

Technical and Quality Challenges of High-Speed Automotive TV Design

by Harald Koch, Marketing Manager Automotive, Microtune®, Inc.

Increased demand for in-vehicle TV entertainment systems is driving the need for compact, high-performance TV tuners that can meet challenging performance requirements and withstand the harsh automotive environment

SUMMARY

This is an exciting time for entertainment packages in the automobile. From humble beginnings as a simple in-dash radio, in-car options are increasingly migrating to include the popular music, video, and TV systems that tech-savvy consumers enjoy in their home. New vehicles are now being equipped with digital radio, rear-seat entertainment, and Internet access available independently for driver and passengers (front-seat passengers might be listening to radio reception while rear-seat passengers are enjoying a separate FM or DVD playback). Thanks to the introduction of digital TV services around the world, high-speed TV, where passengers can watch real-time broadcast TV while the vehicle is traveling at speeds of up to 200km/hour (125 miles/hour), has become technically feasible.

In-vehicle TV requires dedicated TV tuners.

In designing their in-vehicle TV entertainment systems, car makers and their tier-1 suppliers are finding that automotive TV tuners, unlike those found in consumer devices, need to take into account unique technical considerations. In addition to being compliant with demanding automotive-quality standards, the tuners and receivers that enable these systems must also satisfy the size and performance needs of the automotive industry as it migrates to more and smaller electronics content. Equally important, there is increasing demand to deploy advanced and highly integrated solutions that reduce cost while, at the same time, enabling no-compromise TV performance and quality.

In terms of reliability, the major standard of importance is AEC-Q100¹, a qualification test sequence developed by the Automotive Electronics Council². AEC-Q100 is a critical stress test qualification for automotive integrated circuits (ICs), requiring testing in very high and very low ambient temperatures, as well as in changing temperatures and humidity. This testing requires specialized equipment that is typically only found in high-end testing labs.

Automotive TV Opportunities

Since the introduction of liquid crystal displays, TV receivers have become a part of the options list for luxury car manufacturers throughout Europe and Asia. However, TV tuners are no longer being used only in high-end automobiles. In fact, due to lower prices for entertainment electronics, manufacturers are now offering rear-seat multimedia entertainment systems in medium and low-priced autos worldwide, while aftermarket products are further increasing the

¹ <http://www.aecouncil.com/AECDocuments.html>. accessed Nov. 7, 2008

² The AEC Component Technical Committee is the standardization body for establishing standards for reliable, high quality electronic components. Components meeting these specifications are suitable for use in the harsh automotive environment without additional component-level qualification testing.

variety of devices available. Price reductions in electronics are also driving demand for innovative new features, such as units that show different content on multiple screens (navigation in the front seat and TV in the rear seats, for example).

RF Performance Challenges

All of these new systems offer not only unique opportunities, but also challenges for manufacturers, especially for designers of the TV tuner. This is because radio frequency (RF) requirements for automotive applications differ significantly from those of residential digital TVs or even those used in 'mobile TV' services that are accessed using handheld wireless devices. These technical challenges include:

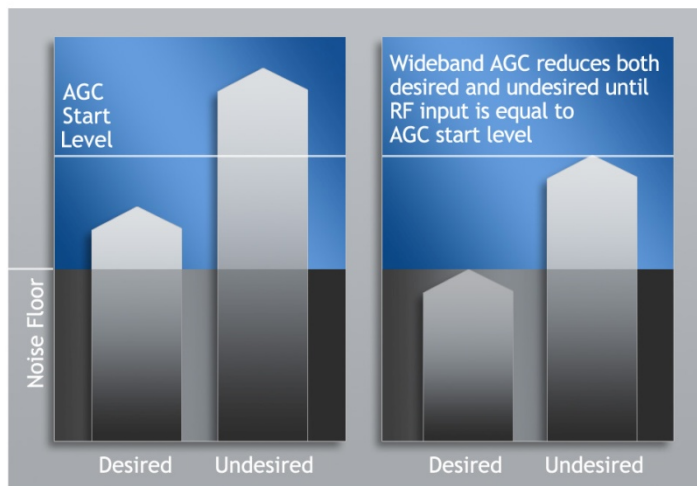
Radio frequency (RF) requirements for automotive applications differ significantly from those of residential digital TVs or even those used in 'mobile TV' services that are accessed using handheld wireless devices.

Dynamic range

Receiving conditions for an automotive tuner 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 tuner has to have good sensitivity, or the ability to pick up a low-power signal. To ensure excellent sensitivity, a tuner IC could incorporate a good low noise amplifier (LNA) in order to compensate for any loss. At the other end of the range, the tuner requires a mechanism to protect the input stages from too much signal in order to prevent what is known 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 the input signal when necessary. A tuner that can handle signals that are transmitting at extremely low, medium, or high power levels is said to have good dynamic range.

Signal Blocking

The presence of strong undesired channels (as can be experienced, for example, in many urban areas) can be a major problem for audio and video quality in automotive TV. To avoid overload and distortion, these signals can be attenuated by the AGC circuitry. However, as a result, the desired channel might then be lower than the overall noise floor (see graphic) and disappear entirely from the in-vehicle display.



In order to avoid these dropouts, a well-designed receiver should not be overly dependent on its AGC circuitry. Optimally, the receiver's input stages should be designed to tolerate and manage these large signals in order to minimize reliance on the AGC circuits.

To address this challenge, some silicon tuner manufacturers have worked to develop new filtering technologies to prevent strong undesired channels from affecting the desired one. Using this additional technology can result in a noticeable improvement in signal robustness for automotive silicon tuners.

Multipath Interference

In a wireless environment, radio waves reflect off of obstacles, such as buildings or mountains, and 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 which would completely cancel 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.

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 receive system, the signals are received at multiple antenna systems, which increases the probability that at least one antenna has good reception.

Reception when vehicle is moving at high speeds

Reception in a fast-moving car can experience signal drop outs due to the Doppler Effect. In short, this means that if the sender is stationary, the moving receiver 'sees' frequency shifts depending on its velocity. (It is also possible to experience the Doppler Effect when listening to an ambulance that drives by on the street.)

To avoid drop-outs of the picture at high speeds due to the Doppler Effect, it is necessary to build a multi-tuner design in which two or more separate tuner-antenna paths are used to receive the same channel. These independent signals are combined in the backend using a method called maximum ratio combining (MRC) diversity to improve the overall signal quality and to increase the attainable maximum speed without signal loss. In MRC, the data from the antenna and tuner are continuously monitored, and incorrectly received data is replaced with data blocks from the other path.

ADVANCED AUTOMOTIVE TUNERS: THE MT2067

Because of unique performance requirements, OEMs are finding that high-performance silicon tuners are the optimal solution for automotive applications. The MicroTuner™ MT2067 is a specialized, automotive-grade silicon TV tuner that is optimized for excellent dynamic range, sensitivity, and superior large-signal behavior to enable stable reception when moving at speeds of up to 200km/hour (125 miles/hour). Addressing global terrestrial digital TV standards, the MT2067 is engineered to offer robust performance even in challenging receiving conditions such as dense, urban signal environments.

Because of its high integration, the MT2067 IC has fewer external components than a module, which improves reliability over lifetime. In addition, since silicon tuners are smaller than modules, they can be placed directly onto the main system board, where they are less sensitive to mechanical stresses.

To provide superb dynamic range, the MT2067 features industry-leading AGC circuitry. Unlike traditional fixed circuitry, the dynamic AGC in the MT2067 allows system designers to change and adjust parameters to address different receiving situations. The MT2067 also benefits from Microtune's patented ClearTune™ technology, a special filtering technique that enables the tuner to reject undesired neighboring channels.

While important, performance is not the only concern for automotive TV tuners. In addition to resolving the technical issues unique to high-speed TV entertainment, automotive designers must also consider system design constraints, including size, power consumption, and cost, when implementing an in-vehicle entertainment system.

The MicroTuner™ MT2067 is a specialized, automotive-grade silicon TV tuner that is optimized for excellent dynamic range, sensitivity, and superior large-signal behavior to enable stable reception when moving at speeds of up to 200km/hour (125 miles/hour).

Multi-Tuner Solutions

To add reliable TV functionality and address performance issues such as reception at high speeds, the industry trend for automotive entertainment systems is to include multiple receiving paths. Industry experts estimate that between two and four tuners will be necessary to fulfill the requirements of OEM automotive customers in the future. With these multi-tuner systems, device size becomes critical. As more electronic components are added to new car designs, there is less 'real estate' space available for multiple receiver units, so tiny silicon tuners rapidly become a necessity. The MT2067, for instance, measures 7x7mm and was designed for ease of use in multi-tuner applications. The integration of buffered loop through output for the antenna signal, as well as programmable reference frequency output, helps to keep the total bill of materials (BoM) small and also reduces the design effort.

Price/Performance

An additional constraint for automotive tuner designs is cost, since OEM manufacturers tend to put significant pressure on their tier-1 suppliers to realize savings. Some cost reductions can be achieved by economies of scale through a growing, expanding market. However, this is not likely to reduce the costs significantly, so manufacturers need to consider new technologies to stay competitive. By deploying silicon IC tuners, as already proven in consumer markets, system designers can take advantage of the price benefits of silicon, as well as its high level of integration.

Continuing in its tradition of leadership in the automotive marketplace, Microtune is the first company to satisfy all of the above specifications and qualify its automotive silicon tuner to the AEC-Q100 standards. The MT2067 silicon tuner offers the highest levels of performance and quality for the automotive market.

SUMMARY OF AUTOMOTIVE TUNER NEEDS

To be successful a silicon tuner must be automotive-tested and satisfy the following criteria:

- Performance guaranteed across a temperature range of -40° to +85°C
- Tolerate extreme environmental and mechanical stresses like changing temperatures, humidity, and vibration
- Provide high linearity at moderate power consumption
- Offer superior sensitivity, selectivity, and large signal behavior
- Comply with the stringent AEC-Q100 quality standards for integrated circuit electronics

The automotive market has rigorous performance and reliability standards, specific qualification processes, and challenges of temperature, vibration, and longer product life times as compared to consumer products. For in-vehicle entertainment systems, there are also unique challenges with mobile reception in a fast-moving vehicle. Car makers and their suppliers are finding that consumer-grade tuners will not satisfy these needs. Instead, silicon tuners, such as the MicroTuner MT2067, which are specifically designed and qualified for use in automotive audio/video/data receivers, are rapidly proving to be the right choice for in-vehicle entertainment.