

Altera Hot-Socketing & Power-Sequencing Advantages

Introduction

Hot socketing refers to the ability to insert or remove a board into or out of a system during system operation without causing undesirable effects to the host system or the cards themselves. It is often also referred to as hot swapping or hot plug-in.

A programmable logic device (PLD) capable of hot socketing must meet the following criteria.

- The device can be driven before power-up without any damage to the device itself.
- The device does not drive out before or during power-up.
- External input signals to the device I/O pins do not power the device's V_{CCIO} , V_{CCPD} , or V_{CCINT} power supplies through internal paths of the device.

This white paper will discuss the rising demand for hot socketing in today's systems and provide information on the hot-socketing and power sequence protection feature supported by Altera devices. This white paper also compares other hot-socketing methods to Altera's hot-socketing solution.

The Rising Demands for Hot Socketing & Hot Socketable PLDs

The growth of the Internet, wireless communication, and storage industries propelled an exponential increase in real-time data traffic. With this increase in real-time data traffic, system operators cannot afford to shut down complete systems for repair, maintenance, or upgrades because the services that these operators provide cannot be interrupted. Thus, high system availability has become a critical requirement as each second of the system downtime translates into revenue losses.

Hot socketing is critical to most systems that require high system availability or redundancy. Table 1 shows some example systems in different market segments.

Table 1. Example Systems in Different Market Segments

Market Segment	Example Applications
Networking	Hubs, switches, and routers
Computing services	Computer servers and workstations
Data storage	Data switch, tape automation system, and storage system data center
Wireless communications	Cellular base station infrastructure
Wireline communications	PBX and central office infrastructure

Hot-socketing and power sequence protection support is even more important due to the rapid advancement in the semiconductor process technology. As the process technology shifts to smaller geometries, lower voltage levels are required to power integrated circuits (ICs). Furthermore, different I/O standards require different voltage levels. Today's printed circuit boards (PCBs) are assembled with a mixture of 5.0-, 3.3-, 2.5-, 1.8-, and 1.2-V devices, and it becomes difficult to guarantee the correct power-up sequence for each component so that systems function properly.

Multi-voltage systems that do not require hot socketing can still benefit from hot-socketing and power sequence protection support. In a multi-voltage system, different voltage levels are often supplied through

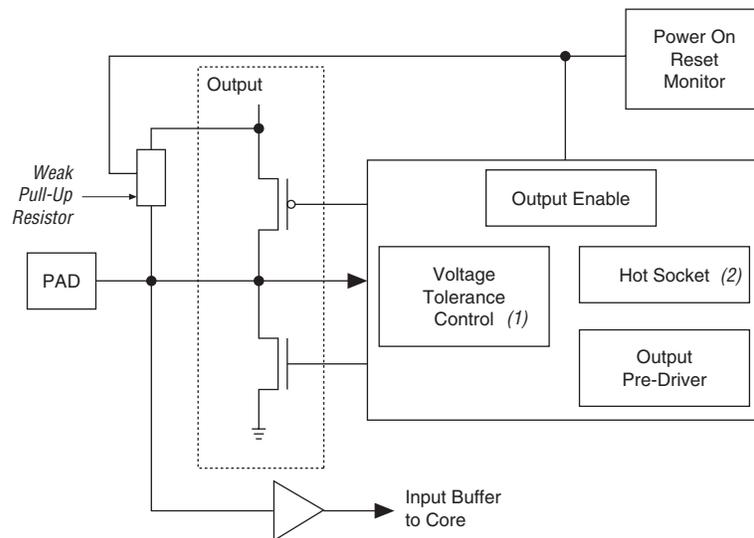
power regulators. The use of power regulators can cause the system power-up sequence to be unpredictable. Devices that require predetermined power-up sequences may not operate normally and can cause the entire system to malfunction.

PLDs are increasingly incorporated into communications, networking, and storage applications due to the lower unit cost and performance, feature, and density advancements. PLDs must support hot socketing and power sequence protection so that the data on the system busses that the devices directly connect to will not be altered during hot swapping. The PLD's hot-socketing support is also vital if PLDs must control the power up of other devices in complex systems.

Altera PLD's Hot-Socketing Implementation

Altera's on-chip hot-socketing solution satisfies the requirements for high system availability and resolves the issues from multi-voltage systems. Figure 1 shows a generic block diagram for the hot socketing feature supported in the Stratix™ II, Stratix, Stratix GX, Cyclone, MAX 7000AE, and MAX 3000A devices. During the device power up, the power-on-reset block monitors the V_{CCINT} voltage and keeps I/O pins in tri-state or weak pull-up. The voltage tolerance block protects I/O pins when they are driven and prevents them from driving out. The hot-socketing block ensures that the signal pins cannot power the device V_{CCINT} , V_{CCPD} , and V_{CCIO} .

Figure 1. Hot Socketing Circuit Block Diagram



Notes to Figure 1:

- (1) The Stratix II, Stratix, Stratix GX and Cyclone families are 3.3-V tolerant. The MAX 7000AE and MAX 3000A CPLDs are 5.0-V tolerant.
- (2) This applies to Stratix II, Stratix, Stratix GX, and Cyclone devices only.

It is a common misconception that hot socketing is not possible for ICs based on 0.13- μ m or smaller process geometries. The hot-socketing capability is a functional problem that can be solved by proper circuit design. The circuit design must ensure that proper device operation occurs regardless of the power-up sequence. The Stratix, Stratix GX, and Cyclone FPGA families are all based on the 0.13- μ m process, and the Stratix II family is based on the 90-nm process, and each family supports hot socketing.

Altera Hot-Socketing Solution vs. Alternatives

For a single-voltage system, hot socketing is achievable by using sequenced connectors to guarantee the proper mating sequence of the ground, power and signal connections. Other FPGA vendors whose products do not support hot socketing also recommend this method. However, in multi-voltage systems, on-board power regulators generate different voltage levels, but designers cannot determine which voltage level is generated first. Thus, even though sequenced connectors are used, the hot-socketed board may still malfunction due to problems such as device latch-up. The data on the host system's bus can also be altered unexpectedly.

Altera's Stratix II, Stratix, Stratix GX, Cyclone, MAX 7000AE, and MAX 3000A devices are fully tested to support hot socketing in a multi-voltage system where power supply sequences are not specified. The power-up sequence no longer dictates the proper functionality of these PLDs. Furthermore, because the I/O pins do not drive out during power-up, system busses that PLDs are connected to will not experience unexpected change.

Another alternative is to use hot swap controllers to manage the flow of current entering the board and the power-up sequence for devices on the board. However, the signal pins may have already been mated to the backplane before the power is properly distributed to the entire board. Furthermore, this solution will result in higher cost and will use more board spaces. See Table 2.

Table 2. Altera Hot Socketable PLDs vs. Alternative Hot Socketing Techniques for PLDs

	Altera Hot Socketable PLD	Sequenced Connectors	Hot Swap Controller
Advantage	<ul style="list-style-type: none"> No-hassle, drop-in implementation Normal PLDs functionality is not influenced by the power-up sequence On-chip support. No external devices or board manipulation are required 	<ul style="list-style-type: none"> Guarantee ground and power pins mate with the back plane before signal pins 	<ul style="list-style-type: none"> In-rush current protection Power-up sequence control
Disadvantage		<ul style="list-style-type: none"> May not work for multi-voltage systems Require careful on-board power distribution 	<ul style="list-style-type: none"> Additional external device is required More board space Contradicts with the pin mating sequence requirement Additional cost May not guarantee PLD I/O buffers hot-socketing capability

Conclusion

Altera devices offer on-chip hot socketing and power sequence protection to meet the demands for high system availability and to resolve the issues in multi-voltage systems. Altera's Stratix II, Stratix, Stratix GX, and Cyclone FPGA families and MAX 7000AE and MAX 3000A CPLDs are designed and tested to support hot socketing.

The detailed report on characterization setup, procedures and results can be found in the Hot-Socketing & Power-Sequencing Feature & Testing for Altera Devices White Paper.



101 Innovation Drive
San Jose, CA 95134
(408) 544-7000
<http://www.altera.com>

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