DESIGN NOTES

Protecting and Monitoring Hot Swappable Cards in High Availability Systems – Design Note 360

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Introduction

Mission critical systems, such as those used by financial institutions and internet providers, require high availability computing equipment. These systems duplicate or make redundant certain functional blocks in the system. This allows the system to operate on the backup elements when blocks fail. High availability systems typically place these blocks into separate cards that can be swapped out if they fail or show signs of trouble. This requires sophisticated monitoring to determine when a functional block has failed and if a back-up is operating.

Redundant Power

Often the reliability of the power distribution is improved by providing two supplies to each card. Each supply is fuse protected and then diode OR'ed to form one supply rail for the card. To further increase reliability, the voltage and current information is monitored for power usage and usage history. This allows the system to determine if the card is using its allotted power or operating abnormally. Cards operating at abnormal currents are likely sources of failure and could be flagged for service before something actually fails. Such information can also be monitored remotely by a maintenance provider. In addition to measuring the board current and voltages, the fuses are monitored for faults. This information warns the user that a blown fuse has compromised the redundant power path to the card.

Monitoring Power through a Hot Swap™ Controller

Before considering the method for current and voltage monitoring, we need to first discuss the function of a Hot Swap controller. For the sake of discussion, let's assume the system backplane provided two well regulated 48V (±5%) supplies to each card. One 48V supply provides power in the event the other supply fails. This requires that upon failure the bad supply is removed and then replaced while the system remains powered. Installing a new supply could lead to a 10% step up in voltage if the lower supply is augmented with
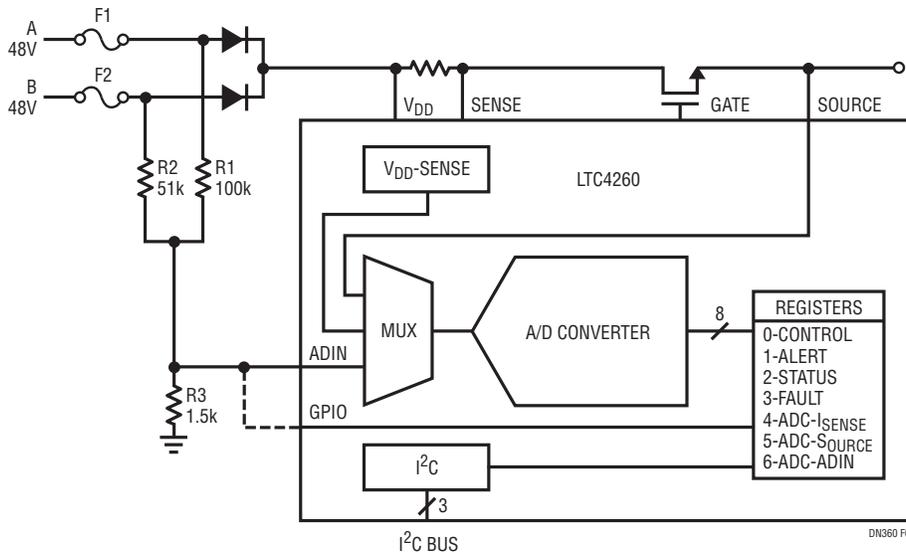
Figure 1. Fuse Monitoring Using the LTC4260

a new supply at the high end of the 48V ±5% range. Such a high voltage step would cause large inrush currents in downstream capacitors on the cards. Similarly, large inrush currents occur when an unpowered card is inserted into a live backplane.

A Hot Swap controller uses a power switch and sense resistor in series with the power rail to eliminate this inrush current. When the current through the sense resistor reaches a limiting threshold, the Hot Swap controller uses the power switch to limit the current. This is useful during power up and also during fault conditions such as the voltage step described above. The current limit feature develops a controlled rise in the voltage across the downstream card capacitance and protects the backplane power bus against disturbances.

The power switch with sense resistor also acts as a gateway for power to the card and it becomes an ideal location to monitor and collect power supply data. Recognizing this, Linear Technology developed the LTC®4260, a Hot Swap controller with power monitoring features. Included in the LTC4260 is an 8-bit ADC capable of measuring the current via the voltage drop across the sense resistor. It also measures the voltage at the load side of the power switch and the voltage at an external general purpose ADC input pin. The part detects faults in the power path such as overcurrent, input overvoltage or undervoltage, output undervoltage and a shorted power switch. The LTC4260 records the occurrence of faults plus the three ADC measurements in registers that are accessible via an I²C bus.

Adding Fuse Detection

If a fuse in series with an OR'ing diode opens, then one of the supplies is lost. The system continues to operate on the remaining supply but without the assurances of redundancy. Additional circuitry is required to detect an open fuse in this configuration.

Adding fuse detection could be accomplished a couple of ways. An external resistor taps off between the fuses and diode to connect to a common point. That common point is terminated through a grounded resistor and feeds the GPIO pin. The GPIO pin is used as a general purpose digital input that is accessible through the I²C bus. If a fuse is blown, the GPIO pin voltage drops. The resulting logic low indicates one of the redundant paths is open.

Of course it would be better to know *which* fuse failed. The solution to this problem uses the general purpose ADC input available on the LTC4260, as shown in Figure 1. By sizing the pull-up resistor to one fuse different from the pull-up to the other fuse, it is possible to detect which fuse is open-circuit. When both fuses F1 and F2 are present, the equivalent resistance of R1 in parallel with R2 is 34k. The R1||R2, R3 resistive divider results in a voltage of 2.04V on the ADIN pin. If one of the fuses fails, the voltage at the common point connected to the ADIN pin drops to a value set by the remaining resistive divider to the remaining 48V supply. If fuse A fails then the R2/R3 voltage divider yields 1.37V on the ADIN pin. Likewise an open on fuse B pulls the pin to 0.71V.

Summary

In order to increase the reliability of high availability systems, it is prudent to monitor the health and integrity of the power distribution network. These systems commonly use a Hot Swap controller to limit inrush current to cards. Since all card power flows through the inrush control circuitry, it is the natural place to add this monitoring capability. In addition to monitoring power, these circuits can also be used to check the integrity of redundant supply networks.