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APPLICATION NOTE 5807

# HOT-SWAPPING AND ORING ENSURE UNINTERRUPTED OPERATION FOR A HIGH-AVAILABILITY AND HIGH-RELIABILITY TELECOM SYSTEM

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*Abstract: The telecom system is classified as high-availability systems, which is not supposed to be powered down for service or repair. This kind of system can only be achieved when the cards are serviced by hot-swapping them in and out without powering down the entire system. The telecom system is also a kind of high-reliability system. It uses the redundant power supply to improve the system reliability. This application note introduces a high integration hot-swapping plus ORing controller, which can build up high-availability and high reliability telecom systems.*

A telecom system is a multcard 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 plugged-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. Using this controller, you can be confident that your system remains highly reliable and always available.

## Understanding the 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. See **Figure 1**.

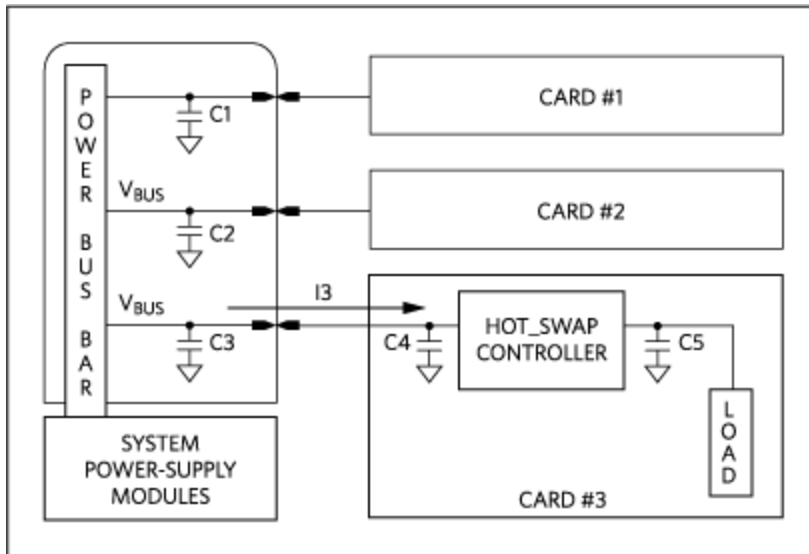


Figure 1. Sequence of board insertion and inrush current at power-up.

When card #3 in Figure 1 plugs 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 magnitudes 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, destruction of the bypass and bulk capacitors, the PCB traces, and backplane connectors.

The best remedy for this phenomenon (even a catastrophe) is to control the peak surge current by using a hot-swapping controller when you are inserting or removing the cards, cables, or other items into or from a fully operational live system.

## 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 this approach: a significant forward voltage drop and 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. To counter this process, use instead a circuit with “ideal” diode behavior, one that eliminates the forward drop and overcomes the power dissipation and voltage loss.

## Use Dual Channels for Hot-Swapping and ORing

A low-drop ORing switch controller is available that independently controls dual-channel back-to-back nMOSFETs to perform power-supply ORing and hot-swapping. This [MAX5944](#) controller incorporates four MOSFET drivers (GATE1\_ and GATE2\_) to control external n-channel power MOSFETs that perform the low-voltage-drop power-supply ORing (GATE1\_) and hot-swapping (GATE2\_). A sense resistor provides accurate current sensing. GATE1\_ and GATE2\_ provide true load disconnect to prevent current flowing from either direction between IN\_ and OUT\_.

### Implement the Hot-Swap Function

The switch controller, here the MAX5944, limits the inrush current by monitoring the voltage across RSENSE at all times (**Figure 2**) and regulating the inrush current, as necessary, to keep  $V_{IS}$  to its current-limit threshold voltage ( $V_{TH}$ ).

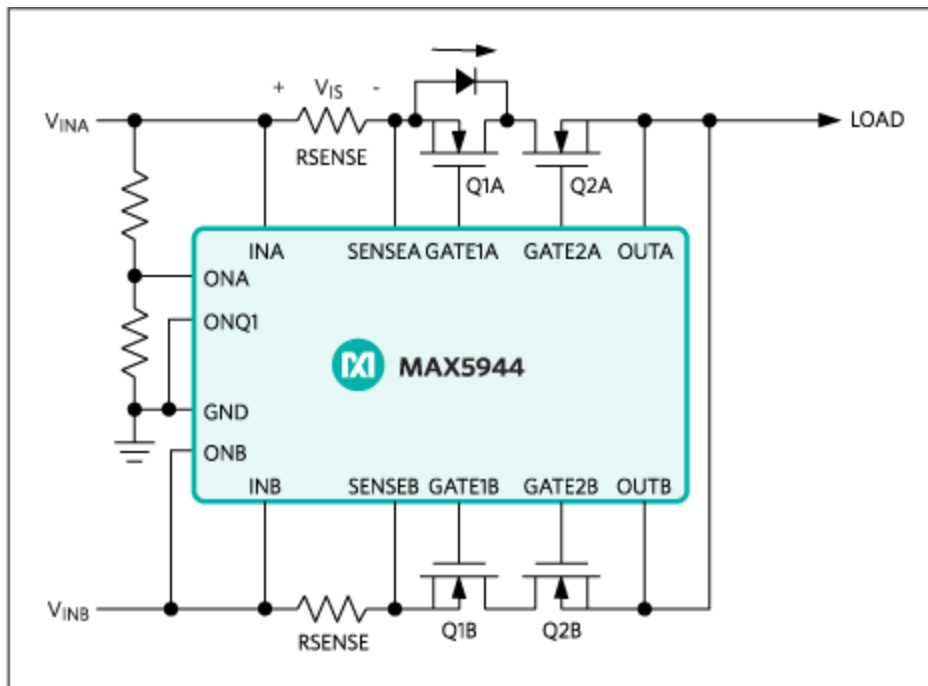


Figure 2. The MAX5944 ORing switch controller limits inrush current by monitoring the voltage across RSENSE at all times.

Set the maximum current limit (ILIMIT) by placing the appropriate sense resistor between IN\_ and SENSE\_, where  $ILIMIT_ = V_{TH}/RSENSE_$ . When the load current is less than ILIMIT, GATE2\_ rises to VG2 (5.5V) to fully enhance MOSFET Q2. When the load attempts to draw more current than ILIMIT, the MAX5944's GATE2\_ pulldown current (IG2D) regulates the current through Q2\_. This action causes OUT\_ to act as a constant-current source. The output current is limited to ILIMIT.

**Figure 3** shows the voltage on the load (Ch1), the power MOSFET gate voltage GATE2\_ (Ch2), and the inrush current (Ch4) while the uncharged card is plugged in. In this case, the load current is 2A; the load capacitor is 220 $\mu$ F.

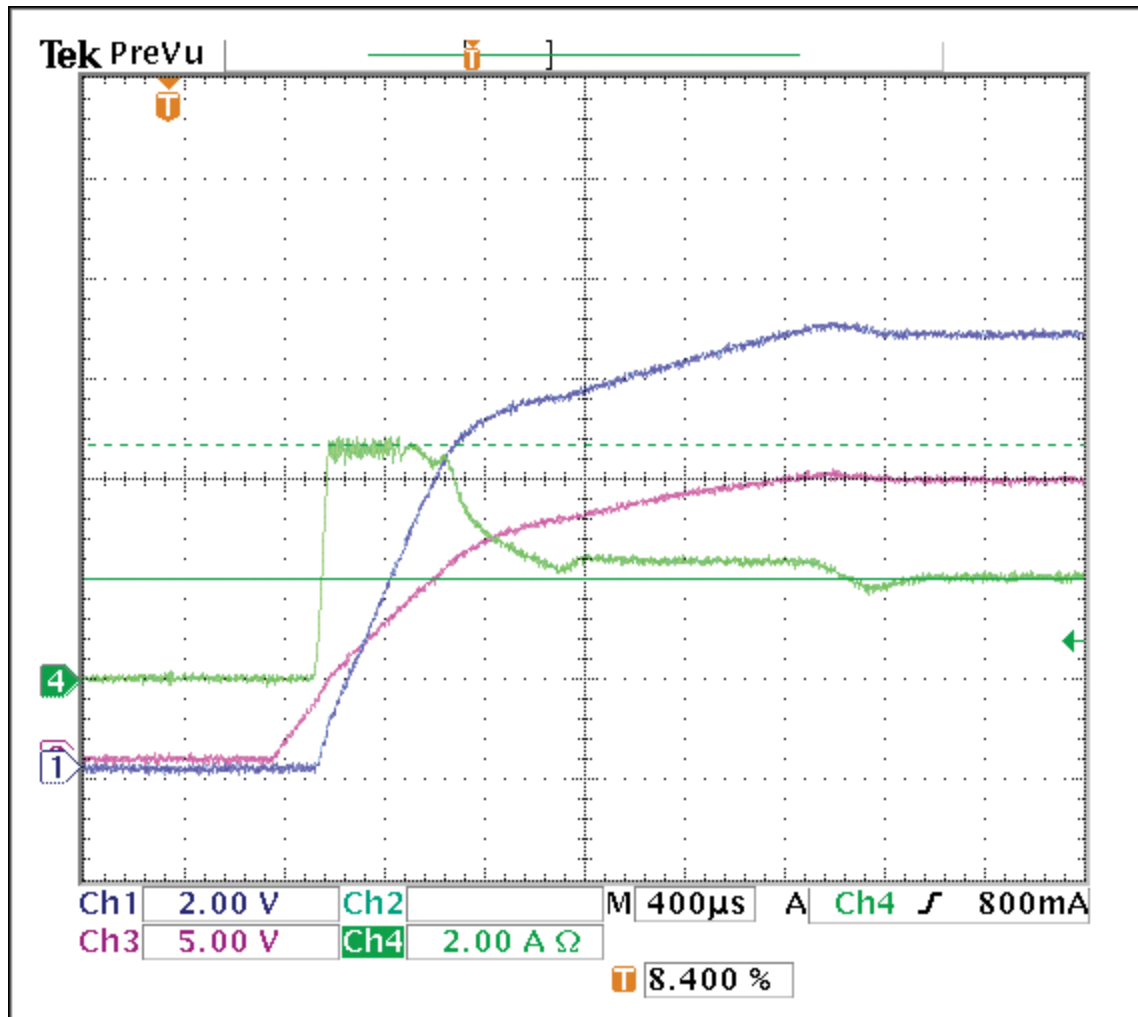


Figure 3. While the uncharged card is plugged in, you see voltage on the load (ch1), the power MOSFET gate voltage GATE2\_ (ch2), and the inrush current (ch4).

### Implement the ORing Function

Connect the regular power source and redundant power source 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\_ (Figure 2). But now GATE1\_ rises to 5.5V above SENSE\_ when  $V_{IS}$  exceeds the 5mV VOR threshold, thus enhancing Q1\_.

Figure 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. In normal 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. When the regular power source (INA) has a fault, then  $V_{INA}$  drops and  $V_{IS}$  drops below the ORing threshold. The MAX5944 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.

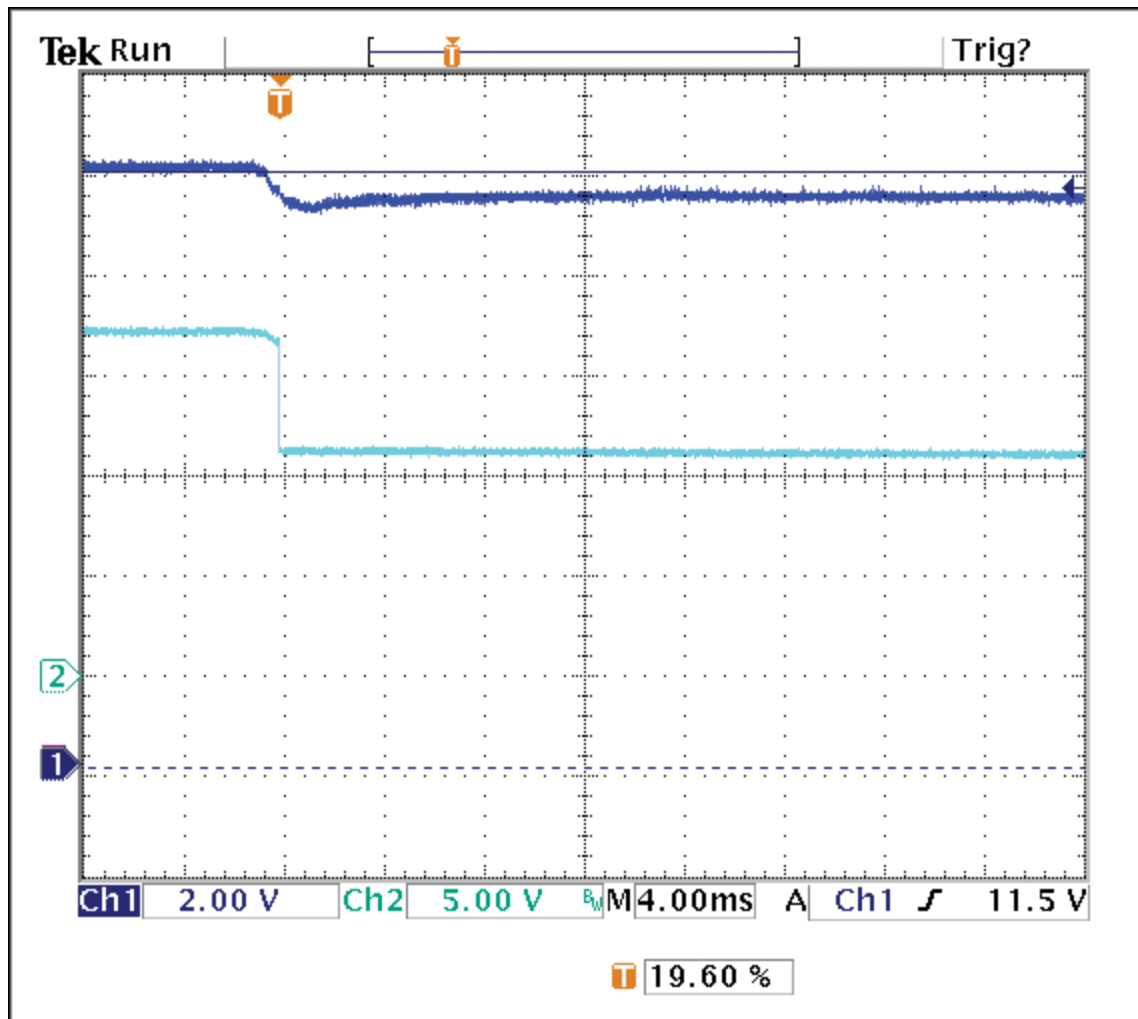


Figure 4. When  $V_{INA}$  drops, the MAX5944 initiates the redundant power supply, INB, and ensures no interruption of power to the telecom system.

## Conclusion

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

## Useful References

1. Hamed Sanogo, "The art of Hot-Swapping in Telecom Systems: Avoid a Patchwork and Implement a

More Effective Solution”, Maxim Integrated application note 4705.

2. Robert V. White, “Using Redundant DC Power in High Availability Systems”, IEEE Xplore Digital Library<sup>®</sup>.
3. Carl Smith, “Active ORing Solutions in Redundant Power System Architectures”, Power Supply Design, Issue 7 2008.

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#### Related Parts

<a href="#">MAX5944</a>	Dual FireWire Current Limiter and Low-Drop ORing Switch Controller	<a href="#">Free Samples</a>
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