Pericom FCT Logic for Hot-Plug Applications

Introduction

"Hot-Plug" and "Live Insertion" are both terms that apply to the technique of adding or removing modular components from a system while power is applied and the system is fully or partially operational.

These systems might typically be a complex computer system used for airline ticket reservations, or for a large department store where even short periods of down-time can result in thousands or even millions of dollars of lost business and good will.

Another typical "Hot-Plug" system might easily be found in a hospital where, although not used directly for life-support, a badly timed (or lengthy) computer failure can seriously delay the movement of critical information necessary for both health maintenance as well as for billing and insurance management.

One growing application that needs hot plug capability is portable computers, where deck insertion and removal from a docking station and the insertion and removal of PCMCIA cards often occur while power is applied.

Pericom Semiconductor's family of FCT, fast TLL-compatible CMOS logic, when used in conjunction with good design practices can allow dynamic removal and insertion of subsystem modules while the power is on and the system is operation.

The Working Environment

Typically, hot-plug modules or cards are connected to a system through a live backplane. In some instances, a disabled or powered-down section of an existing board may be activated and subsequently enabled onto an internal system bus. Both of these instances require similiar design considerations.

When designing a system with hot-plug capabilities, two main issues come to light:

- Uninterrupted system operation
- Protection of all devices during the insertion or removal operation

The management of system operations begins with the impact of the module that is being added or removed. Adding new functionality to an existing system (expanding communications, adding additional processors or memory, etc.) usually depends on the ability of the system to integrate the new devices on-the-fly, assuming that the process of adding the new module is clean.

In this application, (as well as during re-insertion of a repaired or replaced module), the key issue is how to ensure the addition of the module does not create undesirable electrical conditions that may upset the operation of the operating bus. Transient isolation and suppression during the insertion process, as well as during the power-up of the module is critical.

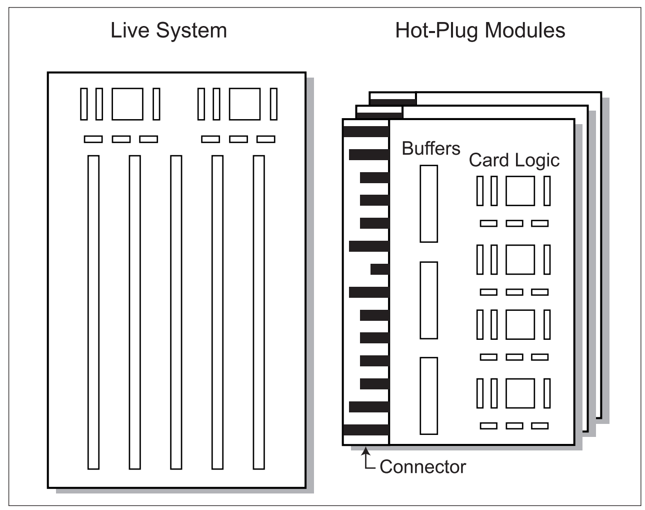

Figure 1. A Bus-Based System with Hot Plug Modules

The second issue concerns protection of both the new circuit components as they power up as well as existing live components. In this situation, the design of the plug-in module, the target host, and the connectors plays a very important role. Although power sequencing has traditionally been the main concern, power-on reset, power-on preset to known conditions, controlled output enables, controlled PCB trace length, device input and output structure design, per-pin and total capacitive load, host power supply characteristics, module power consumption and bypass design, low power detection and valid power detection as well as ESD protection (and more) all play a vital role in the overall design.

The following paragraphs will discuss how Pericom FCT devices can be successfully used as an interface between a host system and a hot-plug module as well as some important related design considerations.

Basic Design Considerations in Hot-Plug Systems

Connectors

When adding a module into a running system, the connecting mechanism must be designed to provide quick and solid electrical connection for the ground, power, and signal lines. It is mandatory that the ground lines be connected as early as possible followed by the signal lines. It is a well understood phenomena that connecting signal lines or VCC lines to a circuit with an unstable ground can result in device damage as well as unpredictable system-level current surges. These current surges may adversely affect system operation. The ground and then the signal lines must be solidly connected before applying VCC. Staggered connector pins and spring-loaded insertion devices are two ways of providing predictable connections.

When using staggered card-edge connector pins, it is important to keep in mind that even with good card guides, it is possible to insert one side of the connector before the other side. This can defeat a card edge connector sequencing that presumes that the insertion is going to be flat and uniform. To minimize the effects of this situation, use extended ground pins on both edges, slightly shorter pins with the output enables and other control signals, and the shortest pins for power in the middle of the connector.

Capacitance

When a hot-plug card is connected to a bus structure, an additional load is applied to the system signal lines. One major effect of this additional load on the target bus is caused by the instantaneous charge redistribution between the system's bus capacitance and the capacitance of the added load. In general, a card used for hot-plug application should have a minimum number of loads connected to the bus signal lines, preferably only one device pin per signal. In addition, the device placement and trace layout of such a board must be designed to minimize trace length between the card edge or the card's connector to the board's components. This will help to minimize the capacitive load connected to the bus. Additional capacitive loads of 5pF up to 20pF will typically have no discernible effect on active signal levels of a bus driven by FCT devices. For an internal bus with weak drivers, pay close attention to the drive characteristics of the devices used and their susceptibility to the addition of capacitive loads while operational. Often, experimentation may be required.

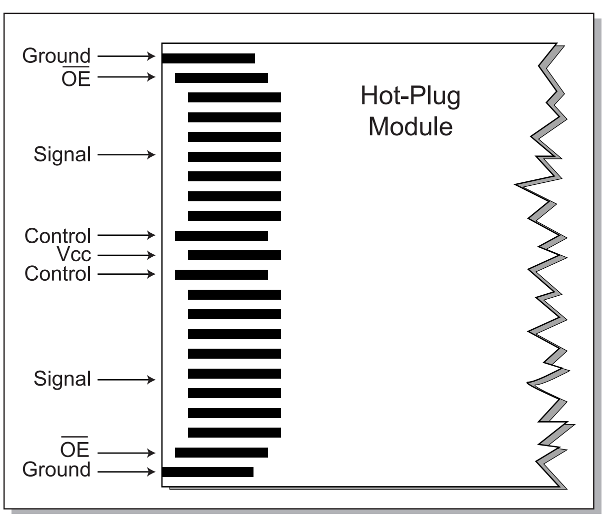

Figure 2. Staggered Finger Arrangement for Hot-Plug Applications

Enables

Logic on the hot-plug card must be designed to disable all output signals going off board while power up is taking place. Once the card has stable power, card logic or the host system may then enable I/Os onto the system bus. Often pull-up (or pull-down) resistors are added to these lines to force them to known states during uncontrolled conditions. This solution has some problems which are addressed later in this paper.

Pericom FCT Input and Output Structures

Signal pins connected to the host bus at the card-edge may be inputs, outputs, or tri-state I/Os. The input structure of a typical FCT device will be reviewed first.

Input Structures

All FCT logic input (and output) structures have industry-standard (2000 volt) ESD protection circuits. All devices have input clamp diodes to ground, and most have hysteresis circuitry. Unlike many TTL devices, Pericom's FCT does not have a clamp diode to VCC.

This lack of a VCC clamp diode is very important for hot-plug applications because it limits the input voltage to the VCC level existing on the device's VCC pin. If the VCC pin is at ground, then the VCC clamp diode shunts the input pin to ground. This is a real problem for an active system! With Pericom's FCT logic, the inputs (and outputs and control lines) can tolerate levels up to 7V, regardless of the VCC level.

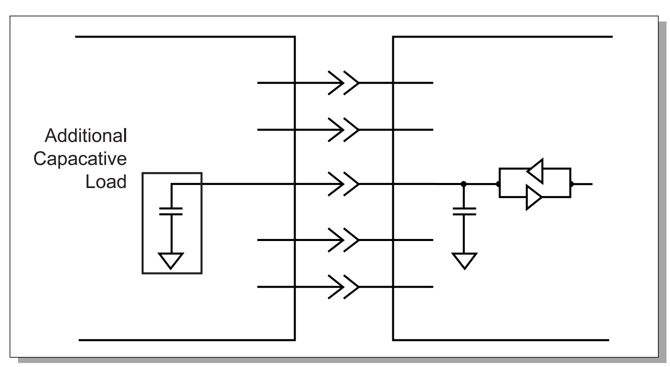

Figure 3. Adding Capacitive Load to the System

Output Structures

Traditional CMOS Logic

Some CMOS logic families have an output structure consisting of an N channel between the output ground and the P Channel transistor from VCC to the output pin. The P-channel transistor creates an inherent diode from the output pin to VCC. As a result, when the output is not driven by the device (disabled) or when the VCC pin at any level below the level seen on the pin, the signal is effectively "clamped" to VCC. Again, this means in hot plug operation such devices will temporarily short some system signals to ground.

Pericom's 5V FCT TTL Compatible CMOS Logic

Pericom's FCT output stage is made up of only N-channel transistors between the output and VCC and ground (Figure 5). This structure isolates the output pin when disabled so that the host system can drive normal logic swings regardless of the VCC supply to the output stage. This allows designers to connect the I/Os of an unpowered FCT device to an active bus without worrying about the integrity of the FCT devices or impacting the active logic state of the bus. Pericom FCT logic typically has about 5pF or 6pF of capacitance per pin, so the insertion is accomplished with minimum trauma.

Hot-Plug Implementation Scenarios

Figure 6 depicts a simple circuit that can be used to disable the hot-plug card I/Os during power-up as well as to allow the hot-plug card's logic to enable/disable the buffers during normal operation. The use of a pull-up resistor guarantees that the $\overline{OE}$ line will follow VCC, thus keeping the FCT I/Os disabled. Once the system has power, a logic low on the $\overline{OE}$ signal will enable the I/Os onto the bus. The enable signal can also be sourced from the host system, allowing the module to be enabled when the system desires.

Special care must be exercised in choosing the value of the pull-up resistor. A resistor with a value of a few hundred ohms will provide a solid disable function even if VCC ramps up in less than 100ns. The disadvantage of a small resistor value is the power dissipation through it when the $\overline{OE}$ is driven low.

The main item of concern with high resistor value is that the $\overline{OE}$ will "lag" in time behind VCC, especially if the VCC ramps up quickly. Here, the outputs may be partially or fully enabled accidentally when power is ramping up. This is obviously unacceptable for a hot plug system.

Related Application Brief:
FCT vs. ABT Logic Comparison (Brief Number 1)

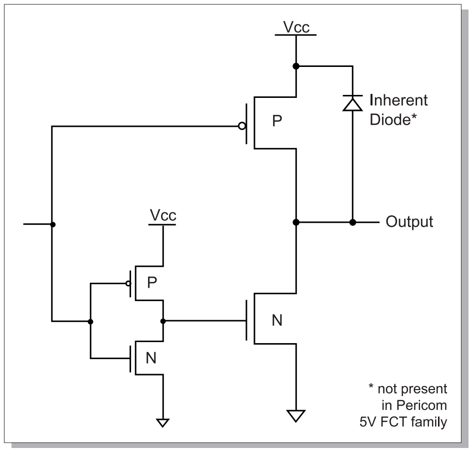

Figure 4. Output Stage with N-P Structure used in LPT Logic Family

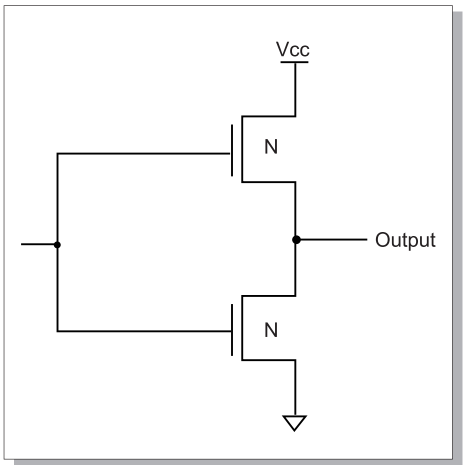

Figure 5. N-N Output Stage Structure

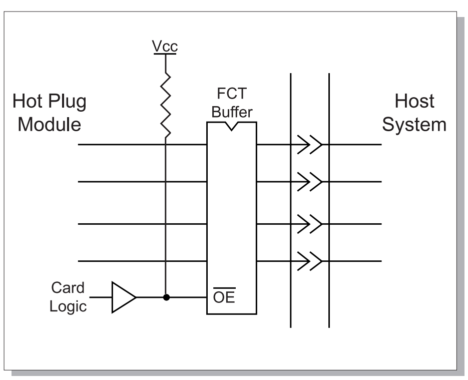

Figure 6. Simple Output Enable Control Circuit for Hot-Plug Applications