DESIGN NOTES

Single LTC1149 Delivers 3.3V and 5V at 17W – Design Note 72

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This Design Note shows how one LTC1149 synchronous switching regulator can deliver both 3.3V and 5V outputs. The design's simplicity, low cost, and high efficiency make it a strong contender for portable, battery-powered applications. The circuit described accepts input voltages from 8V to 24V, to power **any** combination of 3.3V and 5V loads totalling 17W or less. For input voltages in the 8V to 16V range, the LTC1148 may be used, reducing both quiescent current and cost. For operation at input voltages below 8V, please contact the factory.

For convenience, the test circuit was built using mostly through-hole components. A follow-on Design Note will give details on building this circuit with surface mount parts.

Performance

Efficiency of this circuit is excellent, generally approaching and frequently exceeding 90% (Figure 1). The cross-regulation between the two outputs (a measure of their interdependency) is quite good (Table 1). At low power levels, the LTC1149 cleanly enters Burst Mode™ operation with a quiescent current of only 0.7mA.

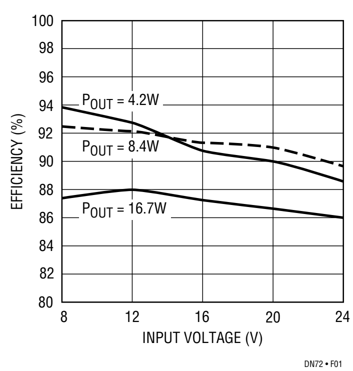

Figure 1. Efficiency vs V_{IN} and P_{OUT}

Table 1. Cross-Regulation vs V_{IN} and I_{OUT}

V_{IN}	$I_{3.3V}$	$V_{3.3V}$	I_{5V}	V_{5V}
8V	0mA	3.43V	0mA	5.14V
	5A	3.27V	0mA	5.19V
	2A	3.42V	2A	4.95V
	0mA	3.52V	3A	4.84V
24V	0mA	3.42V	0mA	5.14V
	5A	3.26V	0mA	5.12V
	2A	3.32V	2A	4.97V
	0mA	3.42V	3A	4.93V

Theory of Operation

The complete circuit is shown in Figure 2. To develop the 3.3V output, the LTC1149 acts as a synchronous step-down (buck) converter. L1A and L1B in series form the 3.3V buck inductor, and the C1/C2 combination is the 3.3V output filter capacitor. When Q1/Q2 are ON, the current through L1 ramps up. When Q1/Q2 turn OFF, Q3 is turned ON to provide the current in L1 with a low resistance recirculation path. This use of Q3 as a synchronous rectifier increases efficiency by virtually eliminating conduction voltage drop.

The 5V output is produced by L1, L2, Q4, and C3/C4. Since Q3 has essentially zero voltage drop when turned ON, the voltage across L1 is fixed at 3.3V during that time. With the voltage across L1 known, transformer action develops a predictable voltage across L2. If Q4 is turned on for the same interval as Q3 (forming a second synchronous rectifier), current will flow from L2 into C3/C4. Using a turns ratio of 2:1 between L1A/L1B and L2, C3/C4 will charge to a total voltage of $(0.5 \times 3.3V) + 3.3V = 5V$. Feedback to the LTC1149's error amplifier comes from the 3.3V and 5V outputs through R1 and R2 (this "split feedback" enhances cross regulation).

In addition to simplicity, this topology offers some more subtle advantages over other dual output techniques:

1) The 3.3V and 5V outputs are inherently synchronous to each other.

2) Both outputs achieve their rated voltage at the same time after power-up or after a short circuit.

3) A short to ground on either output will automatically disable the other output. This is difficult to achieve with techniques employing two independent control loops.

Circuit Particulars

There are three areas of this circuit which require special attention. They are the transformer (L1A, L1B, L2), the input and output capacitors, and the layout.

The transformer must be trifilar-wound. Trifilar winding is a standard production technique in which three wires are wound at the same time on the same magnetic core. The three resulting coils form a transformer with excellent magnetic coupling. In this circuit these attributes improve cross-regulation and efficiency. Two of the three coils are connected in series to form L1. The third coil becomes the boost winding, L2. This inherently provides the required 2:1 turns ratio between L1 and L2. The test transformer was made by using three windings of ten turns #23 wire, on a Kool Mµ® 77050-A7 toroid (finished size: 0.625" diameter × 0.25" high). If an off-the-shelf transformer is desired, Coiltronics, Inc. and Hurricane Labs both carry suitable parts. Coiltronics can be reached at (305) 781-8900; Hurricane's number is (801) 635-8003.

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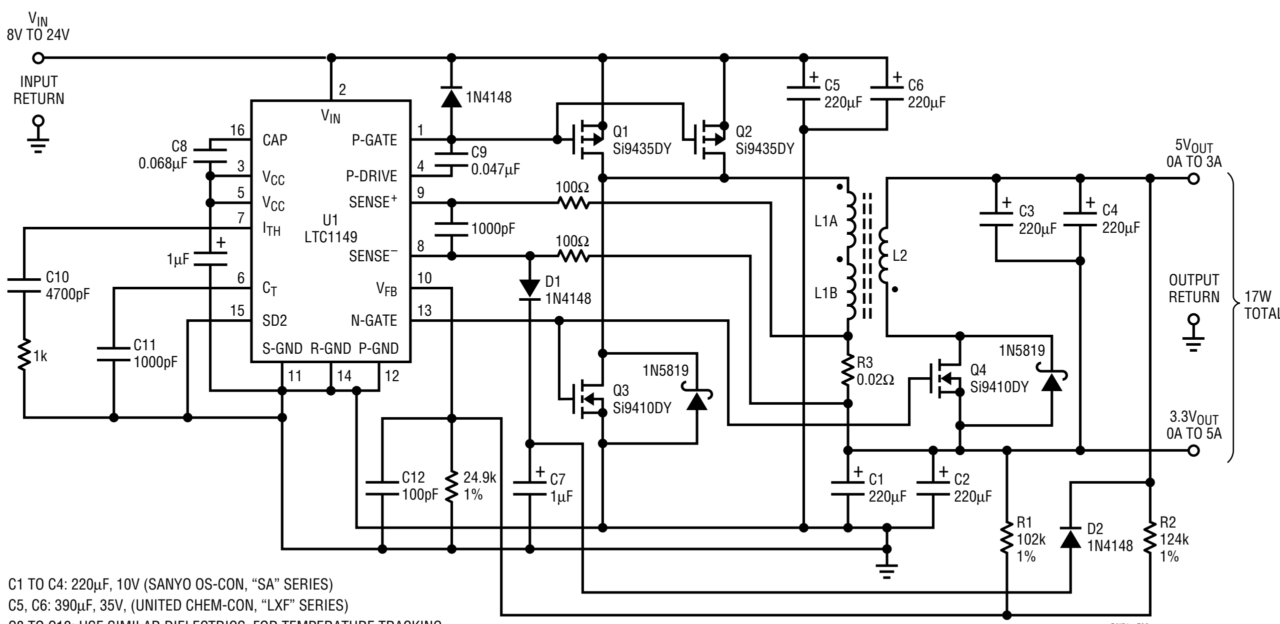
The values and sizes of the input and output capacitors are determined by ESR and ripple current ratings. The following lists critical parameters. Specific vendors and types are suggested in Figure 2.

C1, C2: Total parallel ESR $\leq 0.035\Omega$
Total I_{RMS} rating $\geq$ 2.5A
C3, C4: Total I_{RMS} rating $\geq$ 2.5A
C5, C6: Total I_{RMS} rating $\geq$ 1.6A

In general, layout practices should follow those for other switching power supplies. Some examples are: keep separate types of grounds separate (e.g., signal ground, main power ground), and return the various grounds to a single common point. Power and ground leads should be kept short and isolated as much as possible from signal traces. Details for the successful layout of circuits using the LTC1148/LTC1149 can be found on the data sheets for these parts, which should be consulted for routing recommendations. As noted above, a surface mount layout for this circuit will appear in the follow-on Design Note.



C1 TO C4: 220µF, 10V (SANYO OS-CON, "SA" SERIES)
C5, C6: 390µF, 35V, (UNITED CHEM-CON, "LXF" SERIES)
C8 TO C12: USE SIMILAR DIELECTRICS, FOR TEMPERATURE TRACKING (DO NOT USE TYPE Z5U CERAMIC CAPACITORS)
R3: 0.02Ω, NONINDUCTIVE. IRC TYPE MSM-1-0.02Ω-±5%.
L1A, L1B, L2: SEE TEXT
UNMARKED RESISTORS ARE 0.25W, 5%

Figure 2. Dual Output LTC1149 Supply Provides High Efficiency at Low Cost

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