

# DESIGN NOTES

## Triple Output 3.3V, 5V, and 12V High Efficiency Notebook Power Supply – Design Note 78

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The new LTC1142 is a dual 5V and 3.3V synchronous step-down switching regulator controller featuring automatic Burst Mode™ operation to maintain high efficiencies at low output currents. Two independent regulator sections, each driving a pair of complementary MOSFETs, may be shut down separately to less than 20μA/output. This feature is an absolute necessity to maximize battery life in portable applications. Additionally, the input voltage to each regulator section can be individually connected to different potentials (20V maximum) allowing a wide range of novel applications.

The operating current levels for both regulator sections are user programmable, via external current sense resistors, to set current limit. A wide input voltage range for the LTC1142 allows operation from 4V to 16V. The LTC1142HV extends this voltage range to 20V, permitting operation with up to 12-cell battery packs.

Both regulator blocks in the LTC1142 and LTC1142HV use a constant off-time current mode architectures with Burst Mode™ operation. This results in a power supply that has very high efficiency over a wide load current range, fast transient response, and very low dropout. The LTC1142 is ideal for applications requiring 5V and 3.3V output voltages with high conversion efficiencies over a wide load current range in a small amount of board space.

The application circuit in Figure 2 is configured to provide output voltages of 3.3V, 5V, and 12V. The current capability of both the 3.3V and 5V outputs is 2A (2.5A peak). The logic controlled 12V output can provide 150mA (200mA peak), which is ideal for flash memory applications. The operating efficiency shown in Figure 1 exceeds 90% for both the 3.3V and 5V sections.

The 3.3V section of the circuit in Figure 2 is comprised of the main switch Q4, synchronous switch Q5, inductor L1, and current shunt R<sub>SENSE3</sub>. The current sense resistor

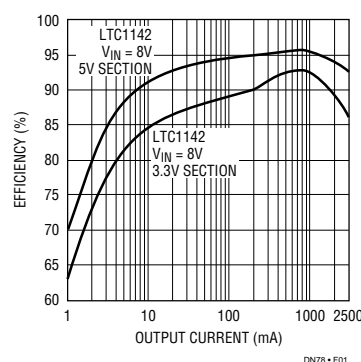


Figure 1. LTC1142 Efficiency

R<sub>SENSE</sub> monitors the inductor current and is used to set the output current according to the formula  $I_{OUT} = 100\text{mV}/R_{SENSE}$ . Advantages of current control include excellent line and load transient rejection, inherent short-circuit protection and controlled start-up currents. Peak inductor currents for L1 and T1 of the circuit in Figure 2 are limited to 150mV/R<sub>SENSE</sub> or 3.0A and 3.75A respectively.

When the output current for either regulator section drops below approximately 15mV/R<sub>SENSE</sub>, that section automatically enters Burst Mode™ operation to reduce switching losses. In this mode the LTC1142 holds both MOSFETs off and sleeps at 160μA supply current while the output capacitor supports the load. When the output capacitor discharges 50mV, the LTC1142 briefly turns this section back on, or “bursts” to recharge the output capacitor. The timing capacitor pins, which go to 0V during the sleep interval, can be monitored with an oscilloscope to observe burst action. As the load current is decreased the circuit will burst less and less frequently.

The timing capacitors C<sub>T3</sub> and C<sub>T5</sub> set the off-time according to the formula  $t_{OFF} = 1.3 \times 10^4 \times C_T$ . The constant off-time architecture maintains a constant ripple current while the operating frequency varies with input voltage. The

3.3V section has an off-time of approximately  $5\mu\text{s}$  resulting in a operating frequency of 120kHz at 8V input voltage. The 5V section has an off-time of  $3.5\mu\text{s}$  and a switching frequency of 107kHz at 8V input voltage.

The operation of the 5V section is identical to the 3.3V section with inductor L1 replaced by transformer T1. The 12V output voltage is derived from an auxiliary winding on the 5V inductor T1. The output from this additional winding is rectified by diode D3 and applied to the input of an LT1121 regulator. The 12V output voltage is set by resistors R3 and R4. A turns ratio of 1:1.8 is used for T1 to ensure that the input voltage to the LT1121 is high enough to keep the regulator out of dropout while maximizing efficiency.

The LTC1142 synchronous switch removes the normal limitation that power must be drawn from the primary 5V

inductor winding in order to extract power from the auxiliary winding. With synchronous switching the auxiliary 12V output may be loaded without regard to the 5V primary output load providing that the loop remains in continuous mode operation.

When the 12V output is activated by a TTL high (6V maximum) on the 12V enable line, the 5V section of the LTC1142 is forced into continuous mode. A resistor divider composed of R1, R5 and switch Q1 forces an offset subtracting from the internal 25mV offset at pin 14. When this external offset cancels the built-in 25mV offset Burst Mode™ operation is inhibited.

For additional high efficiency circuits see Application Note 54.

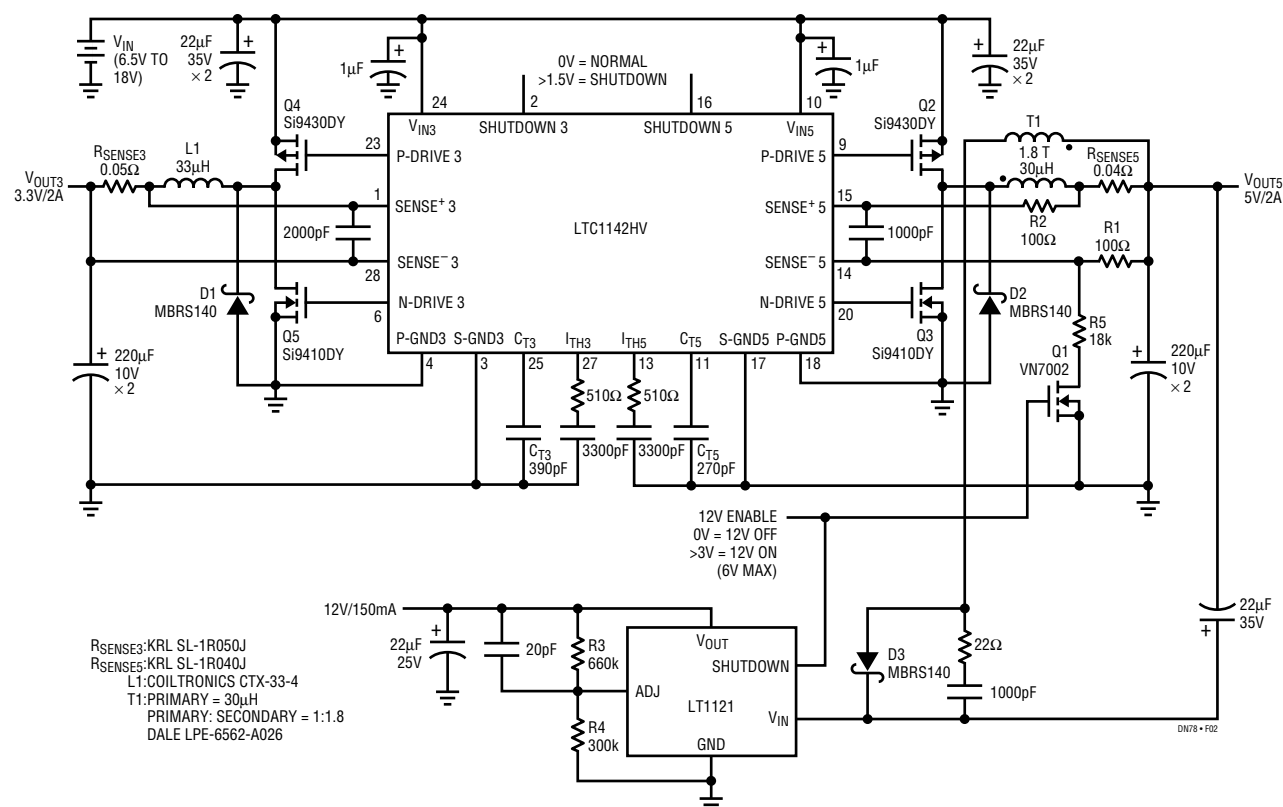


Figure 2. LTC1142 Triple Output High Efficiency Power Supply

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