Using LDOs and Power Managers in Systems With Redundant Power Supplies

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ABSTRACT

For reasons of continuity in some systems, independent power sources must operate in parallel. The traditional way to connect two or more power sources in parallel uses isolation diodes. However, in situations where the associated voltage drop or the presence of voltage-feedback sensing wires makes using isolation diodes undesirable, special types of low dropout voltage regulators (LDOs) and hot-swap power managers are alternatives. The main advantages of these devices are:

- Diode emulation, but without diode voltage drop
- Controlled inrush current and maximum current limiting, which is ideal for live insertion applications

An important characteristic of these special LDOs and power managers is their reverse voltage standoff capability.

Contents

List of Figures

1 Introduction

Often two or more independent power supplies feed critical systems. In most cases diodes are used to keep these supplies separated. When using TI's hot-swap power managers, there is practically no voltage drop. That means that the sensing wires sometimes needed to compensate for the diode voltage drop in traditional connection methods using isolation diodes can be avoided. Most redundant power-supply systems also need reverse-voltage standoff, especially when a circuit needs to be powered from two separate power sources that must be kept isolated, such as when selecting between two or more batteries. Reverse voltage standoff capability means that the pass element in the LDO or power manager prevents reverse current flow when the voltage at the output becomes higher than the voltage at the input.

2 Solutions Without Diodes

2.1 Fault Conditions in Redundant Supplies

In systems with redundant (dual) power supplies, a number of fault situations must be handled correctly. These include:

- Short circuit at the output
- Short circuit or open circuit at either supply input
- A situation in which current tries to feed back into the input of either supply, for example, a stack of batteries in which one cell is shorted

Proposed protection solutions have full thermal and short-circuit protection. No additional circuits are necessary for output short-circuit protection and load inrush currents. Circuit details for hot-swap power managers and LDOs are shown in Figure 1.

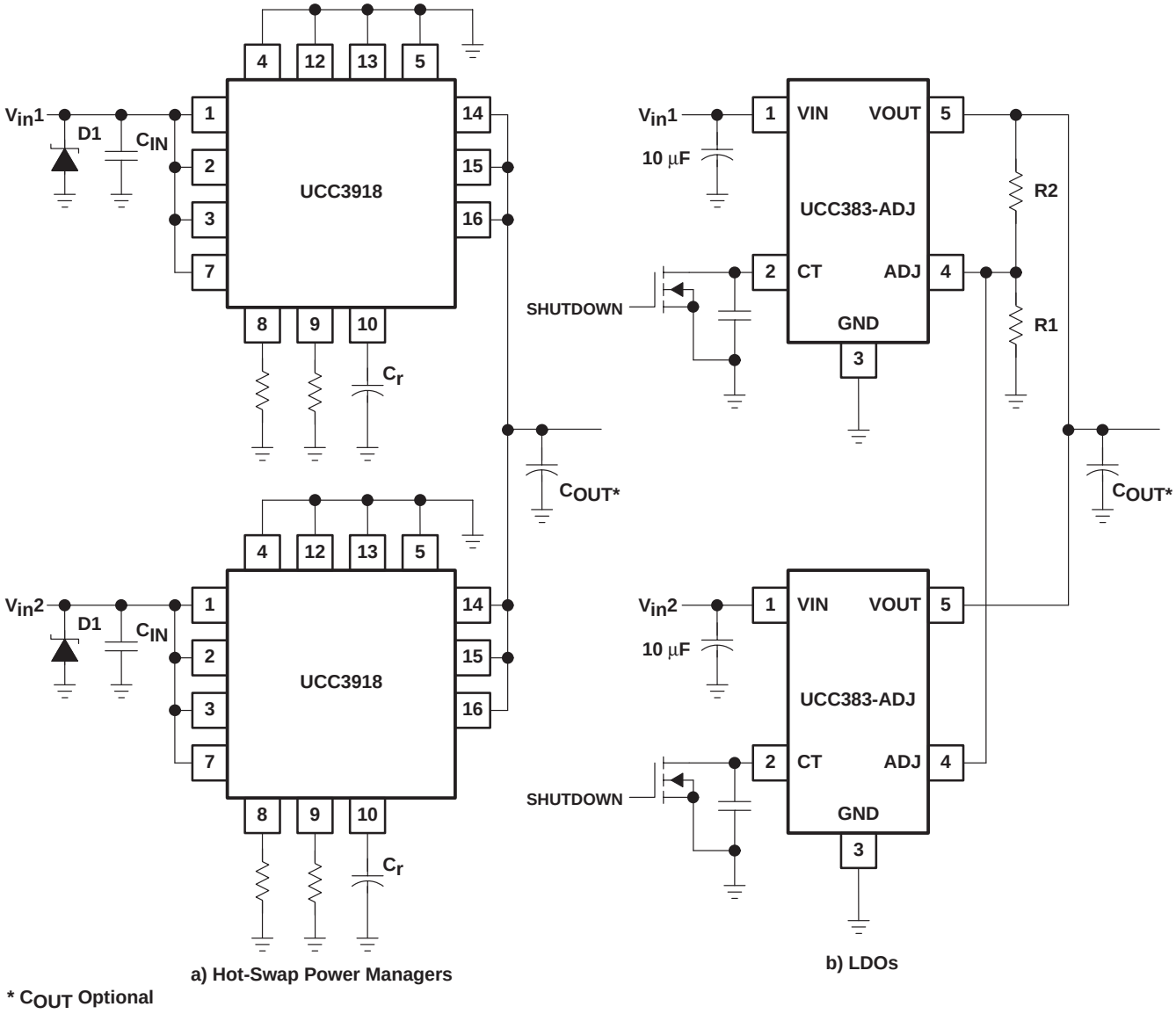

Figure 1. Alternatives With Hot-Swap Power Managers and LDOs

In Figure 1, $V_{in}1$ and $V_{in}2$ are the independent sources. The values of different external components such as resistors and capacitors can be calculated from the UCC3918 or UCC383 data sheets. Some external components, such as for the shutdown option (Figure 1b), are optional, and others, such as output capacitors, do not have to sit next to the components of the LDO or power management circuits themselves, but instead can be placed elsewhere in the application.

2.2 Reverse Voltage Standoff Capability

Devices with reverse voltage standoff capability are designed to operate with the voltage at the output greater than the voltage at the input. When operating under this condition, reverse current flow is prevented. The LDOs UCC383 (3A) and UCC386 (0.2A) are specifically designed to operate under such a condition. Typically, these circuits do not have a body diode in the pass element. The UCC3918 hot-swap power manager also has this feature.

2.3 Parallel Operation

Parallel operation of power managers can be achieved in two ways:

- All power-manager inputs are connected together, and all their outputs are also connected together

- Inputs of individual power managers are connected to independent voltage sources but all the outputs are connected together. This is the situation shown in Figure 1 a). See also section 2.4 on load sharing with redundant supplies.

Devices with N-MOS pass elements can be used in parallel. Because of small differences in resistance of the pass-elements, parallel operation leads to operating temperature differences. After power-on, as the resistance increases with temperature, the current balance stabilizes. To be on the safe side, it is prudent not to exceed 150% load with two devices in parallel. Instead of paralleling devices to increase the maximum current, the following option should be considered.

Scale towards higher current or higher voltage

- Hot-swap power managers with external FETs where the limitations are only in external components like TPS2330 or UC3914. In this case a configuration with back-to-back N-MOS FETs is required. The user also has to issue a shutdown command with an external comparator to switch off the TSP2330 or UC3914 whenever reverse current flow occurs. These options are outside the scope of this report and have not been tested further.

Parallel operation of LDOs where both inputs and outputs are connected together is not advisable. In the example in Figure 1 b), either of the two LDOs must be able to carry the full-load current.

2.4 Load Sharing With Redundant Supplies

The objective of the examples in Figure 1 is not to achieve 100% equal load sharing but to create a redundant supply.

Load sharing depends on both the source voltages and the series resistance of the pass-elements, as well as on small reference-voltage differences between LDOs. If the input voltages do not differ too much, the load will be shared, relieving each LDO or hot swap manager from 100% load and improving the reliability.

3 Safety Considerations

Although most low dropout voltage regulators, power-distribution switches, and hot-swap power managers are designed to provide system protection for all fault conditions, all integrated circuits can ultimately fail short. For this reason, if the products mentioned in this application note are intended for use in safety-critical applications where UL or some other safety rating is required, a redundant safety device such as a fuse should be placed in series with the power device.

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