Bridging from PCI Express® to PCI in Small-Form Factor Embedded Computing Designs

8000000_WP009_02

September 22, 2009

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Printed in U.S.A.

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The introduction of chipsets such as the Intel Atom chipset have opened the door for computing systems that can fit into mobile computing devices or small form factor boards such as COM Express and ExpressCard. While chipsets such as the Atom offer a compact, low power solution they do not provide a PCI interface. For devices that need to interface to external PCI slots or interface to peripherals using PCI, a bridge is required. This article examines requirements for such designs and explores the need for a bridge, the challenges designers face in these form-factors (board space, component count, performance, interoperability and cost) and solutions to meet these challenges.

Solutions discussed include minimizing board area use by designing in small package devices, minimizing the components required by selecting a bridge that integrates needed features and simplifies such design requirements as multiple power supplies and power sequencing constraints. Additionally solutions will be discussed addressing challenges to reduce board cost, complexity, performance needs and compatibility with new and future devices.

Mobile and embedded computing is prevalent both in consumer products and in a wide range of industrial computing applications. Many consumers' PC of choice today is a laptop and smaller portable devices such as mobile internet devices (MID) or Ultra-Mobile PCs (UMPC) are becoming increasingly common. Mobile and embedded computing are also extensively used in industrial, government and military applications – for example rugged laptops or tablet PCs that need to be carried to the work site or on-board computers in a vehicle for security or tracking systems.

Varied applications have a wide range of requirements, the most important of which are: reduce size and complexity; simplify design; improve reliability and reduce cost. In many cases the main challenge is to simply fit the electronics in the space available while providing the needed computing power.

To meet these requirements and make it easier for system manufacturers and component providers to build systems, a number of standard form factors have been introduced. These include Mini-ITX and COM Express (Computeron-module for PCI Express) and adapter cards standards such as ExpressCard (the successor to PCMCIA PC Card). Consequently, processor vendors are releasing new devices to fit designs in these form factors, such as the recently introduced Intel Atom and EP80579 SoC. The Atom is a low-power, small footprint processor. When used with companion chipsets such as the US15W ICH, the Atom provides a computing platform that fits small form factors such as COM Express. The EP80579 is a processor SoC that integrates more components and by doing so helps address the needs to reduce system size and complexity.

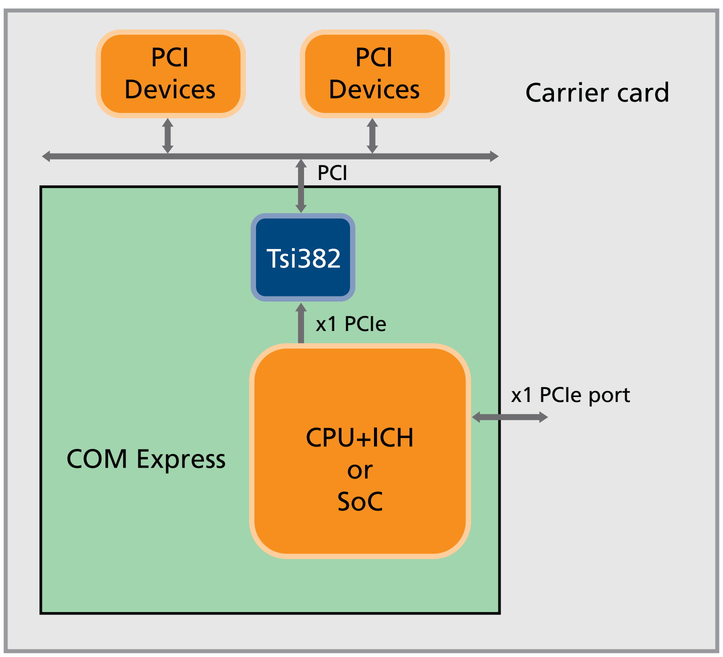
However, these processors do not integrate all of the peripheral devices for every application. Designers may have to choose external components such as graphics controllers, I/O devices for specific standards, media controllers for removable storage or wireless chipsets.

Using the example of the Intel Atom and US15W chipset: Serial PCI Express (PCIe) and USB interfaces are provided. This helps reduce pin-count compared to a parallel PCI interface. Many devices that would commonly be integrated into a system are available with PCIe or USB interfaces; however designers may still be faced with the task of providing a connection to a conventional parallel PCI bus for a number of reasons:

- The devices chosen are only manufactured with a PCI interface
- The developer may be already using a device with a PCI bus: for example an I/O controller ASIC. The cost to redevelop for PCI Express or the timescale involved may preclude this and require designers to use the PCI-based solution
- System designers may find an older component using PCI may be more cost-effective to use than a newer PCI Express-based offering and faster to bring to market
- The developer of a module such as COM Express may need to provide a PCI port off the module while other design factors drove them to select a chipset with no PCI port available

In all of these situations a PCI Express to PCI Bridge is required. An example of such a bridge is the IDT Tsi382™, a small form-factor x1 PCI Express to PCI Bridge (see Figure 1).

Figure 1: Example of COM Express Card Using a Bridge to Provide PCI Connectivity

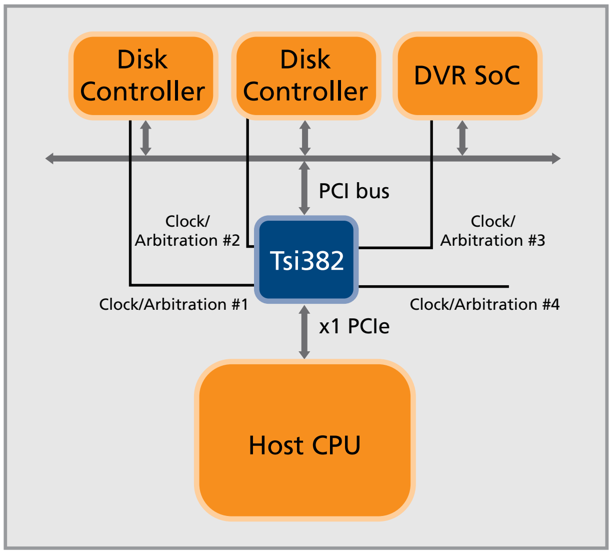


For small form-factor designs the board space occupied by the bridge is often an issue as it is another component to accommodate. Where space is critical the most obvious solution is to use the smallest device available. For example the Tsi382 uses a 10x10mm BGA package – providing the smallest footprint available for such bridges. Ideally parts in a BGA package should keep to a wide enough ball-spacing to allow the use of common manufacturing flows and make it easier to hook up and route signals away from the part. The Tsi382 uses a standard 0.8mm spacing which suits many common manufacturing flows and allows building a system on a PCB with as little as four layers.

To further minimize the space the bridge takes up, the external components required also need to be minimized. PCI devices typically use a 3.3V I/O voltage and a bridge will also require a supply for powering the core logic. If a bridge is used that requires power supplies to be powered up in a specific sequence, this may require additional components. By using a bridge such as the Tsi382 which uses only 2 power rails and that has no constraints on power sequencing, the component count can be minimized.

The other design factor to consider, particularly where the bridge needs to provide access to multiple PCI devices is providing enough timing and control signals from the bridge. A bridge should provide sufficient clocks and control signals for all PCI devices, saving the need to add external clock buffers and logic to support them (see Figure 2).

Figure 2: Example of Embedded DVR System with Multiple PCI Devices



Once the space challenges are met, the designer must also consider other factors such as throughput and latency through the bridge, so that by adding the bridge, system performance is not adversely affected. For example, the Tsi382 provides designers a number of unique features such as short-term caching that can help improve PCI performance along with an efficient design that reduces latency and provides high throughput.

For devices that need to plug into a wide range of systems such as PC adapter or COM Express cards interoperability is critical. The end user of a device could connect one of those components to a wide range of devices (e.g. new motherboard using a new chip set), so it is important that interfacing components are compliant to the latest specification. For PCIe bridging with first generation devices this is PCIe base specification 1.1. The Tsi382 provides compliance with PCIe base specification 1.1 and future proofs designs, providing interoperability with existing and new devices.

Many new products for mobile and embedded computing using processors such as the Intel Atom will require bridges to accommodate PCI devices in many designs. It is important to select a bridge that integrates needed features and simplifies such design requirements as multiple power supplies and power sequencing constraints. As the smallest footprint, high performance solution, the IDT Tsi382 addresses the challenge to reduce board cost, complexity, performance needs and compatibility with new and future devices making it an ideal choice to bring these embedded and mobile computing solutions to market.