Standardizing Power Management Solutions Across Multiple Designs Using a Programmable Power Management IC

A Lattice Semiconductor White Paper

May 2005

Lattice Semiconductor
5555 Northeast Moore Ct.
Hillsboro, Oregon 97124 USA
Telephone: (503) 268-8000
www.latticesemi.com

Phases of Power Management

It will come as no surprise that the power supply management requirements of dissimilar boards will be different from one another, requiring different mechanisms for power supply sequencing and tracking, different voltages for monitoring and so on. Further, the complexity of power supply management functions increases when the board-specific management functions are included. Traditionally, power supply design engineers have treated each board's power management functions as independent designs, for selecting management components as well as methodology.

In fact, all circuit board power management functions can be viewed in terms of standard functions, or phases, performed one after another. Figure 1 illustrates the typical 5-phase power cycle of a circuit board.

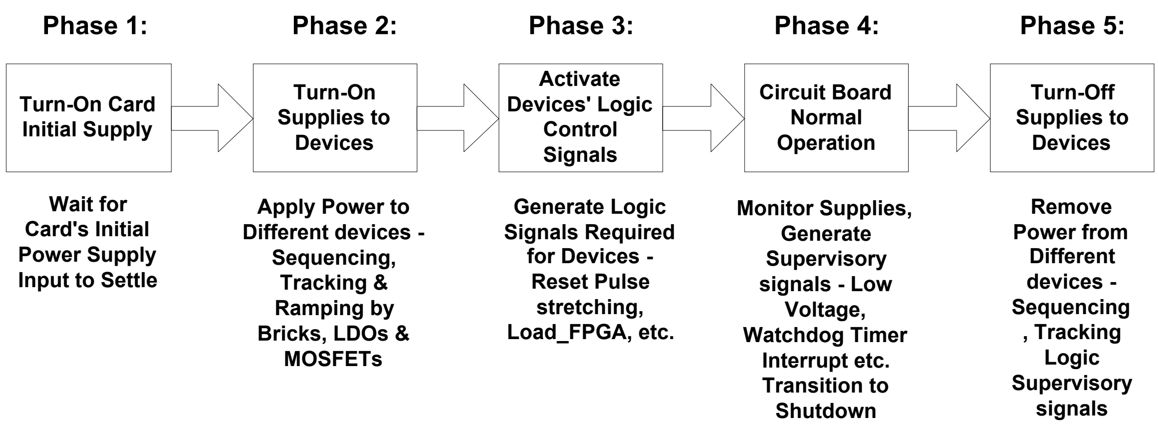

Figure 1 – Typical Power Cycle of a Circuit Board

Phase 1: The power supply to the card is enabled. Different power supply voltages on the circuit board are derived from these initial supply voltages. The on-board power supply conversion and distribution mechanisms, however, must wait for the initial supply to stabilize.

Phase 2: Additional supply voltages, determined by the requirements of multi-voltage devices on the circuit board, are derived from the initial voltages through

DC-DC converters ("Bricks"), LDOs, or use MOSFETs to gate the supply voltage to different devices. These power supply conversion and distribution mechanisms must be precisely controlled to satisfy the sequencing, tracking and ramp requirements of individual devices. For example, this phase often requires one or more Power-FET devices to turn on with precisely controlled high-voltage signal characteristics.

Phase 3: Once the board's power system has stabilized and all devices on the board are powered up, the board is ready to operate. Some devices, however, may need some additional logic signals as part of their initialization procedure. For example, a CPU reset signal may need to be asserted for 50ms for it to complete its internal reset function.

Phase 4: In this phase the board is performing its intended function, and the role of the power management circuitry shifts to monitoring the health of the power supply voltages. All devices are required to be provided with supply voltages within their data sheet limits. If any one of the supply voltages dips below the device's supply tolerance level, remedial action should be taken – for example, generate brownout interrupt to the CPU.

Phase 5: Removing power from a device in a sequenced manner is as important as applying power. The multi-voltage devices determine the exact shutdown sequence.

Designing the Power Management Circuit

Typically, the power management circuit involved in implementing the standard functions shown above has been designed using discrete components. Often, many off-the-shelf, traditional power management devices (supervisors, reset generators and charge pumps, for example) are required to implement all the functions due to:

- Limited voltage coverage
- Limited reset generation capability
- Limited logic associated with the charge pumps
- Requirement for an external CPLD for logic generation
- Limited accuracy
- Factory set power supply monitoring voltages

Because these devices are functionally simple, many devices are needed to implement even a simple power management function. Additionally, these devices force designers to start from the ground up for each type of circuit board they are designing, rendering each power management design unique. Implementation of the power management function also becomes complex when system level digital signals are required to control the power management algorithm. Because the entire design is hardwired, the ability of the design to adapt to changes is drastically reduced. The power supply start-up behavior also affects the timing, and designers must select the R's and C's in their circuit through trial and error. Of course, this increases time to market. Further, using many traditional off-the-shelf devices, often from multiple vendors, increases manufacturing costs.

Power Management Solutions Across Multiple Designs

The 5-phase power cycle identifies the circuit elements required to implement a complex power management function for a CompactPCI card, and shows how traditional, off-the-shelf ICs can be used. A second application example, an industrial control card, requires much simpler power management functionality. Also shown is how a programmable power manager IC can be used to meet the requirements of both power management functions.

Power Management of a CompactPCI card

The CompactPCI specification requires a number of digital control functions to be included in the power management function. Consequently, the designer resorts to multiple chip solutions -- one to satisfy the power supply section of the

CompactPCI standard, and other discrete components to manage the power supplies on the board.

The next step is to identify the components required for the implementation of the power management function in all 5 phases, first using discrete off-the-shelf ICs and then using a programmable power management IC, such as the Lattice ispPAC Power Manager IC.

Figure 2 is the original design using off-the-shelf ICs for power management: 5 ICs and many R's and C's for timing. A programmable power manager IC replaced all these ICs.

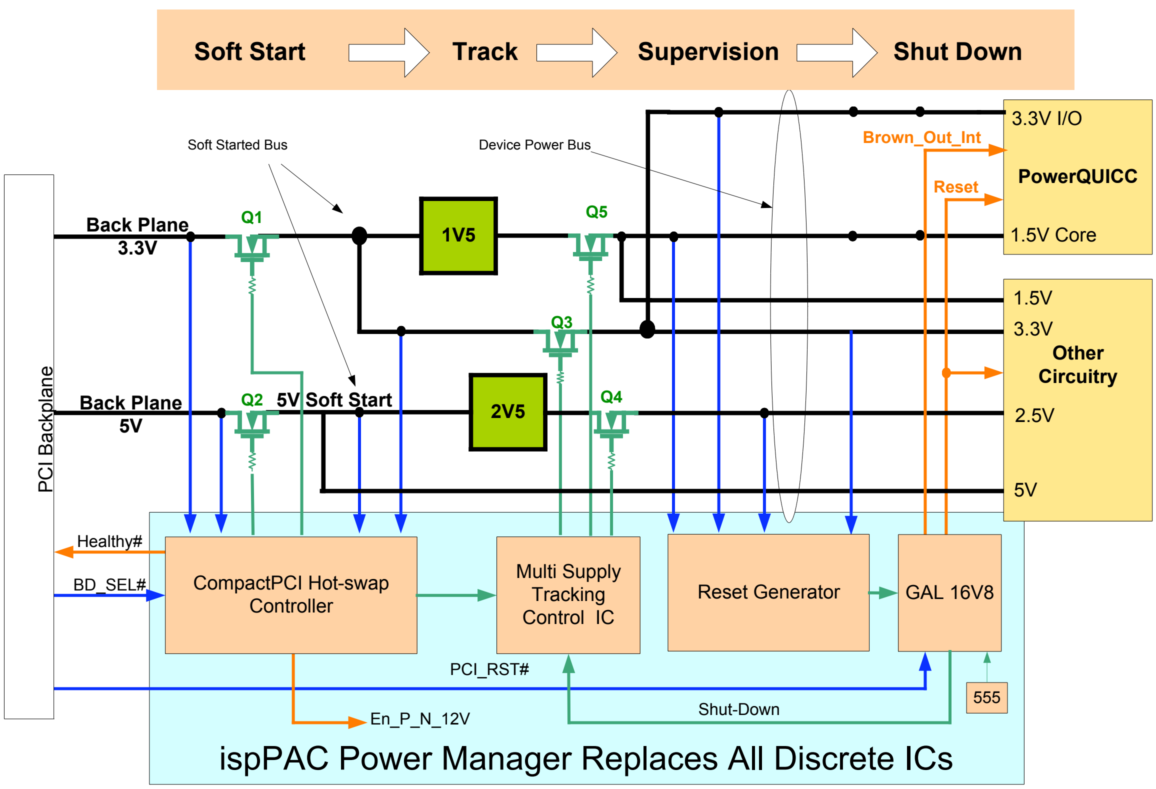

Figure 2 – CompactPCI power management circuit diagram

The following table compares the power management implementation using traditional off-the-shelf discrete ICs with the implementation using the programmable power management IC.

	Phase 1 - Turn-on Card Initial Power Supply	**Phase 2** - Turn-on Supplies to Devices	**Phase 3** - Logic Control Signal Activation	**Phase 4** - Circuit board Normal Operation	**Phase 5** - Turn-off Supplies to Devices	Total Number of ICs used
Traditional Off-the-shelf ICs	CompactPCI **Hot-Swap IC**	**Tracking IC** - For 1.5V, 2.5V & 3.3V Tracking	**Reset Generator IC -** With Manual Reset input and 3 Supply Voltages	2 X 3-supply **Supervisor ICs with Watchdog Timers** for Interrupt and Initiate Shutdown	Uses the same supply tracking IC used in Phase 2	**5**
ispPAC Power Manager	Program PLD (2 Steps), Set Threshold of 4 Comparators, Program MOSFET Driver output, 1 Digital Output	Program PLD (6 Steps), Set 4 Thresold Comparators, Program 2 MOSFET Drivers	Program PLD (3 Steps) & 2 outputs, 1 Timer	Program PLD (2 Steps), 2 Outputs, 1 Timer	Program PLD (3 Steps)	**1**

Because it takes only simple programming steps for the ispPAC Power Manager to perform the phase specific function, it is able to replace heterogeneous types of discrete off-the-shelf ICs.

Power Management of an Industrial Control Card

Power management of the Industrial Controller card is not as complex as that of the CompactPCI card. The power supplies sequencing, during turn on and turn off, is very simple and there are no complex power management algorithms to implement. Even so, four off-the-shelf ICs are required to implement the power management. Further, the off-the-shelf ICs used in this application are completely different from those used for the power management of the CompactPCI board. However, the same power management IC, with a different program in the PLD and threshold levels, is used in both applications.

Figure 3 is the original design using traditional off-the-shelf ICs for power management: it used 4 ICs, transistors for logic and many R's and C's for timing. A programmable power manager IC replaced all these ICs.

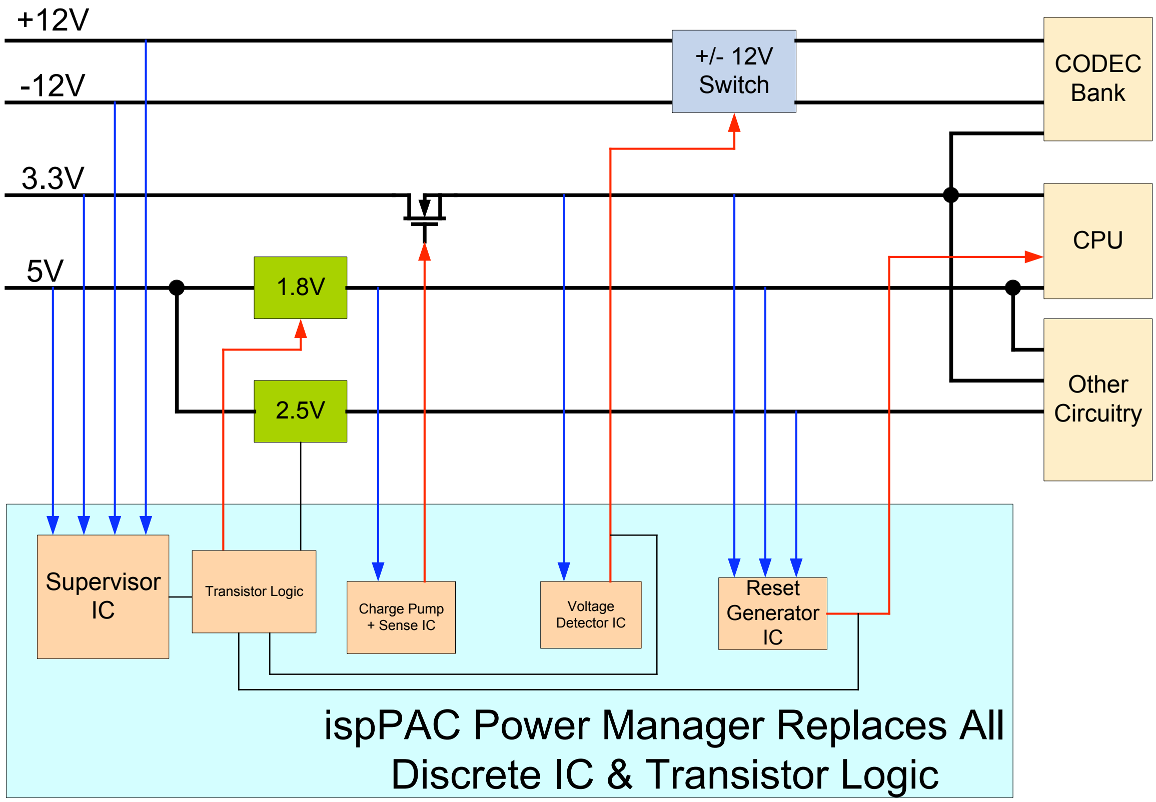

Figure 3 – Industrial Controller Power Management Circuit

The following table compares the power management implementation for each of the 5 phases.

	Phase 1 - Turn-on Card Initial Power Supply	**Phase 2** - Turn-on Supplies to Devices	**Phase 3** - Logic Control Signal Activation	**Phase 4** - Circuit board Normal Operation	**Phase 5** - Turn-off Supplies to Devices	Total Number of ICs used
Traditional off-the-shelf ICs	4 Supply **Supervisor IC** With Power Good Signal	**Voltage Detectors & 1 Charge pump -** One for sequencing 3.3V for CPU and the Other for Sequencing +/- 12V for Codec Bank	**Reset Generator IC** - With Manual Reset input and 2 Supply Voltages	Descrete Transistor based Logic to Combine the Inputs from Phase 1,2 & 3 to generate Interrupt and Enble Shutdown Circuit	Transistor based Shut-down circuit that Disables all Supplies	**4**
ispPAC Power Manager	**Program** PLD (2 Steps), Set Threshold of 4 Comparators	**Program** PLD (3 Steps), Set 4 Thresold Comparators, Program 3 Digital outputs	**Program** PLD (32Steps) &1 output, 1 Timer, Digital input	**Program** PLD (2 Steps), 2Outputs, 1 Timer	**Program** PLD (3 Steps)	**1**

The Advantages of a Programmable Power Management Solution Across Multiple Designs

Practically all traditional, off-the-shelf power management IC functionality can be realized with a few programming steps for the on-chip PLD of the Lattice ispPAC Power Manager. Further, the voltage monitoring threshold, MOSFET driver configuration and output functionality of the Power Manager IC enable the device to interface to various power supplies without the use of any other external components.

In contrast, with traditional off-the-shelf power management devices, each design requires multiple devices and the algorithm is implemented by hardwiring these devices with one another. Designs will often require power management devices from multiple vendors. The resulting circuit not only occupies a larger board area, but also costs more and is difficult to manufacture.

The integration and programmability of the ispPAC Power Manager device provides designers with a complete tool kit for most power management functions that can be customized to suit different power supply voltages as well as power management algorithms. The on-chip PLD enables these functions to meet all 5 phases of power management. As a result, the same device can be used to address different types of power management functions across multiple designs.

###