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BRIEF

Selecting the Correct IC for Power-Supply Applications

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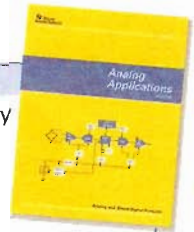

Introduction

To select the correct IC(s) for the job, many factors such as cost, solution size, power source, duty cycle, and required output power must be weighed and ranked by importance. This article covers the rationale for the application solution shown in Figure 1.

This example application is portable, requires the lowest possible battery consumption and a small form factor, and operates from a single-cell Li-ion battery that is charged whenever the 12-V supply is available. While it is desirable to minimize cost, small size and high efficiency for extended battery life are often more important.

Choosing the Topology

Due to the space constraints of this application, using LDOs would be considered first but may not always be possible due to power dissipation and efficiency constraints. Beginning with the 5-V, 2-A rail, it is clear that a switching converter should be used because the power dissipated by an LDO, in this case 14 W, is excessive. For this rail, an inductive step-down converter is the best choice.

Now consider the battery charger. This battery is charged from the 5-V rail. The application has a single-cell Li-ion battery that has a charging voltage of 4.2 V. With the space constraints of the application, a linear charger is a good choice. The charging efficiency is not as much of a concern because the only time this device will operate is when the 12-V power adapter is available. However, when selecting the peak charge current of a battery deeply discharged to 3 V, take care to limit the thermal dissipation of the device.

- For the 3.3-V rail, a switching converter is the best choice due to the large output current required.
- For the 1.50-V rail, either a switching step-down converter or an LDO would be acceptable. With the latter, efficiency would be in the 25% range and would require an input current of 100 mA. Substituting a switching step-down converter can provide efficiencies higher than 90%, which require an input current of 30 mA. There are many very small switching-converter solutions that can supply the required output power, so the size increase over an LDO circuit is not appreciable. To maximize battery life, the step-down converter is a better choice.

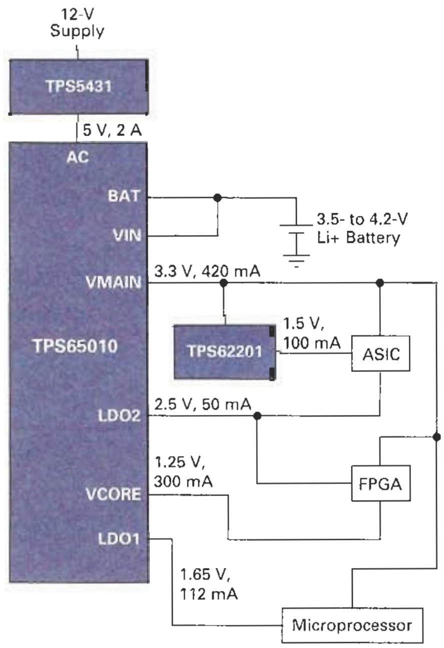

Figure 1: Power-Supply Solution

- For the 2.5-V rail, again, either topology is acceptable. Due to the low current requirements and lower input/output differential, an LDO is the best choice for the smallest size.

- For the 1.25-V rail, a switching converter is the best choice. With the high (300-mA) load requirement and the large input/output differential, an LDO would dissipate too much power and is too inefficient.
- For the 1.65-V rail, again, either topology is acceptable. The same logic as for the 1.50-V case makes a switching converter a possibility, but other factors discussed later require that this be an LDO.

Selecting the Best IC(s) for the Job

Taking size and cost constraints into consideration, the chosen ICs should be as highly integrated as possible and should contain internal MOSFETs. This saves on solution size as well as on production costs. There are also multi-output ICs available that decrease the solution size even further.

The best solution for the 5-V rail is the TPS5431, shown in Figure 1. Its wide input range (5.5 to 23 V) will accept the 12-V, ±10% input. The TPS5431 also provides up to 3 A with an adjustable output voltage down to 1.2 V. The switching MOSFET and the compensation components are integrated, and the 95% efficiency meets the battery-power demands. The device comes in the SO-8 package for a very small solution size.

There are several choices for the battery charger. The bq24010, a small battery charger IC in the 3 x 3-mm QFN package, is a good choice. Its solution size is very small and requires only three external components, but there is a better solution. The TPS65010 is a power- and battery-management IC for Li-ion-powered systems. This IC integrates two switching converters (VMAIN and VCORE), two LDOs (LDO1 and LDO2), and a single-cell Li-ion battery charger. In addition to these rails, the IC also eliminates the need for a switchover circuit when the 12-V power adapter is connected. In this application, VMAIN powers the 3.3-V rail, VCORE powers the 1.25-V rail, LDO1 powers the 1.65-V rail, and LDO2 powers the 2.5-V rail. Using the TPS65010 drastically reduces the solution size as well as the external component count.

The remaining 1.50-V rail can be powered from a step-down switcher such as the TPS62201. This device comes in a five-lead SOT-23 package and requires only three external components (input/output capacitors, inductor, and two feedback resistors). This translates to a very small solution size. To increase efficiency, the input of this device should be connected to the 3.3-V MAIN output of the TPS65010.

Calculating the System Efficiency

For this discussion, it has been assumed that all of the voltage rails are on 100% of the time, which is rarely the case. Sometimes, where an inductive switcher would typically be used, an LDO may be an acceptable choice to minimize solution size. Calculating the efficiency difference between each topology determines which to use.

The percentage of time that an output is enabled (the duty cycle) can be used to determine the effect of each rail on the total solution efficiency. First, the effective total output power is calculated by summing up the effective power for each rail:

$$P_{OUTEFFTOT} = \sum_{i=1}^{n} D_i \times P_i,$$

where P_i is the output power from one output rail and D_i is the duty cycle for the same rail. Next, the power lost by each rail is calculated:

$$P_{LOSS} = D \times P_{RAIL}\left(\frac{1}{\eta_{RAIL}} - 1\right)$$

Summing up the power loss for all of the rails provides the total power loss:

$$P_{LOSSTOTAL} = \sum_{i=1}^{n} D_i \times P_i\left(\frac{1}{\eta_i} - 1\right),$$

where η_i is the efficiency of the individual output rail. The effect of each rail on the overall system efficiency can then be calculated:

$$\eta_{SYSRAIL} = \frac{D \times P_{RAIL}}{P_{LOSSTOTAL} + P_{OUTEFFTOT}}$$

The total system efficiency can be determined by summing all of the rail system efficiencies or by using the following equation:

$$\eta_{SYS} = \frac{P_{OUTEFFTOT}}{\sum_{i=1}^{n} \frac{D_i \times P_i}{\eta_i}}$$

As the duty cycle for an output increases, the calculation of solution size versus efficiency must be examined to determine the optimal solution. For example, with the 3.3-V, 420-mA output on all the time, using an LDO instead of an inductive switcher would reduce the overall efficiency by nearly 4%. If the 3.3-V output was enabled for only 10% of the operation time, then using an LDO instead of a switcher would result in a drop of less than 0.75% in overall efficiency. These two cases are clearly extremes but illustrate how the duty cycle affects the overall efficiency.

Conclusion

Requirements such as available space, available input power, output power, duty cycle, and cost all must be examined to choose the best solution. Start by ranking the requirements by importance, then select the topology for each output based on the requirements. Finally, choose the most cost-effective solution for each output. Following these simple steps should take the difficulty out of power-supply design.

References:

1. TPS5431 Datasheet (SLVS632C)
2. TPS65010 Datasheet (SLVS149B)
3. TPS62201 Datasheet (SLVS417E)