on the ability of the receiver to separate and pick up weak signals. Since automotive antenna systems are designed to fit the trim of the car rather than the performance expectations of the customers, the need for a high-quality receiver increases. At the other end of the dynamic range, the receiver also needs a mechanism to protect the input stage from too much signal, preventing what is often referred to as "overload." The mechanism of choice for this function is automatic gain control (AGC), which is effectively a closed-loop circuit that senses the signal strength and attenuates (reduces) the input signal when necessary. A receiver that can

detect and successfully handle signals that are transmitting at extremely low as well as very high power levels is said to have good dynamic range.

Blocking

The presence of strong undesired channels (which is common in many urban areas) can be a major problem for quality radio reception in a car. To avoid overload and distortion, all of the incoming signals can be attenuated by AGC circuitry. However, as a result, the desired channel might then be lower than the overall noise floor (see graphic) which results in dropouts, hisses, and cracks in the AM/FM reception.



Optimally, the receiver's input stages should be designed to tolerate and manage large signals, which minimizes the need to use the AGC circuits. When a receiver is well-designed, it is not overly dependent on its AGC circuitry, and these problems can be avoided. Strong neighboring channels can be filtered out at a later point much more effectively, and without negative impact on the desired channel.

To address this problem, some silicon receiver manufacturers have developed filtering technologies that immediately reject strong undesired channels. Using this additional technology can result in a noticeable improvement in signal robustness for automotive radios.

Multipath interference

Radio waves reflect off of obstacles, like buildings or mountains, so that the same signal arrives at the antenna from different directions with different time delays and different intensities. These signals interfere with each other, making it hard to receive a desired signal. It is even possible that the signals overlay each other in a phase-reversed orientation, completely cancelling out the signal on that frequency. Any signal degradation due to this phenomenon is known as multipath interference, and it is a significant concern in automotive applications where the receiving environment changes continuously.

A good way to deal with multipath interference (also known as frequency selective fading) is to add a diversity function to the system. In an antenna diversity system, the signals are received at multiple antennas, which increases the probability that at least one antenna has good reception.

Temperature drift

A major difference between the consumer electronics and automotive markets is the variations in temperature experienced by the receiver. An automotive receiver needs to maintain its performance at very high and very low temperatures. If a receiver cannot do that, it was likely designed for use in low-cost consumer devices. For an automotive receiver, the most critical performance indicators like sensitivity, selectivity, and noise figure need to be guaranteed and proven across -40°C to +85°C to handle the climatic conditions of most countries in the world. (Note that the heat dissipation of other hardware in the radio unit also adds to the temperature.)

Summary

Next-generation automotive radio platforms pose new challenges to both OEMs and suppliers. The rapidly accelerating technologies represented by current infotainment systems require robust product design followed by thorough product qualification.

An automotive infotainment system requires a high-quality, reliable receiver that not only offers seamless integration and supports the functionality of a wide variety of new infotainment systems, but also satisfies the vigorous demands of the unique automotive RF environment.