Powering the Future of Autonomous Driving

Analog Devices announced mid July a collaboration with First Sensor AG to develop products aimed at speeding the launch of autonomous sensing technology serving unmanned automotive, aerial and underwater vehicles in transportation, smart agriculture, industrial manufacturing and other industries. How power electronics can pave the route to self-driving cars explains **Tony Armstrong, product marketing director for Analog Devices' Power by Linear product group, USA**

As part of the collaboration, Analog Devices and First Sensor are developing offerings that shrink the LIDAR (light detection and ranging) signal chain to enable higher system performance as well as reduce size, weight, power and cost for manufacturers designing sensing and perception technology into their autonomous safety systems. The companies also plan to develop other LIDAR products that will serve automotive and industrial manufacturing applications.

LIDAR (see Figure 1) is growing in importance in automotive. It is one of the primary perception sensors in today's robo-taxi test vehicles. Additionally, LIDAR systems have appeared in high end luxury retail cars such as the Audi A8, where a short range system is used in a semi-autonomous driving function limited to speeds up to 60 km/h. Cars with autonomous or semi-autonomous driving functions will require a multiplicity of perception sensors to have adequate redundancy in the sensor types for safe operation. The main perception sensors today are cameras, with radar now becoming more ubiquitous and lidar coming in the near future. Cameras have the lowest cost and are already widely deployed in cars. The range of camera systems is limited, particularly in bad weather. Radars are ramping up in volume in mass market automotive and they are robust against weather out to ranges greater than 200 meters. Assuming that a minimum of two sensor modalities are required to enable autonomous modes of driving, then it is likely that LIDAR will be an important and necessary sensor to accompany radar for long-range sensing. In addition to its higher base cost, there are significant technical challenges with lidar systems beyond ranges of 150 meters. Data converter, power management, and signal condition technologies are also making their way into first and second generation LIDAR systems.

The timeline to self-driving cars

There can be no doubt that self-driving cars are coming, even if there are a few setbacks along the way. So, a couple good questions might be: when will we get there and how long will it take to get there?

According to the auto industry, there are two standard terms for this transition: an evolutionary one where existing cars get there little by little (analogous to Tesla's autopilot feature) and a revolutionary one where we have totally self-driving cars (like the ones Google are working on). It is

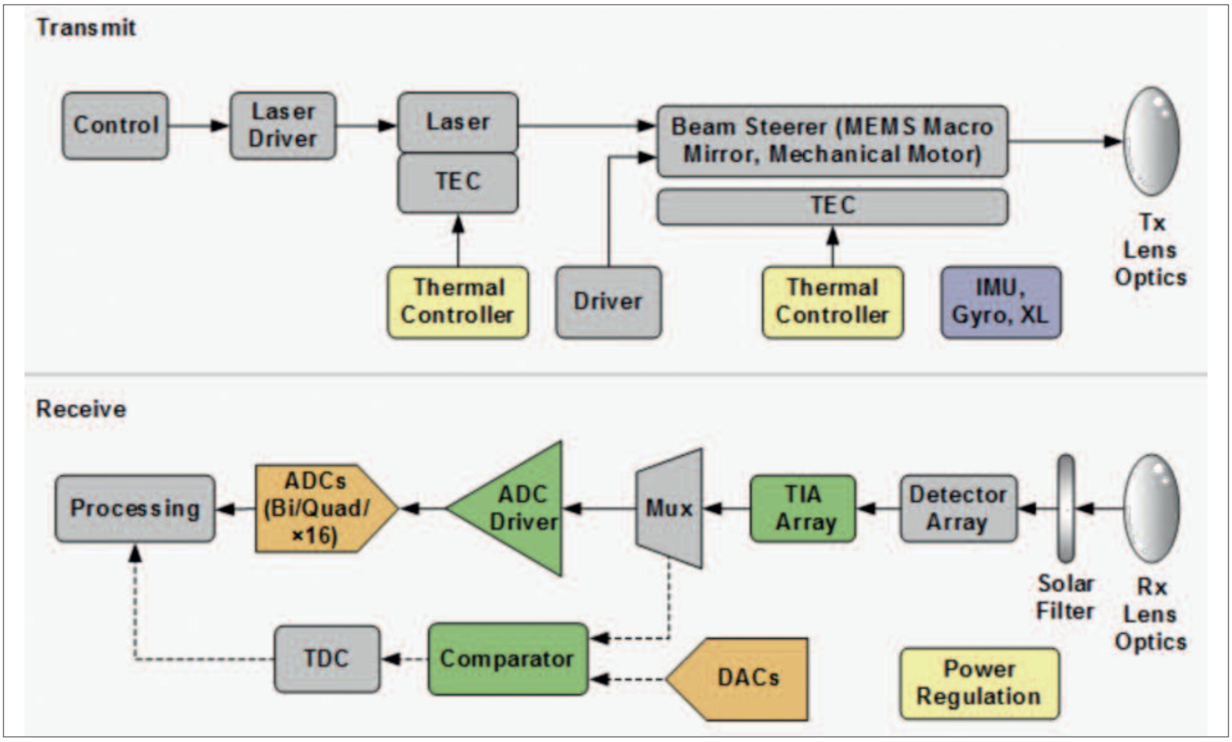

Figure 1: **LIDAR utilizes pulses of light to translate the physical world into 3D digital images in real time with a high level of confidence**

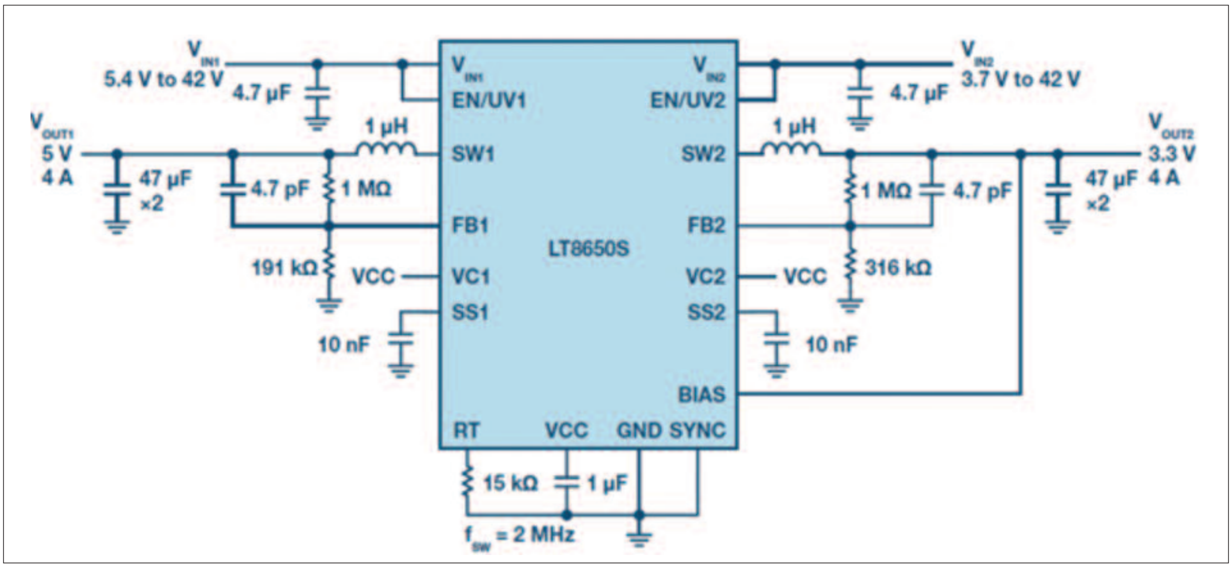

Figure 2: **Simplified LT8650S schematic delivering 5 V at 4 A and 3.3 V at 4 A outputs, at 2 MHz**

unclear to me that either path will succeed by itself, but it will more likely end up being a symbiotic amalgamation of the two. The car makers and high tech auto systems providers will need to closely collaborate with each other so as to ensure that light detection, LIDAR, radar sensors, GPS, and cameras all work cohesively together.

Looking ahead, vehicles equipped with semi-autonomous features should be able to navigate through intersections, traffic lights, and stop-and-go traffic conditions. Nevertheless, even these highly autonomous cars will still require an actual human being to be up front in case of emergency situations. Looking further ahead, these semi-autonomous vehicles will also function normally in more stringent conditions, such as severe weather and night time. By this timeframe, lift-service providers may start using these types of cars without any driver. Of course, automakers will have to make sure their vehicles understand human signals from pedestrians, like waving them on at a crossing or intersection. All of these advancements will necessitate the automakers having many autonomous features in their vehicles, which could potentially allow for autonomous self-driving cars to be on the roads by the mid-2030s.

Of course, all the advancements needed to make this timeline a reality will be a boon to the IC semiconductor industry, since it will supply the majority of the Silicon content for the many systems needed to make it all happen.

Analog ICs

Fully autonomous cars will clearly have many different electronic systems with a mix of both digital and analog ICs. These will include advanced driver assistance systems (ADAS), automated driving computers, autonomous parking assist, blind spot monitoring, intelligent cruise control, night vision, LIDAR, and more. All of these systems require a variety of different voltage rails and current levels for their correct operation; however, they can be required to be powered directly from the automobiles battery and/or alternator and, in some instances, from a postregulated rail from one of these rails. This is usually the case for the core voltages of VLSI digital ICs such as FPGAs and GPUs that can need operating voltages sub-1 V at currents from a couple of amps to 10th of amps.

System designers must also ensure that the ADAS comply with the various noise immunity tandards 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

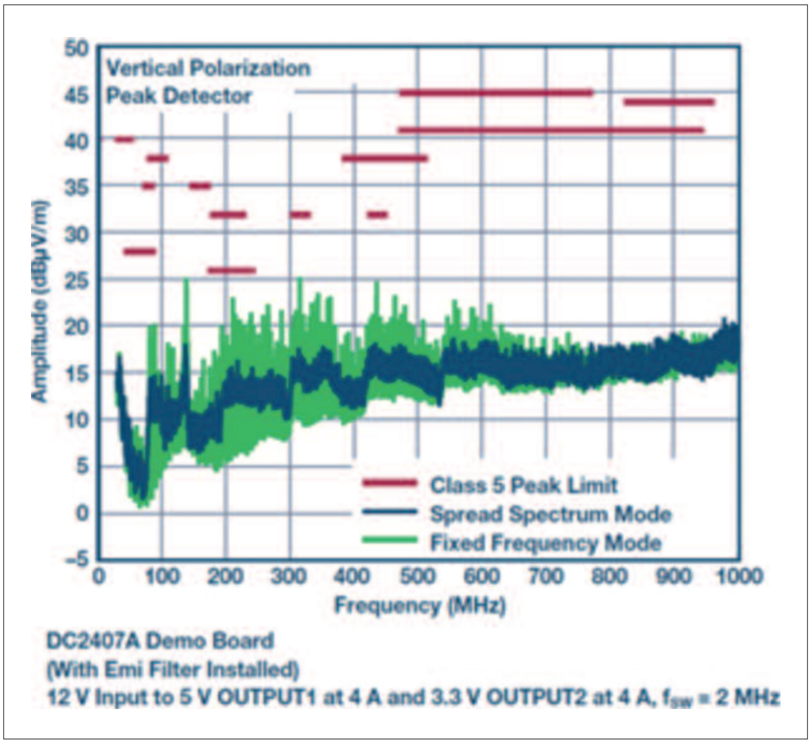

Figure 3: **LT8650S radiated EMI performance graph**

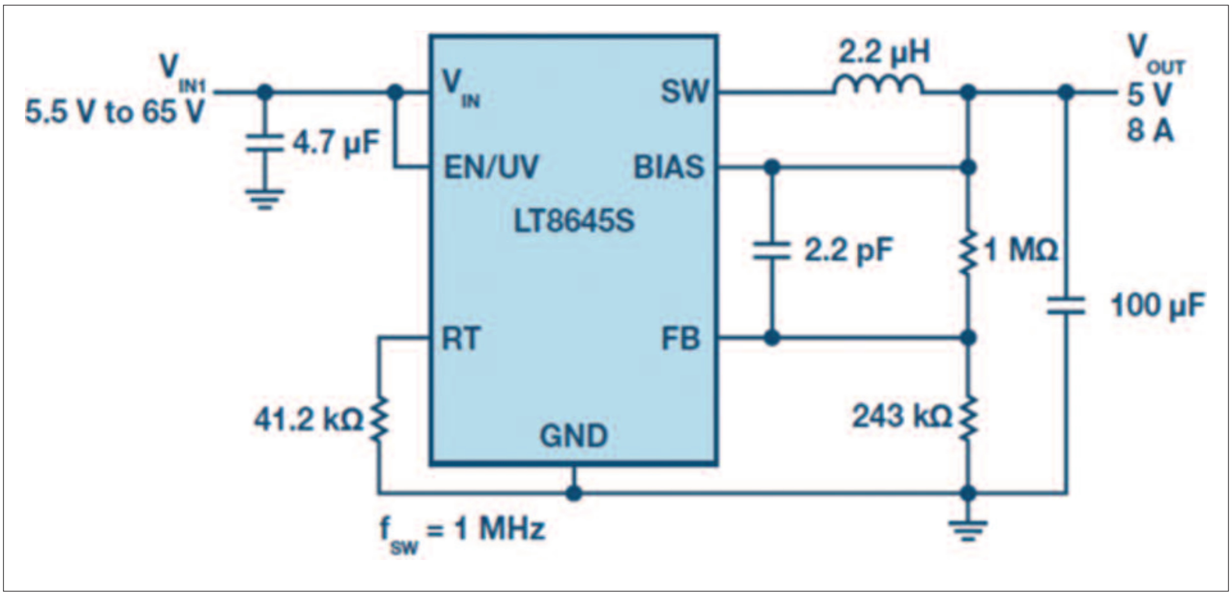

Figure 4: **Simplified LT8645S schematic delivering 5 V at 8 A output at 2 MHz**

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 as already stated.

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.

High-voltage converter with Low EMI/EMC emissions

It was because of the application constraints outlined herein that Analog Devices' Power by Linear™ Group developed the LT8650S - a high input voltage capable, dual output monolithic synchronous buck converter that also has low EMI/EMC emissions packaged in a small thermally enhanced 4 mm × 6 mm IC pin LGA package. Its 3 V to 42 V input voltage range makes it suited for automotive applications, including ADAS, which must regulate through cold crank and stop-start scenarios with minimum input voltages as low as 3 V and load dump transients in excess of 40 V. As illustrated in Figure 2, it is a dual-channel design consisting of two high voltage 4 A channels, delivering voltages as low as 0.8 V, enabling it to drive the lowest voltage microprocessor cores currently available. Its synchronous rectification topology delivers up to 94.4 % efficiency at a switching frequency of 2 MHz, while Burst Mode® operation keeps quiescent current under 6.2 µA (both channels on) in no-load standby conditions making it suited for always-on systems.

The LT8650S's switching frequency can be programmed from 300 kHz to 3 MHz and synchronized throughout this range. Its 40 ns minimum on-time enables 16 VIN to 2.0 VOUT step-down conversions on the high voltage channels with a 2 MHz switching frequency. Its Silent Switcher® 2 architecture uses two internal input capacitors as well as internal BST and INTVCC capacitors to minimize the area of the hot loops. Combined with very well

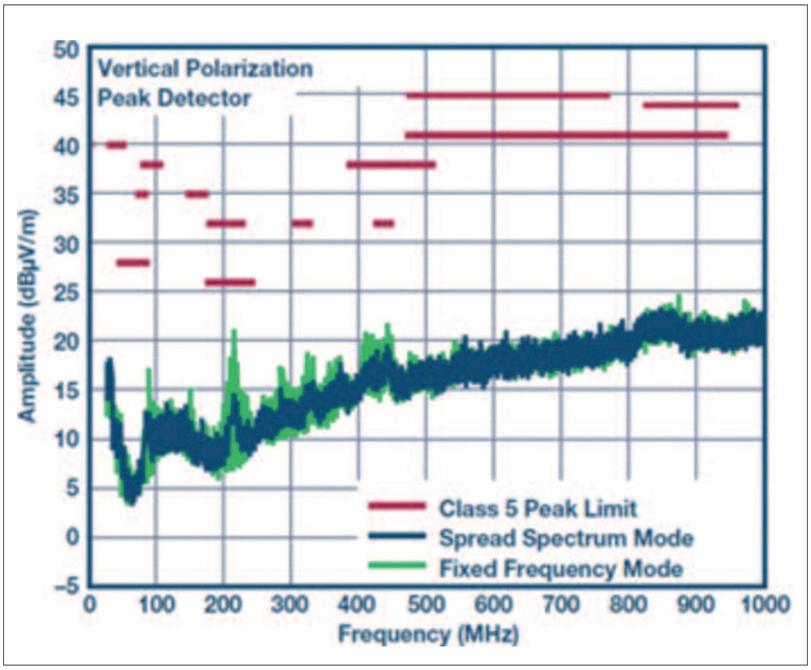

Figure 5: **LT8645S radiated EMI performance graph**

controlled switching edges and an internal construction with an integral ground plane and the use of copper pillars in lieu of bond wires, the LT8650's design dramatically reduces EMI/EMC emissions (see Figure 3). This improved EMI/EMC performance is not sensitive to board layout, simplifying design and reducing risk even when using 2-layer PC boards. The LT8650S can easily pass the automotive CISPR 25, Class 5 peak EMI limits with a 2 MHz switching frequency over its entire load range. Spread spectrum frequency modulation is also available to lower EMI levels further.

Similarly, for applications needing a wider input range than that afforded by the LT8650S, the LT8645S is 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 that 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 can be seen in Figure 4, it 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 suited for always-on systems.

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 LT8645's design reduces EMI/EMC emissions (see Figure 5). This improved EMI/EMC performance is not sensitive to board layout, simplifying design and reducing risk even when using 2-layer PC boards. The LT8645S can easily pass the automotive CISPR 25, Class 5 peak EMI limits over its entire load range. Spread spectrum frequency modulation is also available to lower EMI levels further.

The LT8645S utilizes internal top and bottom high efficiency power switches with the necessary boost diode, oscillator, 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 IC 32-lead LQFN package.

Conclusion

The proliferation of automotive systems that will be necessary for the autonomous self-driving cars (and trucks) of the future continue to gain momentum even here in the present. Of course, voltage and current levels will change; nevertheless, the requirements for low EMI/EMC emissions will not go away - and neither will the hostile environment in which they need to operate. Fortunately, there are a growing number of solutions to assist the system designer in the present and the future, even if the mid-2030s seems a long way off.

Literature

https://www.analog.com/en/technical-articles/self-driving-cars-are-powersystems-up-to-the-task.html