

# Tiny, High Efficiency Monolithic Regulators Power Advanced SoCs and Microprocessors Feature Silent Switcher 2 Technology for Low EMI

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Automotive, telecom, datacom, and industrial systems continue to employ increasing numbers of advanced SoC (System on Chip), FPGA, and microprocessor solutions. Each successive SoC and FPGA generation expands in power budget as power-hungry components are added and data processing speeds rise to support live streams of telecom, audio, or video data. These demands can only be met by robust, easy to use low voltage power supplies with high efficiency, high power density, and low electromagnetic radiation.

SoCs and FPGAs require a number of low voltage supplies, including 1.1 V for DDR, 0.8 V for core, and 3.3 V/1.8 V for I/O devices. Delivering sub-1 V from a wide-ranging automotive battery or industrial bus voltage usually requires two stages: an intermediate regulation stage to 12 V or 5 V, and another to low voltage. Each dc-to-dc conversion must be efficient and pass EMI standards to enable the overall power system to perform to demanding automotive, telecom, datacom, and industrial specifications.

It can be difficult to meet size, efficiency, and EMI design goals using conventional buck regulators. Sub-1 V buck regulators traditionally rely on bulky and EMI noisy PWM controllers and MOSFETs. The demands of automotive and industrial systems mean that devices must give way to something more compact, with higher current capability, higher efficiency, and, more importantly, superior EMI performance. Power by Linear™ monolithic Silent Switcher® 2 buck regulators in the [LTC7150S](#) and [LT8642S](#) family are designed to fulfill advanced SoC power demands with high reliability and robustness, while meeting EMI, size, and thermal constraints.

## Silent Switcher 2 Architecture Yields Excellent EMI Performance

Published EMI standards can be difficult to meet using conventional dc-to-dc controllers, so EMI is typically addressed up front, if possible. EMI issues that crop up in the late phase of the design and development of a system can cost significant money and time in troubleshooting and redesign. The hazards of project delays, loss of market, and damage to business reputation are too risky to leave to chance. To assure EMI qualification throughout the power supply design process, EMI suppression is often prioritized, and sometimes over-engineered, at the expense of other desirable features—namely solution footprint, total efficiency, reliability, and simplicity.

Traditional approaches control EMI by slowing down switching edges and/or lowering switching frequency. For instance, a gate resistor or a snubber can be added to slow down the turn-on or turn-off of the switching edges, and reduce the switching frequency for lower EMI. However, these strategies come with significant trade-offs, including increased minimum on-times, limited voltage conversion ratios, and larger solution size. Alternative mitigation techniques—such as bulky EMI filters or metal shielding—add significant costs in board space, an increased component count, and greater assembly complexity, while further complicating thermal management and testing. None of these strategies meet the requirements of the demanding SoC power budgets of compact size, high efficiency, and low EMI.

LT8642S is an 18 V/10 A step-down monolithic Silent Switcher 2 regulator in a 4 mm × 4 mm LQFN package. Figure 1 shows a 12 V to 1.2 V/10 A LT8642S solution and its ultralow EMI results. With only a ferrite bead and input capacitor as the input EMI filter, LT8642S is able to meet the stringent CISPR 25 Class 5 radiated EMI specification—widely adopted by the automotive industry—with abundant margin. Another popular EMI specification is CISPR 32 often used by consumer electronics manufacturers. LT8642S can easily meet the CISPR 32 Class B radiated EMI specification even without the input EMI filter.

LTC7150S is the first of its kind, a 20 A, high efficiency step-down regulator with Silent Switcher 2 technology incorporated to minimize the electrical magnetic emission, which greatly simplifies the EMI filter design and layout, making it ideal for noise-sensitive environments. The Analog Devices' proprietary Silent Switcher 2 architecture brings in exceptional EMI performance while minimizing the ac switching losses in our monolithic regulators. Hot loop capacitors are included in the IC. This, combined with integrated MOSFETs, significantly reduces noisy antenna size and minimizes EMI.

Switching node ringing is minimized on the very fast switch edges, reducing high frequency noise, and associated energy stored in the hot loop. Also, the hot loop is split in two and symmetrically laid out for EMI self-cancellation. This yields quiet power for the noise-sensitive automotive environments, where powerful SoCs are employed for advanced drive assistance systems (ADAS) or autonomous drive systems. This also satisfies the requirements of telecom, transportation, and industrial systems, where high efficiency, low noise power supplies are needed to power the next generation SoCs, CPUs, and microprocessors.

LTC7150S passes the CISPR 25 radiated EMI peak limit with a simple EMI filter installed in the front, as shown in the schematic in Figure 2, where a simple filter with a ferrite bead is installed. Figure 3 shows the radiated EMI CISPR 25 test result, and it passes the CISPR 25 Class 5 peak limit.

### Parallel Multiple Converters to Expand Output Current

Advanced functions such as autonomous drive and self-parking demand more powerful SoCs to implement live stream visuals or artificial intelligence. Likewise, computing and server systems in telecom and big data installations include high performance SoC solutions, which demand more power than ever before. For processor systems that demand more than 20 A current capability, multiple LTC7150Ss can be paralleled and run out-of-phase.

The LTC7150S features a sync function that enables synchronization to an external clock, and the internal PLL (phase-locked loop) allows the LTC7150S to be operated out-of-phase for multichannel, multiphase operation to reduce ripple. The CLKOUT signal can be connected to the MODE/SYNC pin of a following LTC7150S to line up both the frequency and the phase of the entire system. Multiphase operation is implemented at the PHMODE pin. Tying the PHMODE pin to INTV<sub>CC</sub>, SGND, or floating the pin generates a phase difference between the clock applied on the MODE/SYNC pin and CLKOUT; differences of 180°, 120°, or 90°, respectively, corresponding to 2-phase, 3-phase, or 4-phase operation. A total of 12 channels can be run out-of-phase with respect to each other by programming the PHMODE pin of each LTC7150S to different voltage levels.

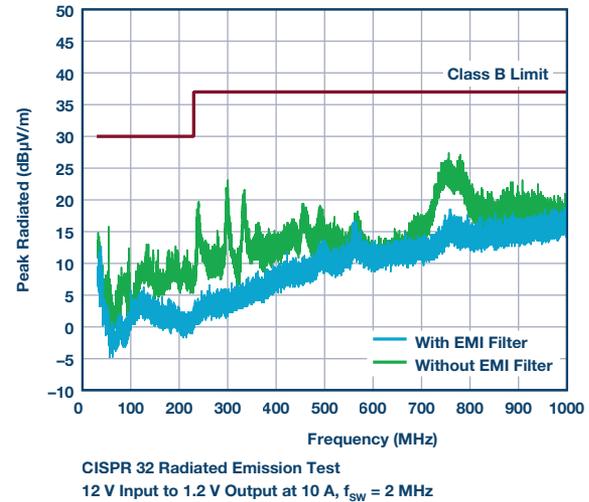
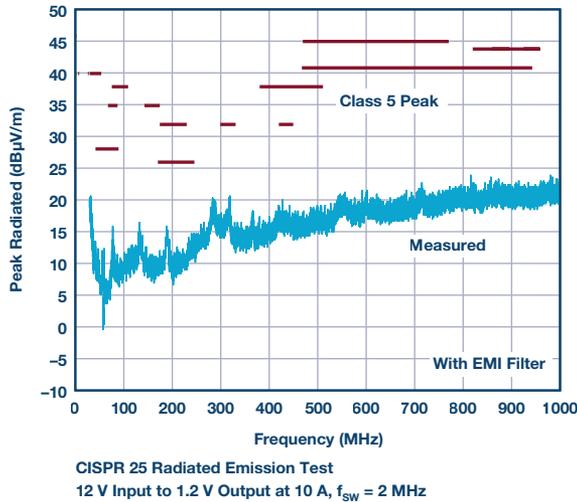
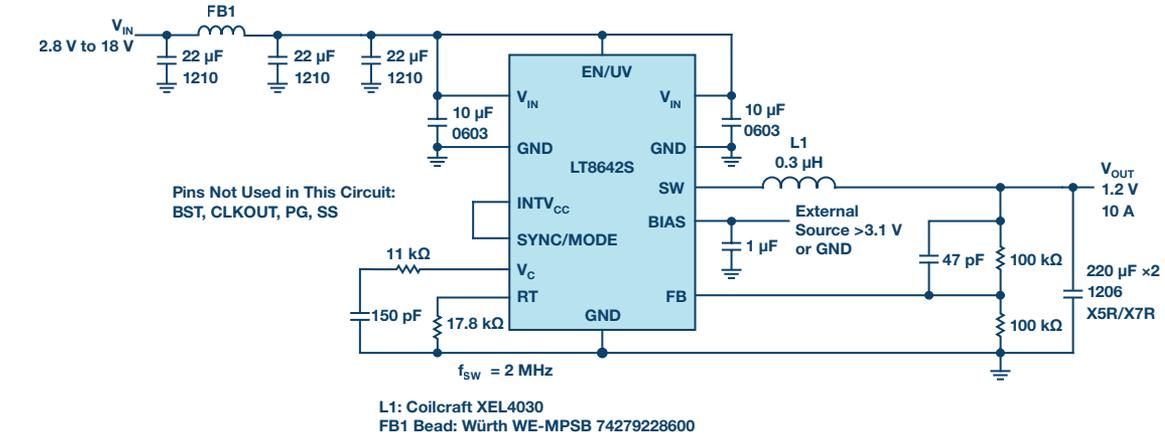


Figure 1. Ultralow EMI 1.2 V/10 A application using the LT8642S.

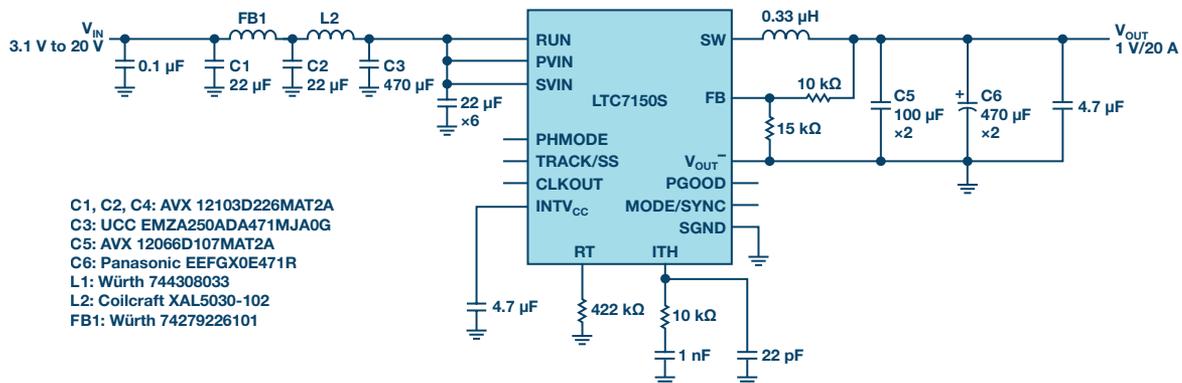
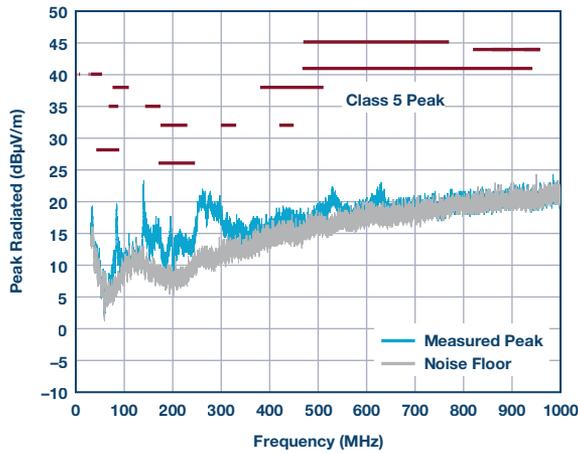


Figure 2. LTC7150S with EMI filter.



CISPR 25 Radiated Emission Test  
14 V Input to 1 V Output at 20 A,  $f_{sw} = 400$  KHz

Figure 3. LTC7150S radiated EMI performance.

Figure 4 shows two converters connected in parallel to provide 40 A output current at 1.2 V. The clock from the master unit is synced to the slave unit by tying the CLKOUT of U1 to the MODE/SYNC of U2. The master PHMODE pin is tied to ground, and the slave PHMODE pin is left floating. This results in 180° phase difference between the two channels, reducing the input current ripple. To ensure better current sharing in steady state and during startup, ITH, FB, and TRACK/SS are tied together. Local  $R_T$  resistors are needed and should not be tied together. Kelvin connection is recommended for accurate feedback and noise immunity. Place as many power vias as possible in the vicinity of the ground pins to the bottom layer to improve the thermal performance. Ceramic caps of the input hot loops should be placed close to the  $V_{IN}$  pins.

The inductor current is balanced during startup and steady state as shown in Figure 6. Efficiency can be as high as 89% at 32 A, when the input is 3.3 V.

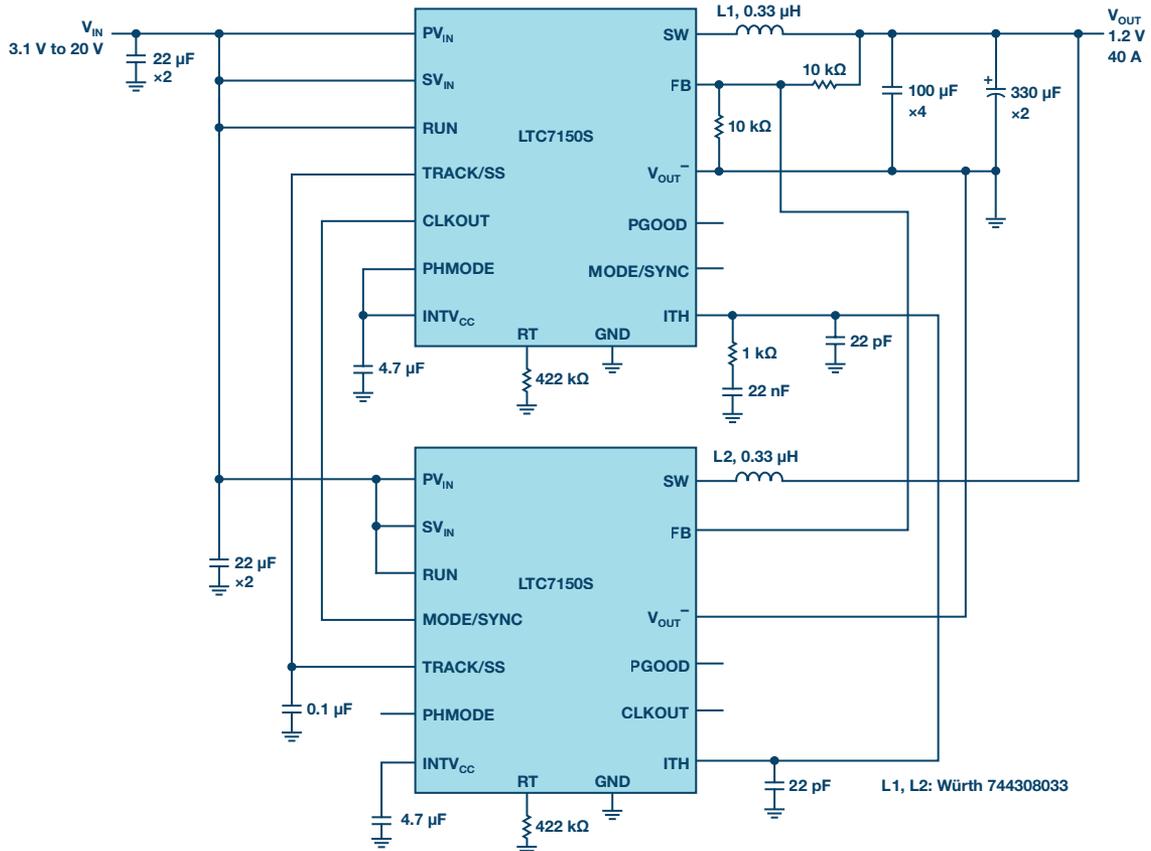


Figure 4. Parallel two LTC7150S regulators to extend output current capability to 40 A.

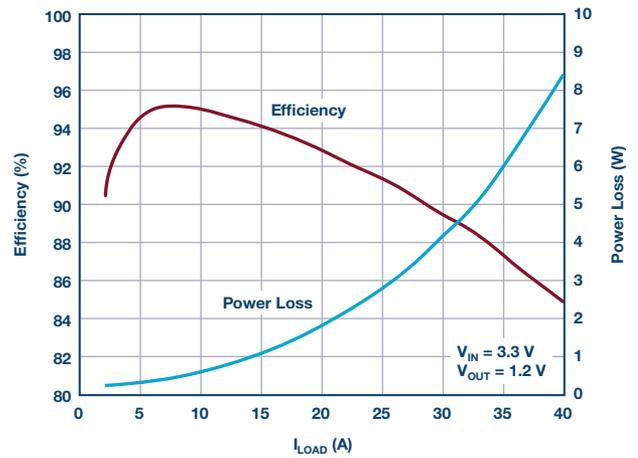


Figure 5. Efficiency of the 40 A circuit in Figure 4.

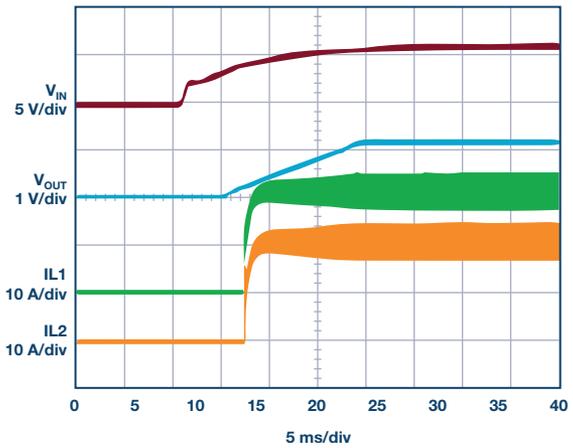


Figure 6. Inductor current waveforms for the parallel solution.

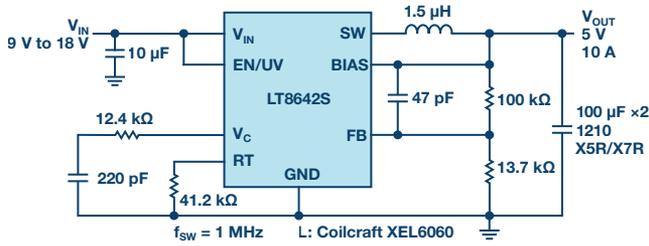


Figure 7. 50 W (5 V/10 A) solution using the LT8642S.

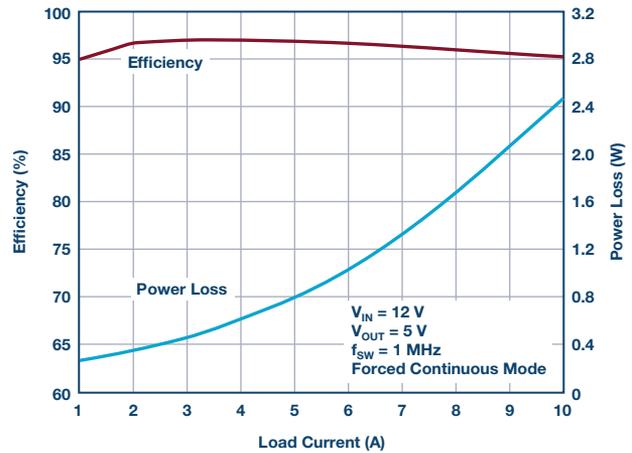


Table 1. High Current Monolithic Regulators

	Input Voltage (V)	Input Voltage (V)	Current (A)	Frequency (MHz)	Min T <sub>on</sub> (ns) Typ	Package
LT8642S	2.8 to 18	1	10	0.2 to 3	20	4 mm × 4 mm LQFN
LTC3636	3.1 to 20	2	6/6	0.5 to 4	30	4 mm × 5 mm QFN
LTC7124	3.1 to 17	2	3.5/3.5	0.5 to 4	50	3 mm × 5 mm QFN
LTC7150S	3.1 to 20	1	20	0.4 to 3	20	6 mm × 5 mm BGA
LTC7151S	3.1 to 20	1	15	0.4 to 3	20	4 mm × 5 mm LQFN

### High Switching Frequency Delivers High Efficiency Compact Solutions

The Silent Switcher 2 architecture does more than just enable exceptional EMI performance in LT8642S applications, it also produces fast and clean switching edges, cutting down switching losses. Minimal switching losses, along with just 20 ns of minimum on-time, enable high efficiency at high switching frequency and small solution size. For example, a 12 V to 1.2 V LT8642S solution can achieve more than 88% efficiency at a 2 MHz switching frequency. Furthermore, the LT8642S can be safely operated with a saturated inductor under the overload or short-circuit conditions, due to its high speed peak current-mode architecture. Therefore, the inductor can be chosen based on the output load requirement.

Compact power solutions usually conflict with thermal performance. The LT8642S is able to overcome this typical trade-off through high efficiency and enhanced thermal packaging. Figure 7 demonstrates a 5 V/10 A LT8642S solution switching at 1 MHz. For a 12 V input, the LT8642S operates with less than 47°C case temperature rise when delivering 50 W power and peak efficiency reaches above 97%.

Figure 8 shows a 3 MHz LT8642S solution. The high frequency operation minimizes the solution size by using a small inductor and a lower value output capacitor.

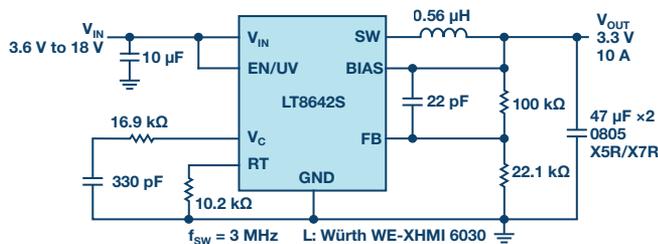


Figure 8. 3.3 V, 3 MHz application using LT8642S.

The LT8642S also features enable control, a power good indicator, and soft-start. These functions are essential to the system power sequencing, required by SoC and FPGA power supplies.

ADI's Power by Linear portfolio offers a range of buck regulators to fulfill the wide-ranging power budgets of advanced SoCs, FPGAs, and microprocessors. Table 1 lists some of the devices and their current capabilities.

### Conclusion

The demand for more intelligence, automation, and sensing in industry and automotive environments has resulted in a proliferation of electronic systems that require increasingly high performance power supplies. Low EMI has risen from afterthought to top priority, while solution size, high efficiency, thermal proficiency, robustness, and ease-of-use remain important.

ADI monolithic regulators excel in these areas, satisfying the requirements of automotive, telecom, data center, and industry customers. In particular, the family of high performance monolithic regulators that includes the LTC7150S and LT8642S meets stringent EMI standards in a compact size by incorporating proprietary Silent Switcher technology. Integrated MOSFETs and integrated thermal management features enable robust and reliable delivery of current from several amperes to beyond 20 A from input ranges up to 20 V. Enable control, power good indicator, and soft-start features are all included, so only a few components are needed to complete the power supply design.

## About the Authors

Ying Cheng graduated from Missouri University of Science and Technology (formerly University of Missouri-Rolla) with a Ph.D. in electrical engineering. She has been with Linear Technology (now part of Analog Devices) for six years as a senior applications engineer in the Power by Linear Group, working on dc-to-dc switching regulators and LDO regulators. She can be reached at [ying.cheng@analog.com](mailto:ying.cheng@analog.com).

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