Hot-Plug and Hot-Swap Bus Switches

Design guidlines and suitability of hot-plug & hot-swap applications using Pericom Bus Switches

By Paul Li

Pericom provides the broadest and fastest switch family. Pericom switches have been designed in many hot plug and hot swap applications. This application note will discuss the suitability of using different switch types for hot plug and hot swap applications and will supply design guidelines.

*Definitions:

Hot-Plug: Indicates that the hot-plug connectors on the back plane are turned off by the switches on the back plane during the card hot insertion into the connectors while the system is running. The Pericom switches for hot-plug applications are deployed on the back plane between the bus devices and the hot-plug connectors on the back plane and are turned off during hot-plug. The cards for hot-plug are generic without special circuit for hot-insertion.

Hot-Swap: Indicates that the connectors on the back plane are alive with signal and power during hot-swap and the hot-swap card should tolerate the impact from the signal and power during hot-swap. The PI3Cxxx and PI5Cxxx switches for hot-swap application are deployed on the hot-swap card between the connector and the devices and should tolerate the impact from hot-swap without clamp or distort the signal from back plane. The back plane for hot-swap is generic without special circuit for hot-insertion.

The terminology of hot plug and hot swap described above are the industry standards. Please refer to the PCI standards "Compact PCI Hot Swap Specification R1.0" and "PCI Hot-Plug specification R1.0" for details.

The table below lists the types of Pericom switches and their suitability for hot insertion application.

Switch Type	Part Number	Suitability for Hot-Plug*	Suitability for Hot-Swap*
NMOS switch and voltage translators	PI5Cxxx, PI3VTxxx	Yes	Yes
NMOS with a charge pump at gate	PI3Cxxx	Yes	Yes
CMOS switch	PI2Bxxx, PI3Bxxx	Yes	Yes, but in a restricted condition
The switch with an internal PMOS pull-up at B-side	PI3Bxxx	Yes	No
Analog switch	PI5Axxx, PSxxx, PI5Vxxx	No	No

Three typical switch types

There are three typical switch types, the NMOS, the NMOS with charge pump on the gate, and the CMOS (NMOS || PMOS). The following section will describe these switch types.

1) The NMOS Switch

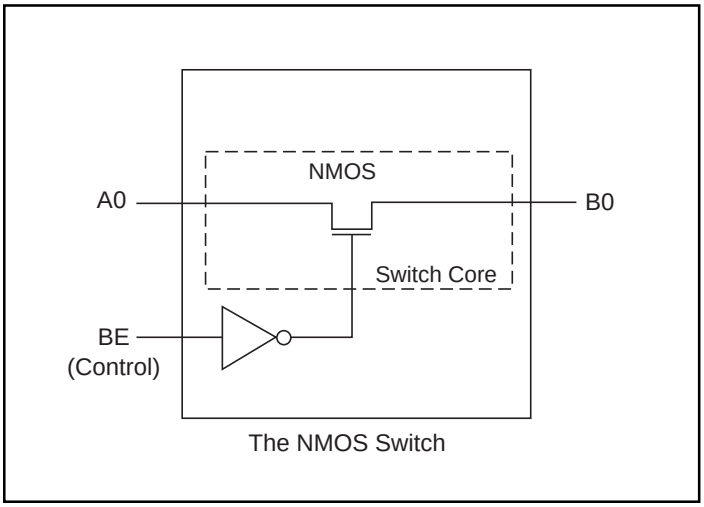

Figure 1. The switch core of a NMOS switch is a simple NMOS transistor

The advantages of NMOS switch

- Fast switching time, 1.5ns typical.
- Low power consumption, less than 10uA at quiescent mode.
- Low C-off and C-on.
- Suitable for hot-plug and hot-swap applications.

The disadvantages of NMOS switch

- The NMOS switch clamps the output voltage below 4.0V if the input was above 4V at 5V V_{CC} and 1.0V threshold of the NMOS.
- The NMOS switch can only use 5 volt V_{CC}, because at lower V_{CC}, the output voltage is clamped too low.

The threshold of the NMOS switch core causes voltage clamping (V_clamp) of the switch output:

V_clamp = V_{CC} – V_threshold

Where:

V_{CC}: the power supplied to the switch, it is also applied to the gate of the NMOS switch.

V_threshold: the threshold of the NMOS switch core.

V_clamp: The switch output clamping voltage, it is also called the V_pass or V_out.

If the switch input voltage is below V_clamp, the switch will pass through the full voltage range of the input without clamping. If the input voltage is higher than V_clamp, the switch will clamp the output voltage at V_clamp.

Pericom PI5Cxxx switches use a NMOS switch core; they are suitable for hot-swap and hot-plug applications.

2. The NMOS switch with a charge pump on the gate

The purpose of the charge pump at the gate of the NMOS switch core is to increase the voltage at the gate in order to avoid the output voltage clamp caused by the threshold.

Advantages of NMOS switch with a charge pump on the gate

- Wider Vcc range
- Rail to rail output voltage without clamp
- Low C-off and C-on
- Suitable for hot plug and hot swap applications

Disadvantages of NMOS switch with a charge pump

- The power consumption is slightly higher, 260µA typical
- Switching time is slightly slower than NMOS and CMOS switches

Pericom's PI3CXXX switches use an NMOS switch core with a charge pump on the gate of the NMOS; they are suitable for hot-swap and hot-plug applications.

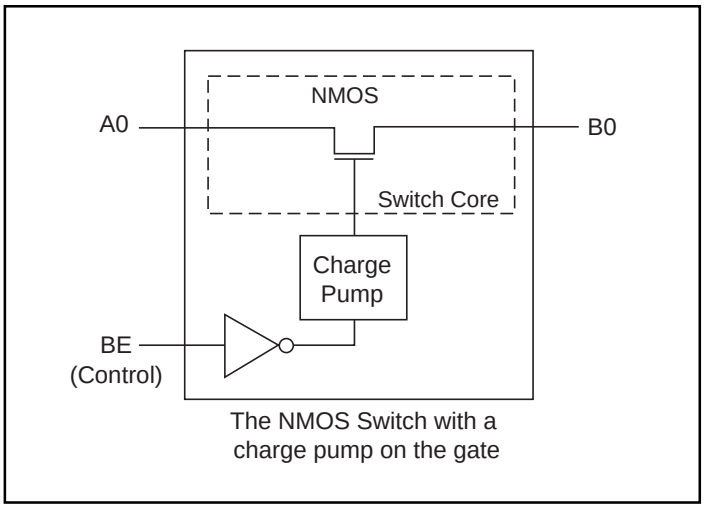

Figure 2. NMOS Switch with Charge Pump on Gate

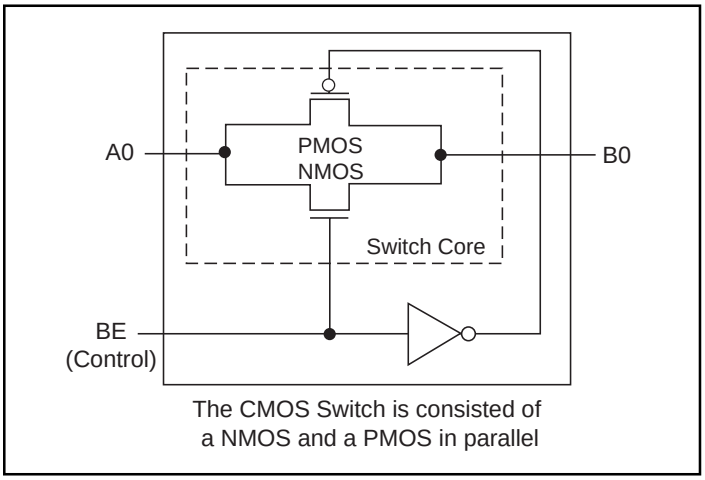

Figure 3. The CMOS Switch

3. The CMOS Switch

The CMOS switch core consists of a NMOS and a PMOS transistor in parallel. The NMOS and PMOS transistors are mirrors to each other. When the CMOS switch is set "on", the voltage at the gate of NMOS is equal to V_{CC}, and the gate of PMOS is 0V.

When the voltage of the CMOS switch input is rising up and reaching the threshold of NMOS switch, the NMOS switch is turning off, while the PMOS switch is getting more conductive (vice-versa for the falling edge). Thus, the CMOS switch will pass through the full range of the input voltage without clamping.

The Advantages of CMOS switch

- Wider V_{CC} range
- Rail-to-rail output voltage without clamp
- The power consumption is low, 10µA typical
- Fast switching time

The Disadvantages of CMOS switch

- Higher C-off and C-on.
- Not suitable for hot-swap unless designed with special circuits.

Why is the CMOS Switch not suitable for hot-insertion applications?

During hot-inserting, when a signal from the back plane is applied to the input of the CMOS switch, the voltage applied to the V_{CC} pin is 0V. This is due to the power delay caused by the bypass capacitance. Thus, during hot insertion, the PN junction of the PMOS in the switch will forward the signal from the back plane to ground through the V_{CC} pin.

Pericom PI3Bxxx family of switches use CMOS switch cores and are suitable for hot-plug applications. The PI3Bxxx family has a special circuit for restricted hot-swap applications.

Please contact Pericom's Application group for restrictions involved in designing a hot-swap application using Pericom's PI3Bxxx switch family.

Why use Pericom switches for hot-insertion applications?

Many chip sets are not suitable for hot-plug and hot-swap applications and are also expensive. Pericom switches are used in these hot-plug and hot-swap applications as buffers or "fuses" to take the impact from hot-insertion and protect vital and expensive chip sets from damage. See Figure 4 below for a hot-swap application using Pericom switches.

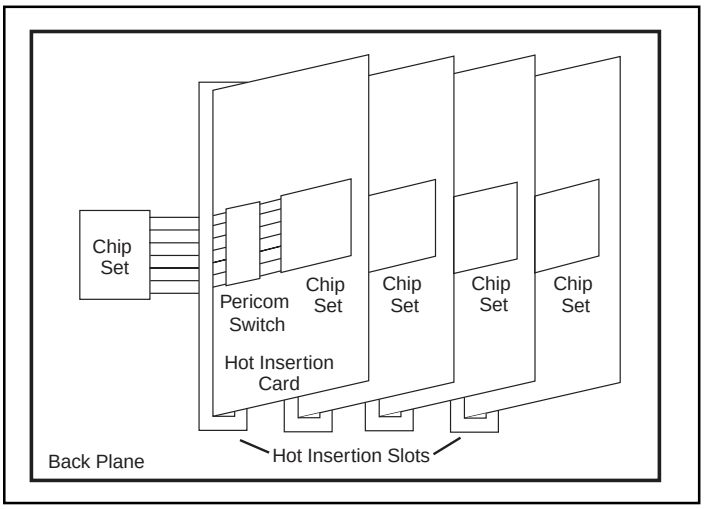

Figure 4. Hot-Swap Application using Pericom Switches

The design guideline for hot insertion application using switch

1. There is a major request for hot swap design**:** during hot swap, the ground pin of the hot-swap card must connect to the ground pin of the back plane **before** any other signal or power pins. This is the main request for hot insertion. It is the industry standard for the hot insertion applications of both logic and switch devices. Otherwise, when hot swap, the voltage of the power and signal at the connector will go wild due to lack of ground reference and could burn the switch.

2. When using PI3CXXX and PI5CXXX switches for hot insertion application, for the switches with control pins /BE, it is suggested to connect the /BE pins to the logic "high" from the back plane during hot insertion. This will minimize the glitch leaked from back plane to the card.

3. Pericom PI3CXXX and PI5CXXX switches are suitable for hot plug and hot swap applications. Pericom PI3BXXX switches are suitable for hot plug application and are designed with special circuit for restricted hot swap applications. Please contact Pericom application group for restrictions involving designing a hot swap application using Pericom's PI3BXXX switch family.

4. The PI3CXXX, PI3BXXX and PI5CXXX switches with an internal PMOS pull-up resistor at B-side (see figure 5) are only suitable for hot plug but not for hot swap application. During hot swap, the PN junction of the PMOS pull-up will forward the signal from back plane through BIASV pin to the ground, while the voltage at BIASV pin

is 0V due to the power delay caused by the bypass capacitance on the card.

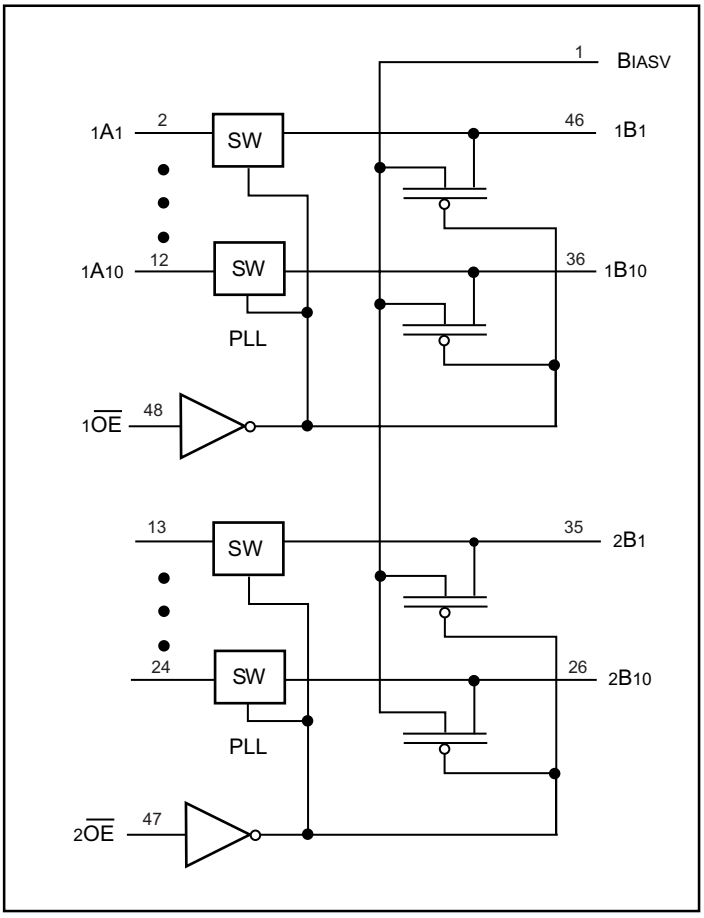

Figure 5.