# How to Design Better High Current Switching Power Supplies for Vehicle ADAS

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## Abstract

All automakers are enhancing their ADAS to assist drivers in driving and parking. Evolving ADAS consume more power than their antecedents. Therefore, low current switching regulators can't meet this growing power requirement anymore. This article proposes two high current monolithic Silent Switcher® buck regulators, LT8638S and LT8648S, as a possible solution. The application circuits of both regulators are presented. The efficiency, temperature, and emission test results demonstrate that LT8638S and LT8648S are perfect power supply candidates for the rapid developing ADAS.


## Introduction

Advanced driver assistance systems (ADAS) are increasingly prominent in today's automotive vehicles. They enhance driver and road safety by minimizing human errors. Early ADAS only included a single automated driver assistance feature, such as adaptive cruise control using one radar sensor. Now more ADAS functions are being added to automotive vehicles, such as automatic emergency parking, blind sport monitoring, vehicle/pedestrian warning and avoidance, lane departure warning and assistance, etc. The evolution of ADAS means that these new vehicles need to draw more power than ever before, due to increased number of sensors and cameras, powerful real-time data processing and computation, and ultrahigh speed communications. For example, the first generation ADAS system on chip (SoC), such as Mobileye EyeQ in 2008, which only consumed 2 W to ~3 W. Newly released ADAS SoCs, like NVIDIA® Xavier™, consume 20 W to ~30 W or more due to their powerful data processing and computation capability. The power of ADAS comes from a 12 V battery. It is converted into 5 V or 3.3 V intermediate power rail at first, and then is transformed into different low voltages that are required by a SoC core, interfaces, peripherals, and so on. Since the power consumption of the ADAS SoC increases, the intermediate rail converter should be able to output 10 A or more to meet that requirement.

A traditional solution to design a high current intermediate power supply is using buck controllers. However, the total solution size of this method is large, due to the necessity of external MOSFETs. Therefore, it is challenging to fit the controller power solution into a confined space, which is a common situation for the ADAS application in the automotive. Another concern for the switching power supplies in the vehicles is the electromagnetic emission. Power supply designers need to address the challenges from the strict radiated and conducted electromagnetic emission limits, which are mandatory in the automotive industry. With increased power consumption, those electromagnetic emission criteria become more difficult to meet. To comply with the constraints of power, size, and electromagnetic emissions, Analog Devices developed two 42 V high current monolithic Silent Switcher regulators: LT8638S and LT8648S.

## Compact 10 A/12 A peak Power Solution Using LT8638S

LT8638S is a 42 V, 10 A, one-channel buck regulator, which includes all the control circuitry and MOSFETs on a 4 mm × 5 mm LQFN package. Its output current can reach up to 12 A for a short time. LT8638S is a perfect candidate for the compact 10 A intermediate power rail. Figure 1 shows a typical 5 V/10 A LT8638S schematics. The switching frequency of LT8638S regulator is adjustable from 200 kHz to 3 MHz. Table 1 lists the main components for 400 kHz LT8638S circuit and 2 MHz LT8638S circuit. Figure 2 shows the efficiency and temperature rise of LT8638S on the demo board DC2929A, at 400 kHz and 2 MHz, respectively.

Comparing LT8638S 400 kHz circuit with LT8638S 2 MHz circuit, the inductor footprint for 400 kHz is 2.5 times of the 2 MHz inductor, and the output capacitor for 400 kHz is 3 times of the 2 MHz output capacitor. So, for the size and cost sensitive applications, 2 MHz switching frequency is preferred. The major concerns that prevent the power supply design engineers from using 2 MHz are the efficiency and thermal performance, since switching losses can be significantly increased at high switching frequency. LT8638S calms down those concerns by minimizing the switching losses with fast switch edges, as shown in Figure 3. In Figure 2, LT8638S's temperature increase is only 60°C with 50 W output power at 2 MHz switching frequency. The efficiency difference between 2 MHz and 400 kHz is within 1.5% at 10 A load.

Fast switch edges are good for the efficiency at high switching frequency but may worsen the electromagnetic emissions. The LT8638S is equipped with Silent Switcher architecture, enabling it to operate with both fast switch edges and significantly low EMI at a much smaller solution size. Figure 4 shows an ultralow EMI 2 MHz LT8638S circuit. To achieve the best EMI performances, the regulator operates in the spread spectrum mode by connecting SYNC/MODE pin with $INTV_{CC}$ pin. Figure 5 shows LT8638S emissions of Figure 4 circuit, with the test setup defined in CISPR 25 standard. The red lines represent CISPR 25 Class 5 limits, which are the most stringent emission specifications in automotive industry. With very few additional components generating an input filter, as shown in Figure 4, LT8638S can meet CISPR 25 Class 5's stringent peak and average limits.

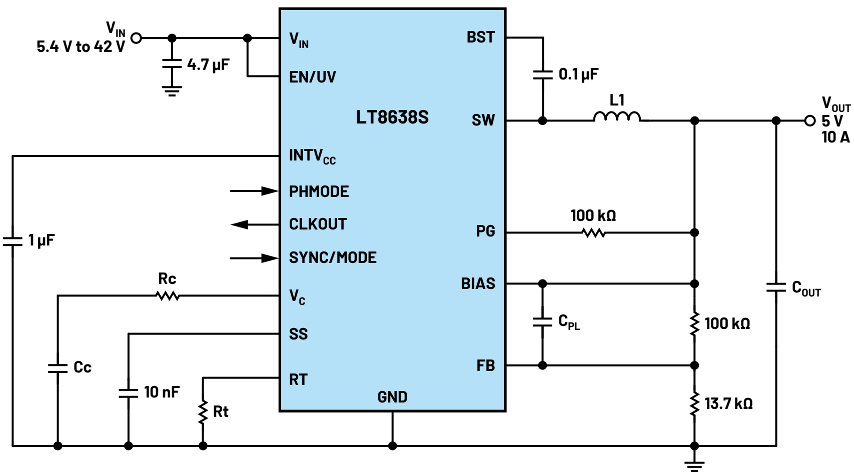


*Figure 1. A 5 V/10 A power supply using LT8638S.*

## Table 1. Components for Figure 1 Schematics

| Switching Frequency | 400 kHz | 2 MHz |
|---|---|---|
| L1 | 3.3 µH (10 mm × 11.3 mm × 10 mm) | 0.56 µH (6.36 mm × 6.56 mm × 6.1 mm) |
| $C_{OUT}$ | 47 µF × 3 | 47 µF × 1 |
| Rt | 105 kΩ | 16.9 kΩ |
| Rc | 9.31 kΩ | 13.7 kΩ |
| Cc | 820 pF | 220 pF |
| $C_{PL}$ | 33 pF | 10 pF |

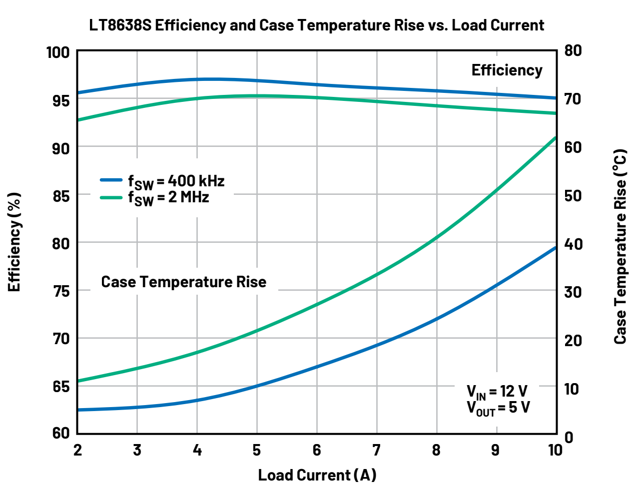


*Figure 2. Efficiency and temperature rise of Figure 1 circuits.*

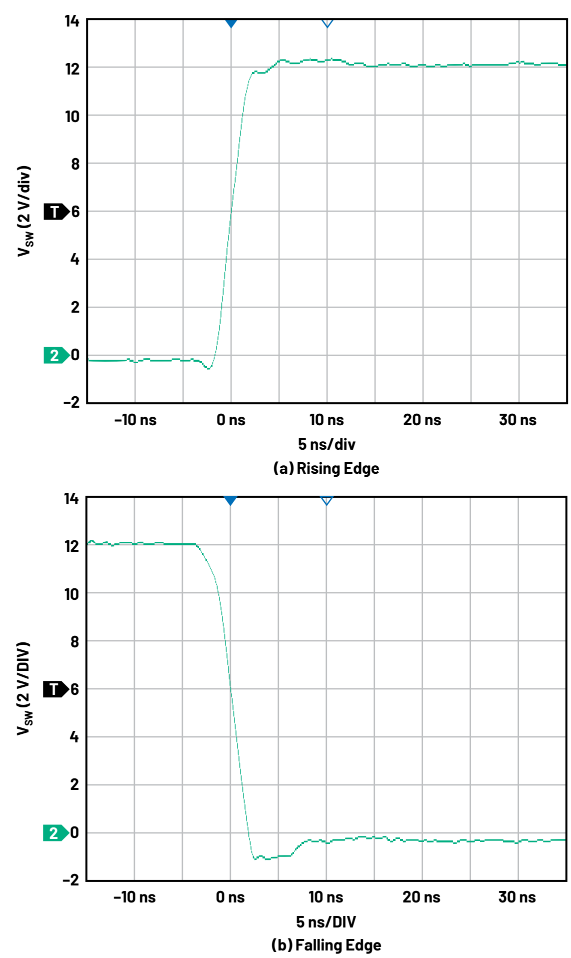


*Figure 3. LT8638S switch edges at 12 V input and 10 A load.*

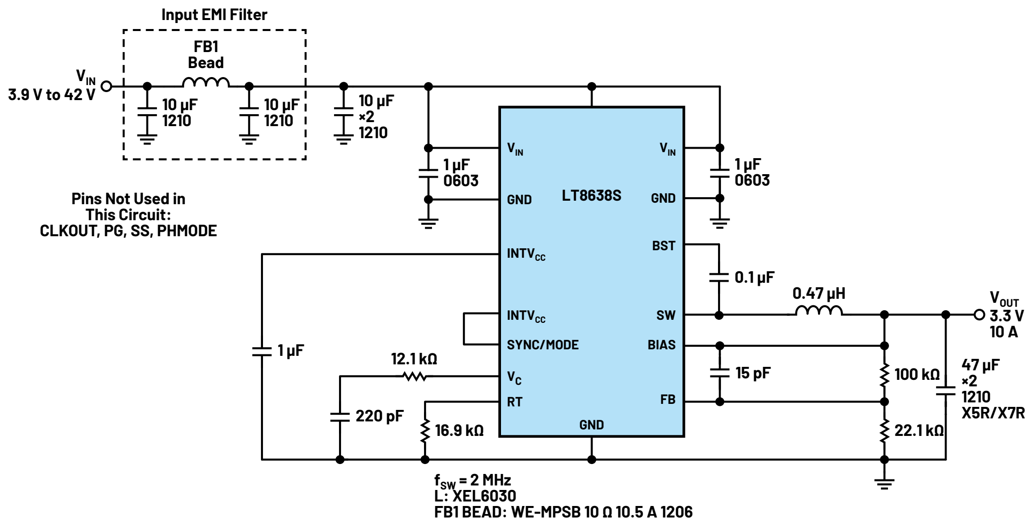


*Figure 4. An ultralow EMI LT8638S circuit.*

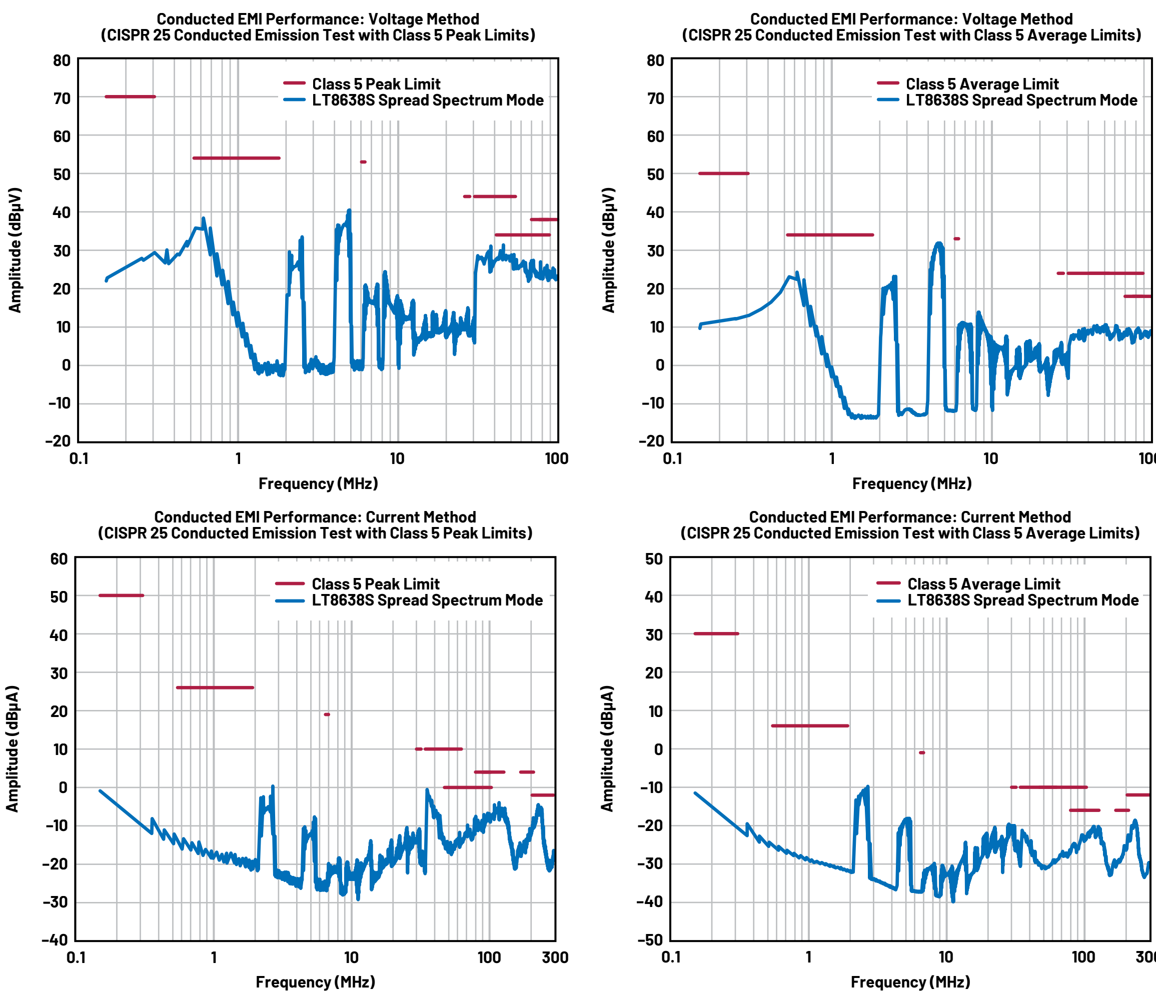


*Figure 5. Radiated EMI and conducted EMI of Figure 4 circuit (12 V input to 3.3 V output at 10 A).*

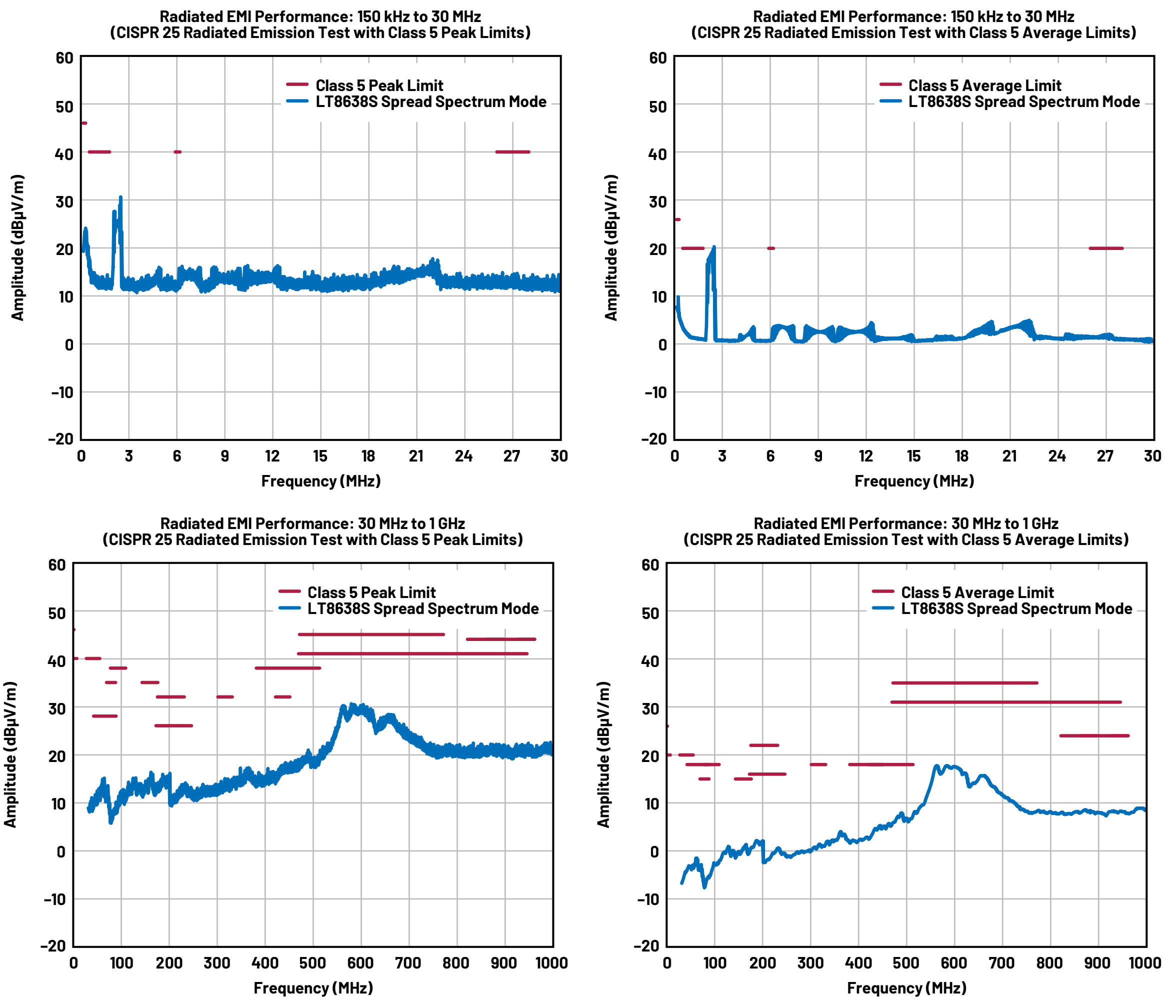


*Figure 5 (continued). Radiated EMI and conducted EMI of Figure 4 circuit (12 V input to 3.3 V output at 10 A).*

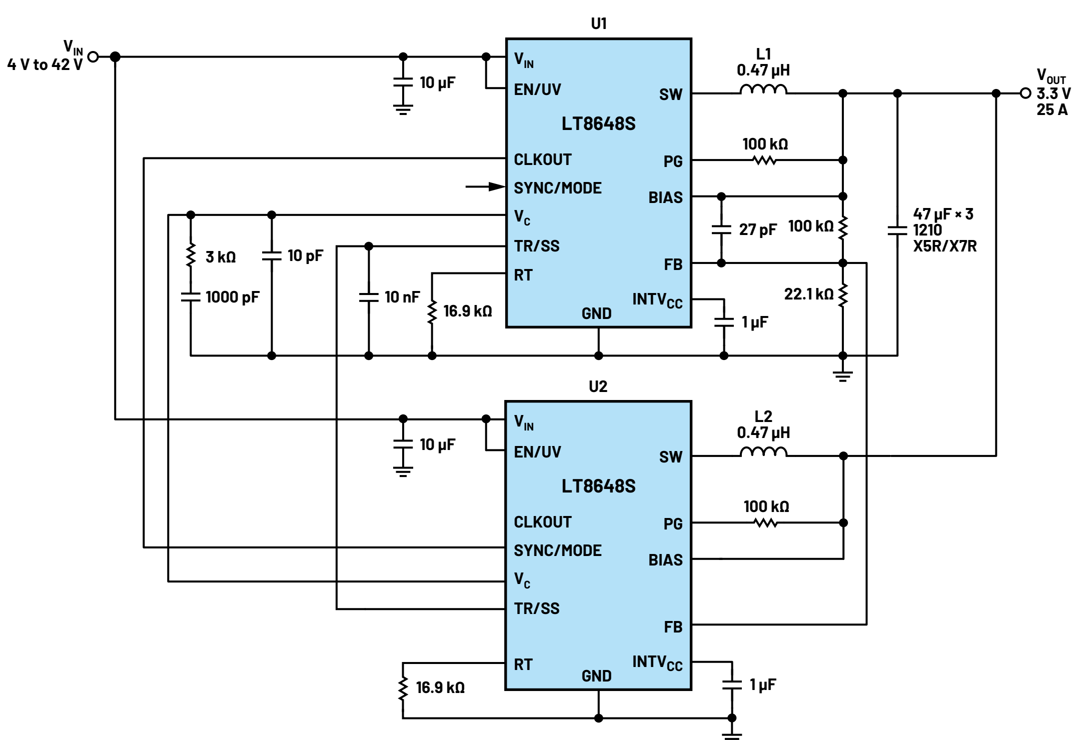


*Figure 6. 2 MHz 3.3 V/25 A application using two LT8648S in parallel.*

## Higher Current Monolithic Power Solution Using LT8648S

A complex ADAS requires more than one SoC, along with several cameras and sensors. For instance, a hands-free ADAS could include multiple power hungry chips and up to 11 cameras. LT8648S has higher output current capability than LT8638S. It fits in the intermediate power rail required by those complicated ADAS. As a monolithic 42 V, 15 A buck regulator, the output current and power level of LT8648S are close to a power controller solution using external MOSFETs. Its current capability can be further extended by paralleling several LT8648S together.

Figure 6 demonstrates 3.3 V/25 A, 2 MHz schematics using two LT8648S devices in parallel. The two LT8648S regulators have common input and output. The EN/UV and SS pins are connected to ensure that the two regulators start up simultaneously with the same slew rate. LT8648S uses peak current mode control, which makes the error amplifier output $V_C$ voltage correlated with the load current. By connecting $V_C$ and FB pins, the two parallel LT8648S can achieve good current balancing without the need for an extra circuit. The CLKOUT pin of U1 LT8648S is connected to the SYNC/MODE pin of U2 LT8648S. With this connection, two LT8648S regulators are synchronized with 180° phase shift.

Figure 7 shows the efficiency and temperature rise of Figure 6 circuit. U1 and U2 have almost the same temperature, which indicates good current balancing in this parallel application. High switching frequency and external compensation allow the fast transient response. Figure 8 shows the load transient response of the circuit shown in Figure 6.

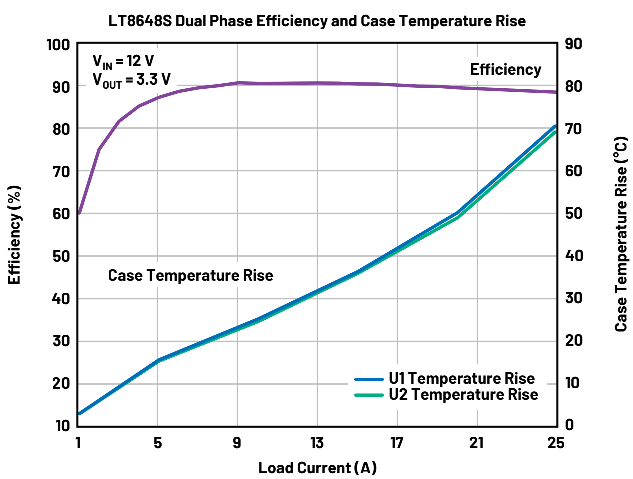


*Figure 7. The efficiency and temperature rise of the circuit shown in Figure 6.*

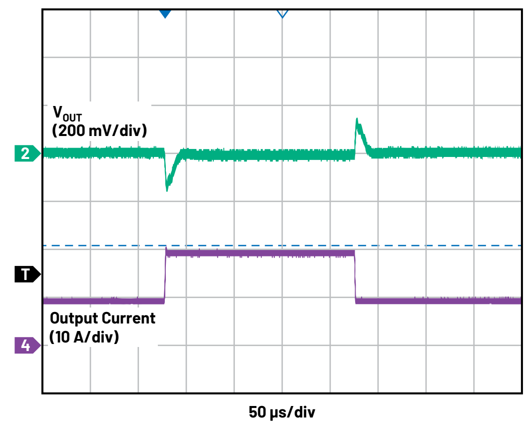


*Figure 8. 10 A to 20 A Load transient response of the circuit shown in Figure 6.*

## Conclusion

This article introduces two high current 42 V monolithic Silent Switcher regulators, the LT8638S and LT8648S. Their great efficiencies and ultralow emissions soothe the thermal and EMI concerns under the harsh automotive application environments. With integrated MOSFETS, LT8638S and LT8648S offer a small solution size for the high current intermediate power supplies required by rapid expanding automotive ADAS.


## About the Author

Ying Cheng is a staff applications engineer for power products in the Industrial and Multimarkets Business Group at Analog Devices in Santa Clara, California. She has been working at ADI since 2010. She currently provides applications support for nonisolated monolithic step-down converters. Ying Cheng's interests in power management include high performance power converters and regulators of high efficiency, high power density, and low EMI for automotive, telecom, medical, and industrial applications. She received B.S.E.E. and M.S. degrees from Shanghai Jiao Tong University, China, and obtained a Ph.D. degree in electrical engineering from Missouri University of Science and Technology (formerly University of Missouri-Rolla), Rolla, Missouri. She can be reached at ying.cheng@analog.com.