Low EMI/EMC Emission Switching Converter Eases ADAS Designs

By Tony Armstrong

Background
ADAS is an acronym for advanced driver assistance system, which is commonly found in many of today's new automobiles and trucks. These systems usually facilitate safe driving and can provide the driver with an alert if the system detects risks from surrounding objects such as errant pedestrians, cyclists, or even other vehicles on an unsafe trajectory! Furthermore, these systems typically provide dynamic features such as adaptive cruise control, blind spot detection, lane departure warning, driver drowsiness monitoring, automatic braking, traction control, and night vision. As a result, the increasing focus of consumers on safety, demands for comfort while driving, and the continued increase of government safety regulations are the main growth drivers of ADAS in automobiles for the latter half of this decade.

This growth does not come without challenges for the industry, which include pricing pressure, inflation, complexity, and difficulty in testing these systems. Moreover, it should come as no surprise that the European automotive industry is one of the most innovative automotive markets, and, as such, it has seen major market penetration and adoption of ADAS from its customers. Nevertheless, both the American and Japanese automotive makers are not far behind. The ultimate goal is an autonomous driving machine without the need for a human being behind the wheel!

System Challenges
Generally speaking, an ADAS incorporates some kind of microprocessor to gather all of the input from the numerous sensors within the vehicle and then processes them so that they can be easily presented to the driver in a way that it can be easily understood. Moreover, these systems are usually powered directly from the vehicle’s main battery, which is a nominal 9 V to 18 V in a car, but could be as high as 42 V due to voltage transients within the system, and as low as 3.4 V during a cold-crank condition. Therefore, any dc-to-dc converters within these systems must be able to handle the wide input voltage range of 3.4 V to 42 V at a minimum. Furthermore, many dual battery systems, such as those commonly found in trucks, require an even broader input range, pushing the upper limit as high as 65 V. As a result, some ADAS manufacturers design their systems to cover a 3.4 V to 65 V input range so that they can be used in either cars or trucks; while gaining economies of scale during the manufacturing process.

Many ADASs use a 5 V and 3.3 V rail to power their various analog and digital IC content; correspondingly, the manufacturers of such systems prefer to use a single converter to address both the single and double battery configurations simultaneously. Furthermore, the system is usually mounted in a part of the vehicle that is both space and thermally constrained, thereby limiting the heat sinking available for cooling purposes. While it is commonplace to use a high voltage dc-to-dc converter to generate a 5 V and 3.3 V rail directly from the battery, in today’s ADASs a switching regulator must also switch at 2 MHz or greater, rather than the historical switching frequency of sub-500 kHz. The key driving force behind this change is the need for smaller solution footprints while also staying above the AM frequency band to avoid any potential interference.

Furthermore, as if the designers’ task is not already complicated enough, they must also ensure that the ADAS complies with the various noise immunity standards within the vehicle. In an automotive environment, switching regulators are replacing linear regulators in areas where low heat dissipation and efficiency are valued. Moreover, the switching regulator is typically the first active component on the input power bus line, and therefore has a significant impact on the EMI performance of the complete converter circuit.

There are two types of EMI emissions: conducted and radiated. Conducted emissions ride on the wires and traces that connect up to a product. Since the noise is localized to a specific terminal or connector in the design, compliance with conducted emissions requirements can often be assured relatively early in the development process with a good layout or filter design.

However, radiated emissions are another story altogether. Everything on the board that carries current radiates an electromagnetic field. Every trace on the board is an antenna and every copper plane is a resonator. Anything, other than a pure sine wave or dc voltage, generates noise all over the signal spectrum. Even with careful design, a power supply designer never really knows how bad the radiated emissions are going to be until the system gets tested—and radiated emissions testing cannot be formally performed until the design is essentially complete.

Filters are often used to reduce EMI by attenuating the strength at a certain frequency or over a range of frequencies. A portion of this energy that travels through space (radiated) is attenuated by adding metallic and
magnetic shields. The part that rides on PCB traces (conducted) is tamed by adding ferrite beads and other filters. EMI cannot be eliminated but can be attenuated to a level that is acceptable by other communication and digital components. Moreover, several regulatory bodies enforce standards to ensure compliance.

Modern input filter components in surface-mount technology have better performance than throughhole parts. However, this improvement is outpaced by the increase in operating switching frequencies of switching regulators. Higher efficiency, low minimum on- and off-times result in higher harmonic content due to the faster switch transitions. For every doubling in switching frequency, the EMI becomes 6 dB worse while all other parameters, such as switch capacity and transition times, remain constant. The wideband EMI behaves like a first-order, high-pass filter with 20 dB higher emissions if the switching frequency increases by 10 times.

Savvy PCB designers will make the hot loops small and use shielding ground layers as close to the active layer as possible. Nevertheless, device pinouts, package construction, thermal design requirements, and package sizes needed for adequate energy storage in decoupling components dictate a minimum hot loop size. To further complicate matters, in typical planar printed circuit boards, the magnetic or transformer style coupling between traces above 30 MHz will diminish all filter efforts since the higher the harmonic frequencies, the more effective unwanted magnetic coupling becomes.

High Voltage DC-to-DC Converter with Low EMI Emissions

It was because of the previously described application constraints that Analog Devices’ Power by Linear™ Group developed the LT8645S—a high input voltage capable, monolithic, synchronous buck converter that also has low EMI emissions. Its 3.4 V to 65 V input voltage range makes it ideal for both automotive and truck applications, including ADAS, which must regulate through cold-crank and stop-start scenarios with minimum input voltages as low as 3.4 V and load dump transients more than 60 V. As seen in Figure 1, the device is a single-channel design delivering an 8 A output at 5 V. Its synchronous rectification topology delivers up to 94% efficiency at a switching frequency of 2 MHz, while Burst Mode® operation keeps quiescent current under 2.5 μA in no-load standby conditions, making it ideal for always on systems.

The LT8645S’s switching frequency can be programmed from 200 kHz to 2.2 MHz and synchronized throughout this range. Its unique Silent Switcher® 2 architecture integrates internal input capacitors, as well as internal BST and INTVCC capacitors to reduce the solution footprint. Combined with very well controlled switching edges and an internal construction with an integral ground plane and the use of copper pillars in lieu of bond wires, the LT8645S’s design dramatically reduces EMI emissions. Furthermore, its Silent Switcher 2 design also provides robust EMI performance on any printed circuit board (PCB), including 2-layer PCBs. Moreover, it is much less sensitive to the PCB layout when compared to other comparable converters. This new level of performance is due to the LT8645S’s internal, dual-input, BST and INTVCC capacitors that minimize the area of the hot loops. It still requires dual external input capacitors, but the requirement of placing them as close to the input pins is greatly relaxed. Combined with the internal capacitors minimizing the area of the hot loops, the BT substrate’s integrated ground plane significantly improves EMI performance (see Figure 2). The multilayer BT substrate also enables the I/O pins to use the exact same pattern as a QFN package, while enabling large grounded thermal pads. This laminate-based QFN (LQFN) package is more pliable and flexible than the standard QFN and has demonstrated much better performance in solder joint reliability during board level temperature cycle, allowing customers to use LQFN where previously they could only use leaded parts.

Figure 1. LT8645S schematic delivering 5 V at 8 A output at 2 MHz.
The LT8645S can easily pass the automotive CISPR25, Class 5 peak EMI limits over its entire load range. Spread spectrum frequency modulation is also available to lower EMI levels further (Figure 2). The LT8645S utilizes internal top and bottom high efficiency power switches with the necessary boost diode, oscillator, and control and logic circuitry integrated into a single die. Low ripple Burst Mode operation maintains high efficiency at low output currents while keeping output ripple below 10 mV p-p. Finally, the LT8645S is packaged in a small thermally enhanced 4 mm × 6 mm, 32-lead LQFN package.

**Figure 2.** LT8640S radiated EMI performance graph.

**Conclusion**

The proliferation of ADASs in cars and trucks is not going to end anytime soon. It is also clear that finding the right power conversion device that meets all the necessary performance metrics so as not to interfere with the ADAS is not a simple task. Fortunately, the designers of these automotive systems can now have the high performance capabilities afforded by the Silent Switcher 2 dc-to-dc converters from Analog Devices. Not only do they greatly simplify power designers’ tasks, they simultaneously deliver all the performance needed without requiring sophisticated layout or design techniques.

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