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**IN THIS ISSUE**

one-size-fits-all battery charger **9**

control color of LED stage and architectural lighting **13**

power GPS sampling ADC in half the space **23**

**THIS COULD BE YOUR  
LAST PRINTED ISSUE**  
See page 2 for details.

## Tiny, High Efficiency Monolithic Regulators Power Advanced SoCs and $\mu$ Processors, Feature Silent Switcher 2 Technology for Low EMI

Ying Cheng and Zhongming Ye

Automotive, telecom, datacom and industrial systems continue to employ increasing numbers of advanced SoC (System on Chip), FPGA and  $\mu$ P 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 1.1V for DDR, 0.8V for core, and 3.3V/1.8V for I/O devices. Delivering sub-1V from a wide-ranging automotive battery or industrial bus voltage usually requires two stages: an intermediate regulation stage to 12V or 5V, and another to low voltage. Each DC/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.

*(continued on page 4)*



Silent Switcher 2 regulators power SoCs, FPGAs and  $\mu$ Processors in datacom and telecom systems

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.

(LTC7150S/LT8642S, continued from page 1)  
 It can be difficult to meet size, efficiency and EMI design goals using conventional buck regulators. Sub-1V 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

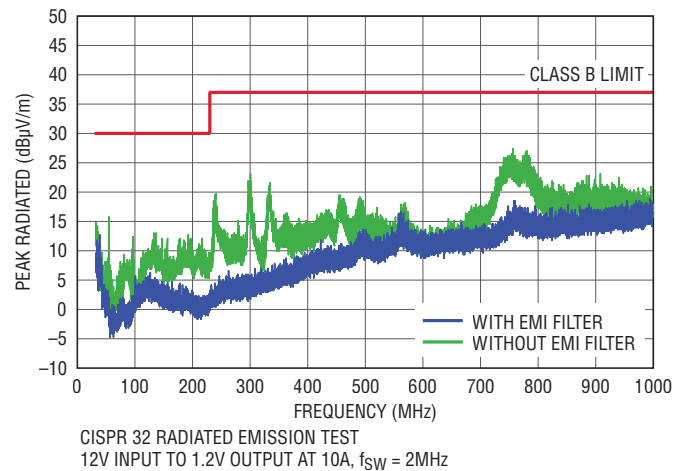
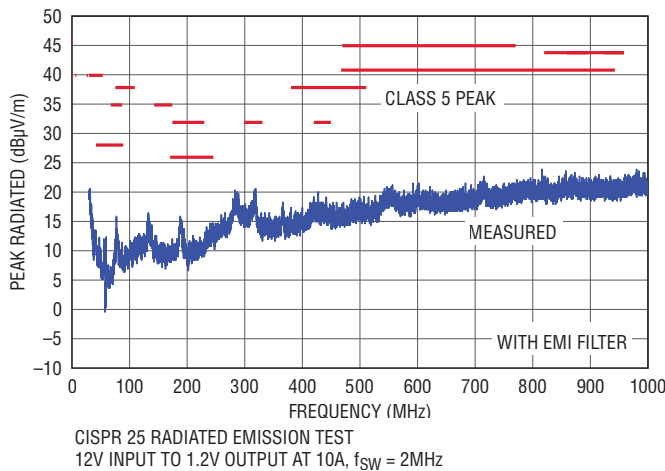
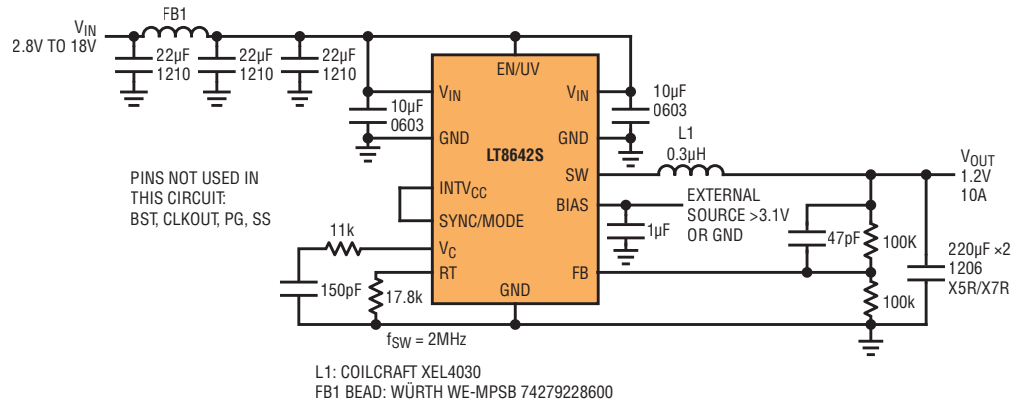
LTC7150S and LT8642S family are designed to fulfill advanced SoC power demands with high reliability and robustness, while meeting EMI, size and thermal constraints.

### SILENT SWITCHER 2 ARCHITECTURE YIELDS EXCELLENT EMI PERFORMANCE

Published EMI standards can be difficult to meet using conventional DC/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.

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



Power by Linear monolithic Silent Switcher 2 buck regulators in the LTC7150S and LT8642S family are designed to meet the needs of advanced SoC power budgets and EMI specifications, while fitting SoC size and thermal constraints with high reliability and robustness.

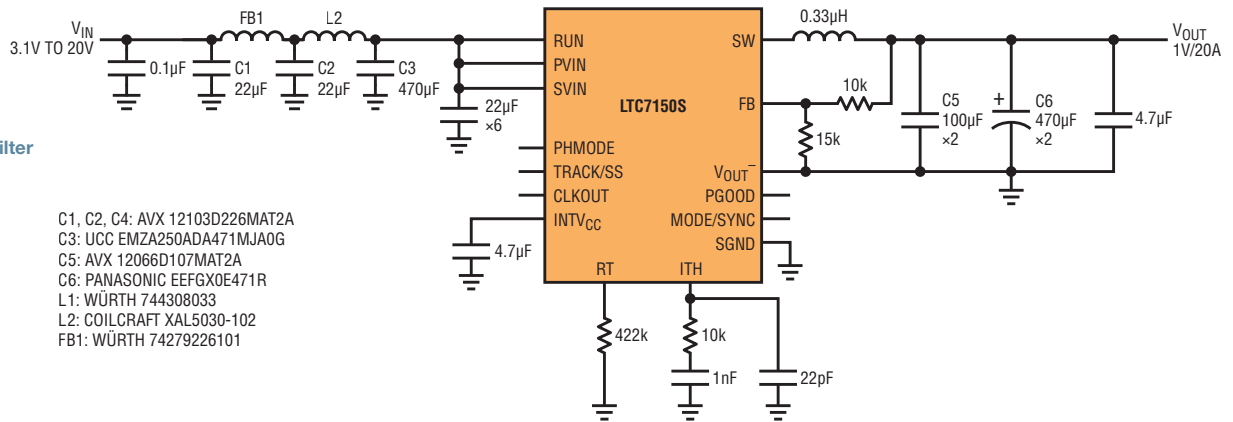


Figure 2. LTC7150S with EMI filter

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 the switching frequency reduced for lower EMI. However, these strategies come with significant tradeoffs, including increased minimum on times, limiting voltage conversion ratios, and larger solution size. Alternative mitigation techniques—such as bulky EMI filters or metal

shielding—add significant costs in board space, component count and 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 18V/10A step-down monolithic Silent Switcher 2 in a 4mm × 4mm LQFN package. Figure 1 shows a 12V-to-1.2V/10A 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 cited by the consumer electronics manufacturers. LT8642S can easily meet CISPR 32 class B radiated EMI specification even without the input EMI filter.

LTC7150S is first-of-its-kind 20A high efficiency step-down regulator with Silent Switcher 2 technology incorporated to minimize the electrical-magnetic emission, greatly simplify 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 noise antenna size; minimizing EMI.

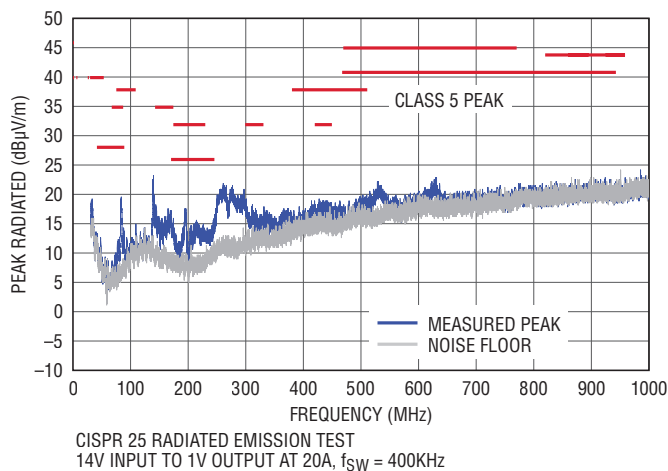


Figure 3. LTC7150S radiated EMI performance.

Multiphase operation is implemented by tying the PHMODE pin to  $INTV_{CC}$ , SGND or floating the pin to generate a phase difference 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.

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 system (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  $\mu$ Ps.

LTC7150S passes the CISPR 25 radiated EMI peak limit with 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, self-parking, etc. 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 20A current capability, multiple LTC7150S can be paralleled and run out-of-phase.

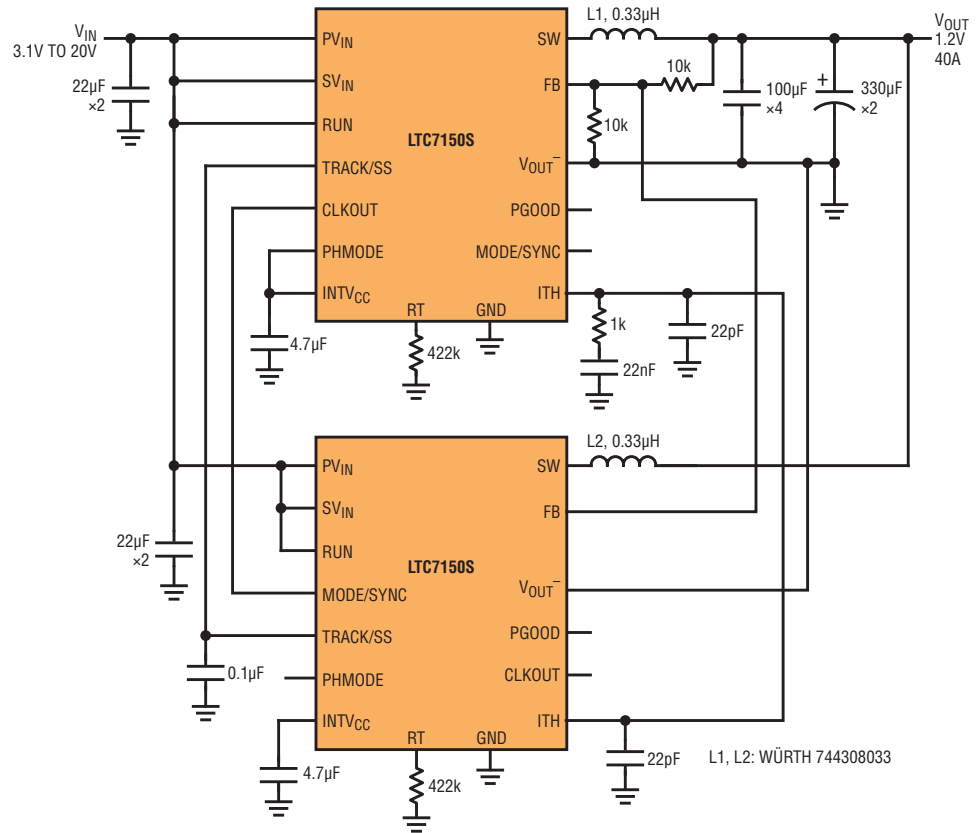


Figure 4. Parallel two LTC7150S regulators to extend output current capability to 40A.

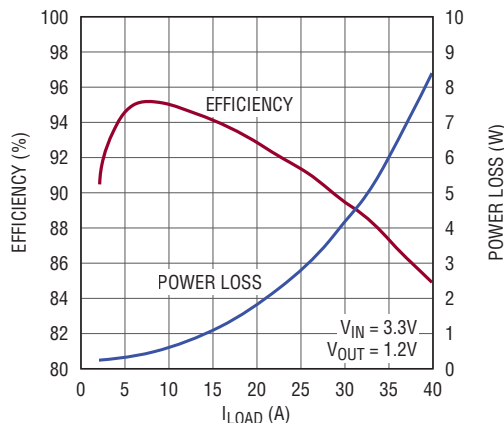


Figure 5. Efficiency of the 40A circuit in Figure 4.

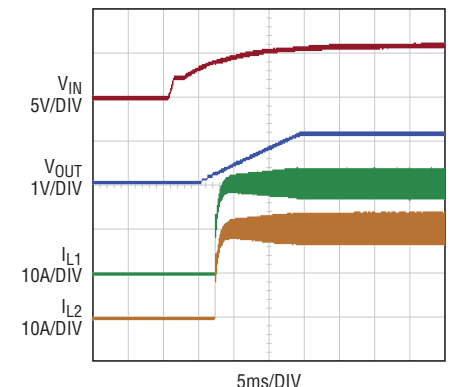


Figure 6. Inductor current waveforms for the parallel solution.

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 20ns of minimum on-time, enable high efficiency at high switching frequency and small solution size.

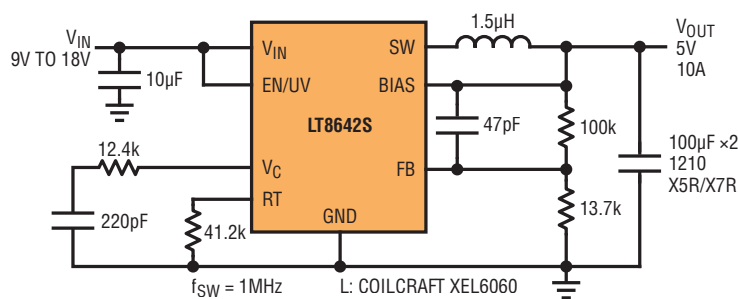
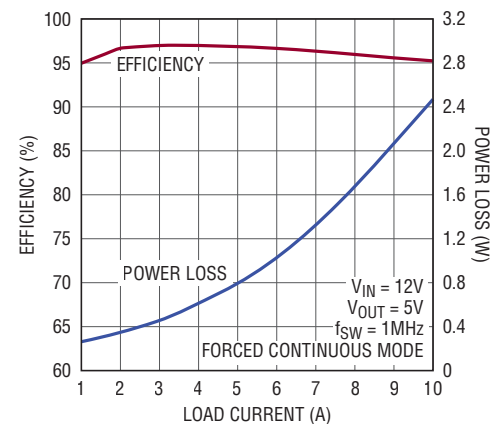


Figure 7. 50W (5V/10A) solution using the LT8642S



The LTC7150S features a SYNC function that allows it to sync 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 4 shows two converters connected in parallel to provide 40A output current at 1.2V. 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 start-up, ITH, FB, and TRACK/SS are tied together. Local R<sub>T</sub> 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<sub>IN</sub> pins.

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

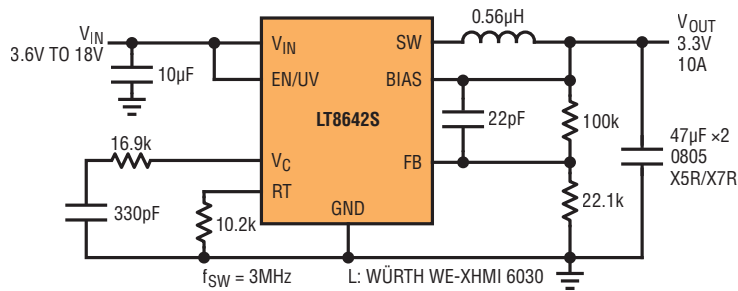
Table 1. High current monolithic regulators

	INPUT VOLTAGE (V)	# OUTPUTS	CURRENT (A)	FREQUENCY (MHz)	MIN T <sub>ON</sub> (ns) TYP.	PACKAGE
LT8642S	2.8–18	1	10	0.2–3	20	4mm × 4mm LQFN
LTC3636	3.1–20	2	6/6	0.5–4	30	4mm × 5mm QFN
LTC7124	3.1–17	2	3.5/3.5	0.5–4	50	3mm × 5mm QFN
LTC7150S	3.1–20	1	20	0.4–3	20	6mm × 5mm BGA
LTC7151S	3.1–20	1	15	0.4–3	20	4mm × 5mm LQFN



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.

Figure 8. 3.3V, 3MHz application using LT8642S



## 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.

Power by Linear 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 include the LTC7150S and LT8642S meet 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 20A from input ranges up to 20V. 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. ■

## 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 zons of minimum on-time, enable high efficiency at high switching frequency and small solution size. For example, a 12V-to-1.2V LT8642S solution can achieve more than 88% efficiency at a 2MHz 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 in conflicts with thermal performance. The LT8642S is able to overcome this typical trade-off through high

efficiency and enhanced thermal packaging. Figure 7 demonstrates a 5V/10A LT8642S solution switching at 1MHz. For a 12V input, the LT8642S operates with less than 47°C case temperature rise when delivering 50W power and peak efficiency reaches above 97%.

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

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.

Power by Linear 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.