

# Power-Management Solutions for InfiniBand<sup>SM</sup> I/O Modules

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## ABSTRACT

InfiniBand, a scalable, modular, channel-based, switched-fabric architecture, is defined for the connection of servers with servers and with storage and networking devices. Because appropriate power-management is essential for quality implementations, this report presents straightforward solutions for both high-power and low-power applications as required by the InfiniBand specification.

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# 1 Introduction

InfiniBand is a scalable, modular, channel-based, switched-fabric architecture with a performance range from 500 Mbps to 6 Gbps. Supporting a wide range of applications, InfiniBand (or IB) is defined for connection of servers with servers as well as with storage and networking devices.

The basic InfiniBand interconnection is a link—a full-duplex interfabric transmission path—where a fabric is simply a collection of links, switches, repeaters, and routers connecting nodes. InfiniBand is basically a back-planed implementation, and the specification defines power requirements for the system and each module as well as the digital and communication requirements. This set of digital and analog signals is defined as a port, which is the termination point for a link.

The physical attach point to a port is one of the following:

- A cable connector, defined for use with copper cables.
- A fibre connector, defined for use with optical cables.
- An IB module that defines the form factors and backplane connector housing a function.

An InfiniBand port is a set of signals as seen on a connector interface, identified by InfiniBand specification. Some connectors will contain all signals (e.g., backplane), while others may contain subsets (e.g., cable and optics). Each IB port contains four groups of signals, which serve different purposes. These groups are:

1. IB signaling
2. System management
3. Bulk-power
4. Auxiliary-power

There are two power connections available for each IB module:

1. Bulk power, intended for the major functions of the module. This is a 12-V supply with a  $\pm 2$ -V tolerance and transient peak of 16 V. In most module implementations this voltage will have to be regulated down to a more useful voltage level, such as 3.3 V. The maximum current load on this supply rail is 2.5 A dc.
2. Auxiliary power, intended for management and enumeration functions of the module, even when the bulk power is not available. Auxiliary power is supplied to the module as 5 V and may be regulated within the module as required. The maximum current load on this supply rail is 0.26 A dc.

A single IB port is capable of providing up to 50 W, but provisions are made to allow the chassis backplane the option to supply 25 W and indicate that only 25 W is available; concurrently, the IB module will indicate that up to either 25 W or 50 W is required. This ensures that an appropriate match of power required vs power delivered is in place while allowing for both flexible systems and module designs.

The combination of staggered pins in the connector and power-control circuitry built into the module allows InfiniBand modules to be hot-pluggable—inserted and removed while the system is powered—without affecting system operation or causing physical damage. Additional features are defined that allow for *graceful removal*, whereby software is notified of a pending removal so that appropriate actions can take place prior to the actual removal of the module. The purpose is to eliminate any potential disruptions to system operation. LED indicators on the module indicate whether a module is in an operational state allowing safe removal.

For additional information, refer to the specification. See Chapter 6, *Low-Speed Electrical Signaling*, for details on the electrical parameters of the bulk and auxiliary power groups, and Chapter 8, *Power/Hot Plug*, for details on power functionality, in InfiniBand Architecture Specification Volume 2A. This report addresses the solutions for the bulk- and auxiliary-power groups.

## 2 Bulk-Power Group Implementation

The bulk-power group is included in Chapter 8 of the Infiniband Specification Volume 2 A. The topology diagram is shown in Figure 1.

The bulk-power group includes two stages: hot-plug control stage and dc/dc converter stage. In order to limit inrush current caused by the bulk capacitor  $C_{Bulk}$ , current ramp at input is limited by the FET in the hot-plug control stage. In the specification, the maximum  $dv/dt$  ramp rate of  $VB\_In$  is 40 A/ms.

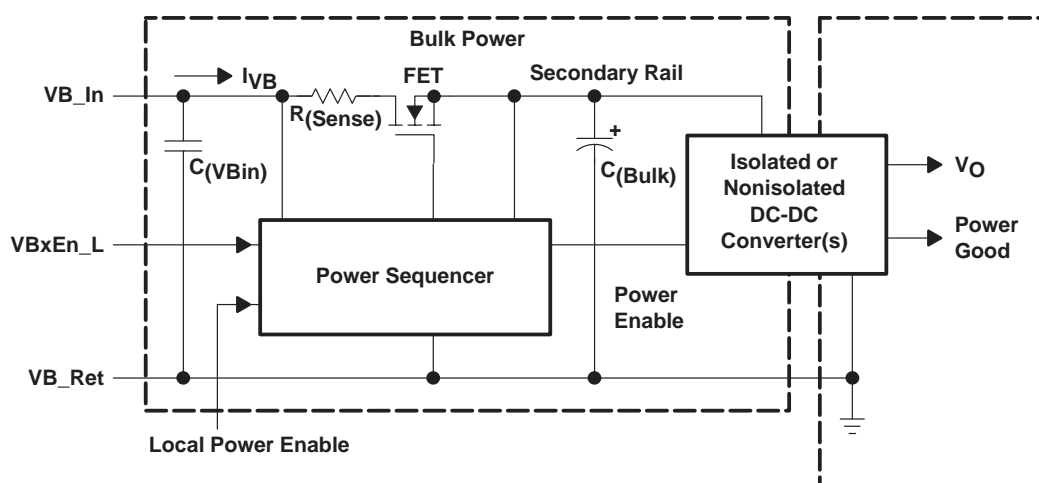
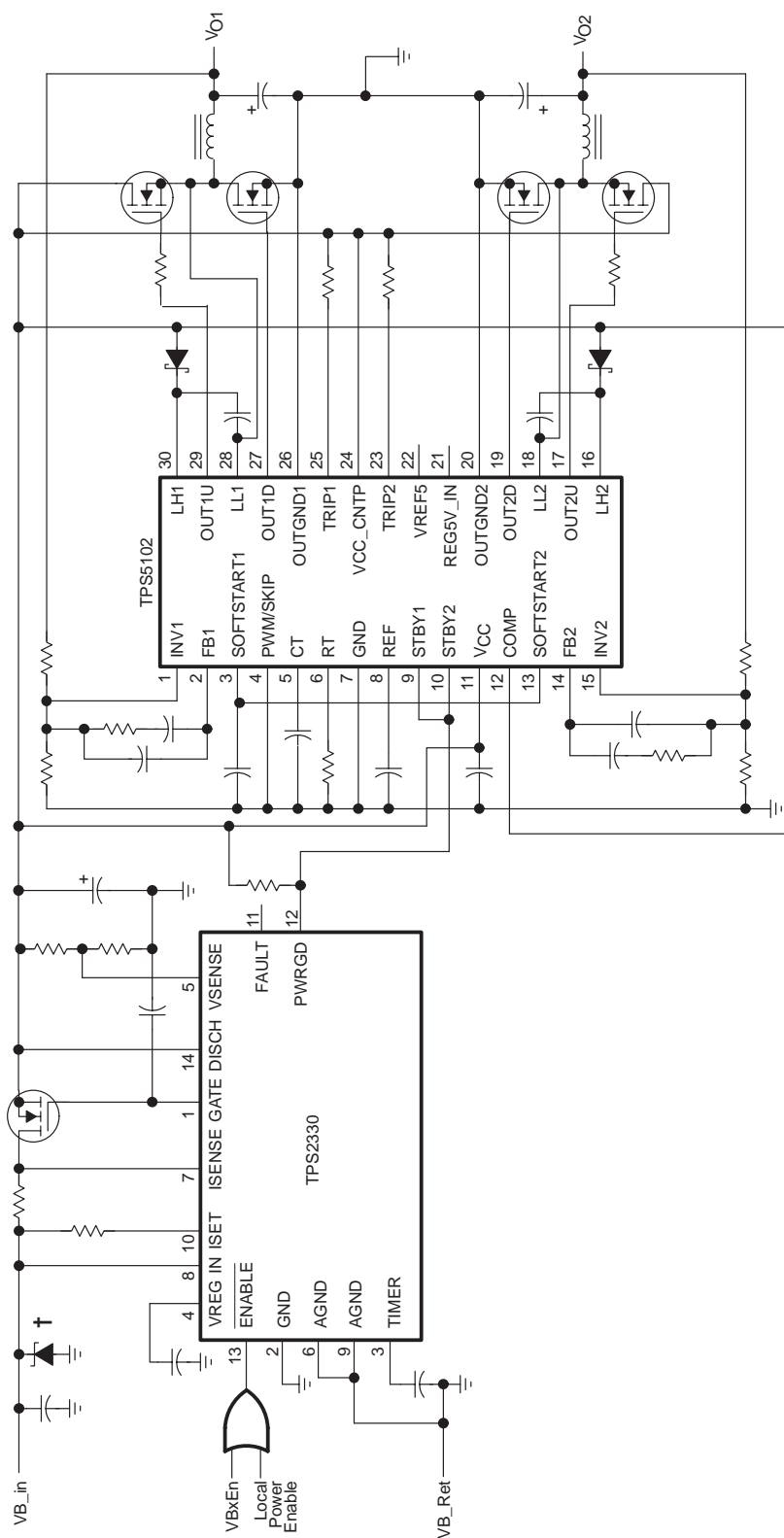


Figure 1. Bulk-Power Topology

The TPS2330 or the TPS2331 from Texas Instruments can be used for implementing the hot-plug control circuit as required, and the TPS5603 or TPS5102 can be used where a dual dc/dc converter is required. As an example, if two supply voltages are required by I/O functions, which are loads on the bulk power, then the bulk-power group with nonisolated dc/dc converters can be implemented as shown in Figure 2.



† A 15-V zener diode may be required to limit the line transient voltage within the maximum voltage range of the TPS2330.

**Figure 2. Implementation of the InfiniBand Bulk-Power Group**

For more comprehensive information on the functionality of the TPS2330 and TPS5102, go to:

<http://www.ti.com/sc/docs/products/analog/tps2330.html>

<http://www.ti.com/sc/docs/products/analog/tps5102.html>

To look at the TPS5602, refer to:

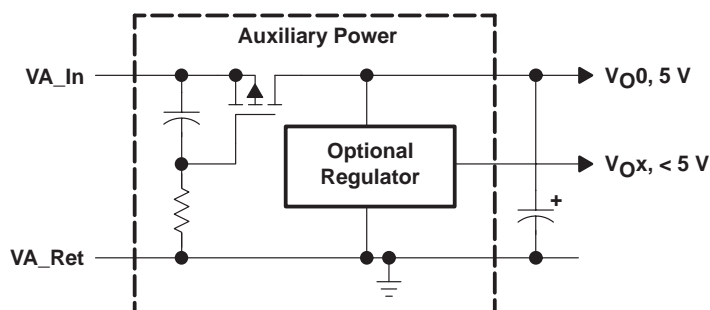
<http://www.ti.com/sc/docs/products/analog/tps5602.html>

If isolated dc/dc converters are required, the dc/dc converting topology in Figure 2 needs to be changed according to isolation requirements. Many isolation dc/dc topologies can be used, such as forward, flyback, and other alternatives. For help with isolated power design, contact TI's systems engineers through the product information center for solutions.

To create more output voltage levels, add more channels of dc/dc converters, or simply use LDOs such as TPS765xx, following the dc/dc converter stage, to regulate the  $V_{O1}$  or  $V_{O2}$  to the voltages required.

### 3 Auxiliary-Power Group Implementation

Chapter 8 of InfiniBand Specifications Volume 2A also recommends an auxiliary-power group, as shown in Figure 3. In this topology, a P-channel FET is recommended and should be turned on as long as the required 5 V is on the input  $VA\_In$ . Therefore, 5 V is available without additional regulation. Because most modern electronic circuits work at a lower voltage such as 3.3 V, further regulation may be necessary.



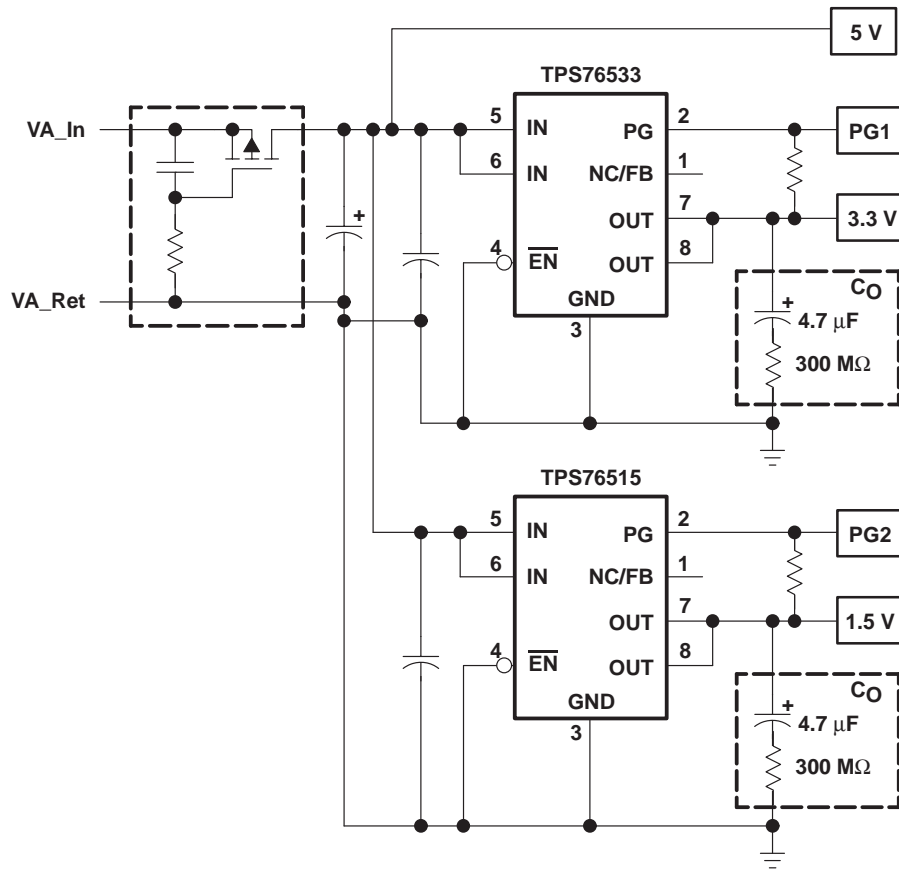
**Figure 3. Auxiliary-Power Topology**

A slow-start control circuit, the RC network associated with the FET implementation, is shown in this topology. This circuitry limits the current ramp-up rate of the auxiliary-power group to below 0.1 A/ms (or 100 A/s) if the appropriate capacitance and resistance is selected.

Figure 4 shows a simple implementation of the auxiliary-power group using TPS765xx low-dropout regulators.

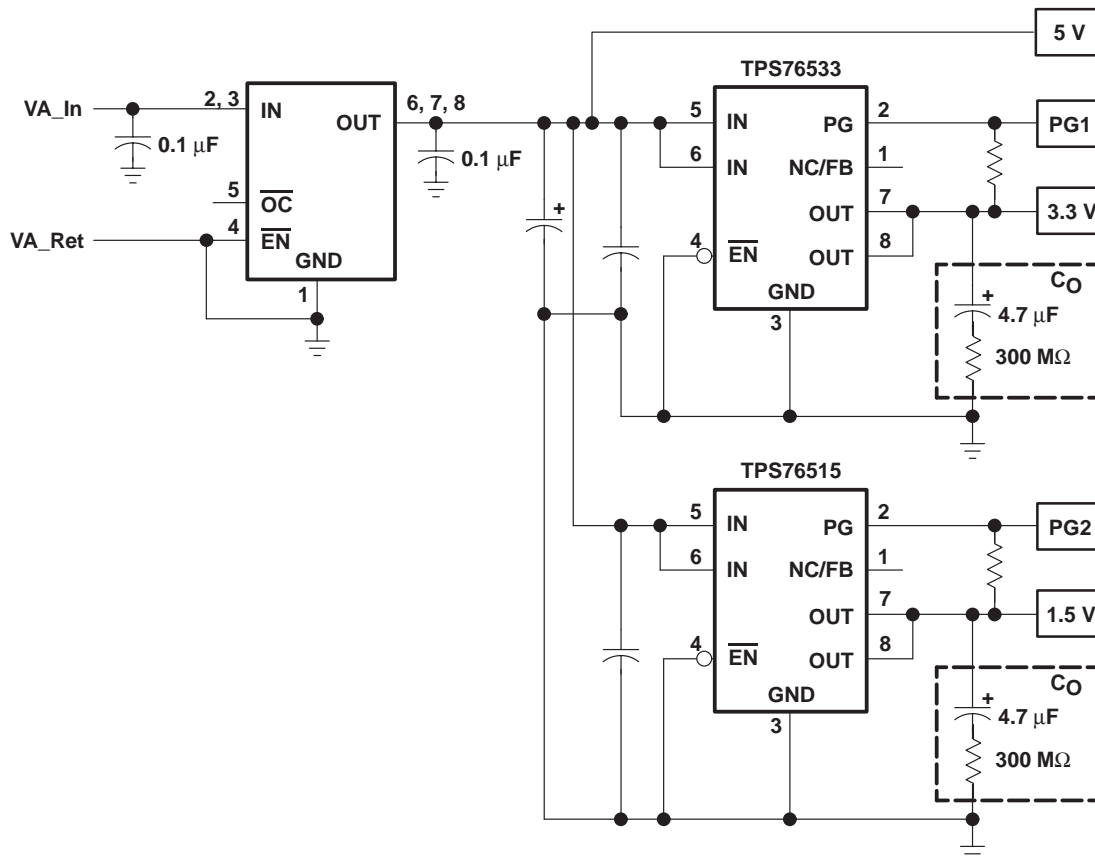
Additional information about the TPS765xx LDO can be found at <http://www.ti.com/sc/docs/products/analog/tps76501.html>

The TPS765xx LDO family can regulate the output voltage to any points between 1.25 V and 4.8 V with a 5-V input. The family includes eight fixed-output voltage versions (1.5 V, 1.8 V, 2.5 V, 2.7 V, 2.8 V, 3 V, 3.3 V, and 5 V) and an adjustable version. As shown in Figure 4, two voltages are generated by the LDOs for management functions.



**Figure 4. Implementation of the InfiniBand Auxiliary-Power Group**

A simpler solution of the auxiliary-power group can be implemented using a TPS2021 current-limited power-distribution switch plus the TPS765xx LDO, as shown in Figure 5.



**Figure 5. Auxiliary-Power Implementation Using TPS2021 and TPS765xx**

The TPS2021 switch has controlled rise time and ramp-up rate, which eliminates the need for additional control circuitry, as well as overcurrent and overtemperature protections. To view the specifications for TPS2021, refer to:

<http://www.ti.com/sc/docs/products/analog/tps2021.html>

## 4 Conclusion

The InfiniBand architecture creates a very large market, targeting many applications. To have reliable and quality implementations, appropriate power management is essential. This report presents straightforward solutions for both high-power and low-power implementation required by the InfiniBand specification. Texas Instruments, as a member of the InfiniBand Trade Association, will continue supporting InfiniBand applications, and the Power Management Products (PMP) group at TI can provide diverse power management solutions in InfiniBand and other areas.

## 5 References

1. *TPS2020, TPS2021, TPS2022, TPS2023, TPS2024 Power-Distribution Switches* data sheet, Literature Number SLVS175A
2. *TPS2330, TPS2331 Single Hot Swap Power Controller With Circuit Breaker and Power-Good Reporting* data sheet, Literature Number SLVS277A
3. *TPS76515, TPS76518, TPS76527, TPS76528, TPS76530, TPS76533, TPS76550, TPS76501 Ultra-Low Quiescent Current 150-mA Low-Dropout Voltage Regulators* data sheet, Literature Number SLVS236
4. *TPS5102 Dual, High-Efficiency Controller for Notebook PC Power* data sheet, Literature Number SLVS239
5. InfiniBand Architecture Specification Volume 2A Release 0.9.



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