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Controller IC Implements Compact, Power-Saving Solution For Hot-Swapping And Active ORing In Telecom Systems

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A telecom system is a multicard application with embedded microprocessor-based cards plugged into the backplane. Once up and running, these cards are not supposed to be powered down for service or repair. These plug-in cards must be repaired, upgraded, configured, and sometimes even expanded "on the fly" without disturbing the rest of the system.

All updates can only be done by hot-swapping the cards in and out without powering down the entire system. This is why a telecom system is classified as a high-availability system—one that is running 24/7. A telecom system is also a high-reliability system, one that uses redundant power supplies to ensure the system reliability described here.

This article introduces a high-integration hot-swap and ORing controller that protects a telecom system against a power supply fault. This controller, the MAX5944, has been designed to ensure that systems remain highly reliable and always available. The operation of the MAX5944 is explained in this article and measurements demonstrating its performance are presented.

Although the MAX5944 was released to the market several years ago, its usage in the telecom industry has only recently become widespread among telecom system manufacturers as these companies look to replace diode-based solutions for ORing with power-saving, active ORing solutions. With its combination of the hot-swapping and ORing functions, the MAX5944 enables both reductions in power consumption and a highly integrated design.

Understanding Hot Swapping

In a fully operational telecom system, all the bulk and bypass capacitors on the plug-in cards are fully charged. When another card, whose capacitors are uncharged, is plugged into the live backplane, those capacitors act as a short and generate a large charging current (Fig. 1.)

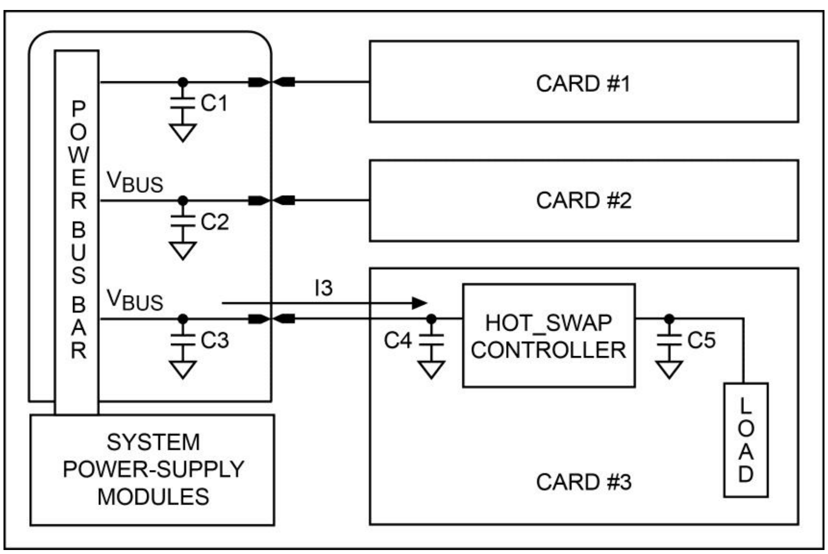

Fig. 1. Sequence of board insertion and inrush current at power-up.

When card#3 in Fig. 1 is plugged into the system, some inrush charging current comes from the fully charged capacitors C1, C2, and C3, which are already active in the system. Other charging current comes from the previous power stage. Depending on the system, this uncontrolled charging current can reach a magnitude of hundreds of amperes in a very short time.

This inrush charging current can cause the backplane or power supply to experience a voltage drop which, in turn, can inadvertently generate system resets. This unrestricted current surge can also cause physical damage to the components, specifically, the destruction of the bypass and bulk capacitors, the PCB traces, and backplane connectors.

The best remedy for this phenomenon (which is potentially catastrophic) is to control the peak surge current by using a hot-swap controller when you are inserting or removing the cards, cables, or other items into or out of a fully operational, live system.

Leveraging Redundant Power Supplies

High-availability telecom systems use redundant power supplies to enhance system reliability. Discrete diodes are commonly used to combine these power sources at the point of load.

There is, however, a disadvantage to the discrete-diode approach: a significant forward voltage drop and the resulting power dissipation, even with Schottky diodes. This voltage drop also reduces the available supply voltage, which is sometimes critical at the low end of the input operating range.

Designers can avoid this problem by using a circuit with "ideal" diode behavior rather than an actual discrete diode. Such a circuit performs a function known as "active-ORing" and it eliminates the forward drop, power dissipation and voltage loss that occurs when a regular diode is used for passive ORing of power supply outputs.

Using Dual Channels For Hot Swapping And ORing

A low-drop ORing switch controller is available that independently controls dual-channel, back-to-back n-channel MOSFETs to perform power-supply ORing and hot swapping. This controller, the MAX5944, incorporates four MOSFET drivers (GATE1_ and GATE2_) to control external n-channel power MOSFETs, which perform the low-voltage-drop power-supply ORing (GATE1_) and hot swapping (GATE2_) as shown in Fig. 2.

A sense resistor provides accurate current sensing. GATE1_ and GATE2_ provide true load disconnect to prevent current flow from either direction between IN_ and OUT_. The switch controller limits the inrush current by monitoring the voltage across RSENSE at all times and regulating the inrush current, as necessary, to keep V_{IS} to its current-limit threshold voltage (V_{TH}).

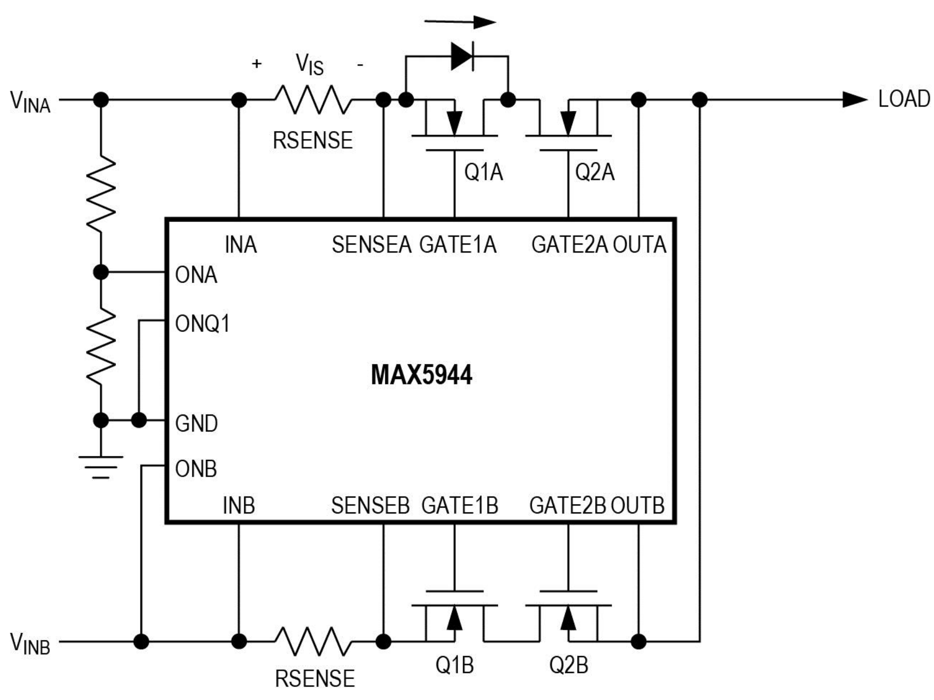

Fig. 2.The MAX5944 ORing switch controller limits inrush current by monitoring the voltage across RSENSE at all times.

Setting of the maximum current limit (I_{LIMIT}) is accomplished by placing the appropriate sense resistor between IN_ and SENSE_, where $I_{LIMIT\_} = V_{TH}/RSENSE\_$. When the load current is less than I_{LIMIT}, GATE2_ rises to V_{G2} (5.5 V) to fully enhance MOSFET Q2. When the load attempts to draw more current than I_{LIMIT}, the MAX5944's GATE2_ pulldown current (I_{G2D}) regulates the current through Q2_. This action causes OUT_ to act as a constant-current source. The output current is then limited to I_{LIMIT}.

Fig. 3 shows the voltage on the load (Ch1), the power MOSFET gate voltage GATE2_ (Ch2), and the inrush current (Ch4) when the uncharged card is plugged in. In this case, the load current is 2 A; the load capacitor is 220 µF.

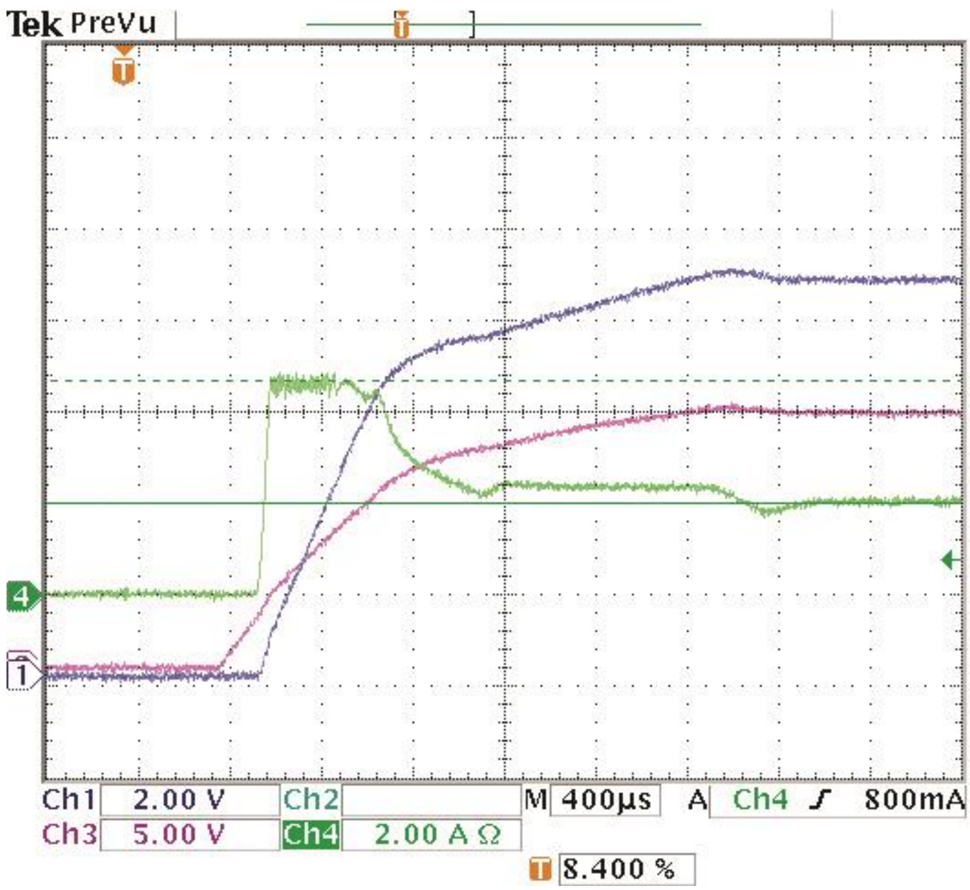

Fig. 3. When the uncharged card is plugged in, you see voltage on the load (Ch1), the power MOSFET gate voltage GATE2_ (Ch2), and the inrush current (Ch4).

To implement the ORing function, the regular power source and the redundant power source are connected at INA and INB, respectively. The MAX5944 switch controller automatically and smoothly kicks in the redundant power source when a fault occurs in the main power supply. GATE1_ controls the ORing function. Initially, GATE1_ is off and the load current conducts through the body diode of Q1_ (Fig. 2). But now GATE1_ rises to 5.5 V above SENSE_ when V_{IS} exceeds the 5-mV V_{or} threshold, thus enhancing Q1_.

Fig. 4 shows what happens when the redundant power supply kicks in. The voltage on load is Ch1 and the GATE1_A is Ch2. Power supply A connects to INA; power supply B connects to INB. Under normal operating conditions, the voltage at INA (V_{INA}) is higher than the voltage at INB (V_{INB}). As a result, power supply A works as a regular power source, and power supply B works as a redundant power source.

But when the regular power source (INA) has a fault, V_{INA} drops and V_{IS} drops below the ORing threshold. The MAX5944 then immediately turns off Q1A, blocking reverse current flow from load to OUTA, and then to INA. Power is then routed from the redundant power supply (INB) to OUTB, and then to the load.

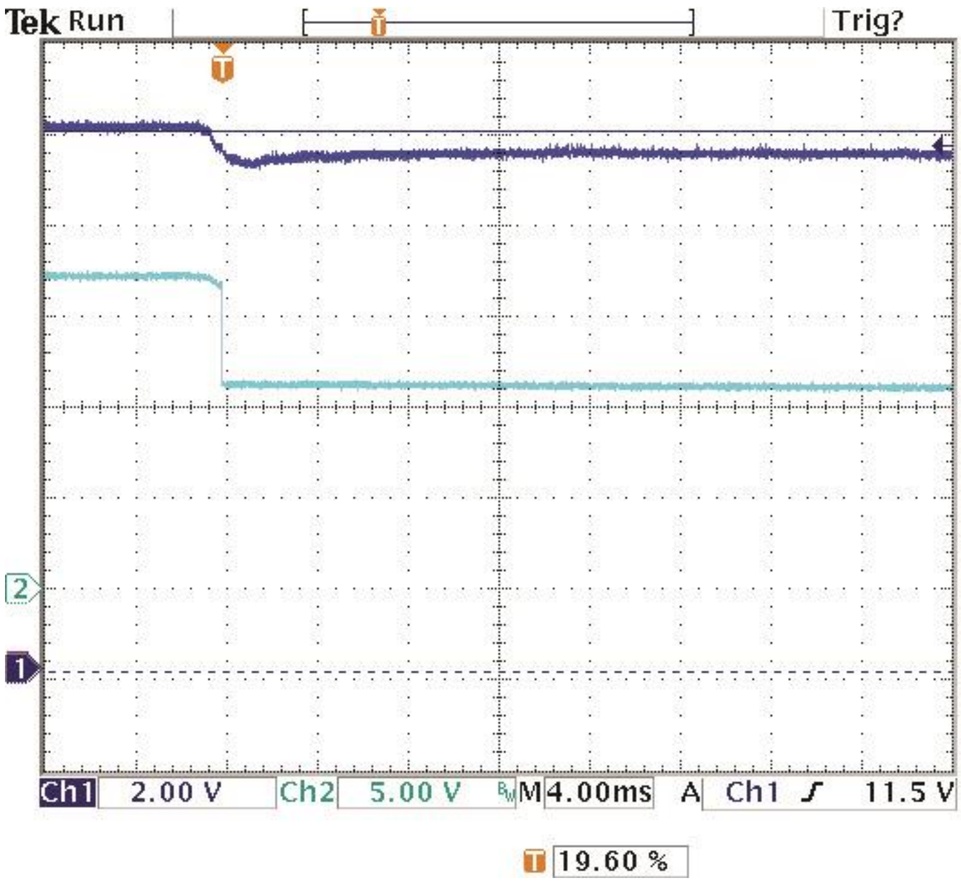

Fig. 4. When V_{INA} drops, the MAX5944 initiates the redundant power supply, INB, and ensures no interruption of power to the telecom system.

Conclusion

Hot swapping is an important and very necessary function to ensure uninterrupted operation of a high-availability and high-reliability, multicard telecom system. In this application the redundant power supply with the ORing function provides the necessary system stability. The MAX5944 ORing switch controller provides a highly integrated solution for the necessary hot swapping and ORing operations.

References

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2. "Using Redundant DC Power in High Availability Systems," by Robert V. White, IEEE Xplore Digital Library.

3. "Active ORing Solutions in Redundant Power System Architectures," by Carl Smith, Power Electronics Europe, Issue 7 2008, pages 39-41.

About The Author

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For further reading on the design of hot-swapping and ORing circuits, see the How2Power Design Guide, select the Advanced Search option, go to Search by Design Guide Category and select "Power Protection" in the Design Area category.