ATA I/O

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Abstract

Contemporary personal computers lack interfaces suited to attach application-specific hardware the simple way. It has been investigated to use the ATA interface for this purpose. In contemporary PCs, ATA is the last remaining low-latency interface providing a straightforward hardware/software API. Besides the obvious application of using up legacy hardware, it is especially compellingto apply such adapters together with miniaturized motherboards of the commercial high-volume market, such as Mini-ITX, Nano-ITX, and Pico-ITX. Supporting Serial ATA (SATA) will be the next logical step.

Interfacing PC hardware to real-world applications

When personal computer (PC) systems are to be used within embedded systems, it is necessary to select appropriate interfaces for attaching the application-specific hardware. The basic requirements are obvious:

- Adapter hardware easily to develop.
- Software easily to develop.
- Low cost of ownership (cheap hardware, affordable development and driver software, no licence fees, no costly certifications).
- Low latencies.
- Long-term availability.

The legacy interfaces of the past were comparatively well suited to these requirements. But many contemporary PCs have no legacy interface at all. PC hardware in “industrial“ form factors (like PC/104 or PICMG) supports those interfaces, but is quite expensive. Modern PC interfaces have been designed mainly with multimedia and gaming applications and with ease of use in mind (extreme data rates, supporting of continuous data streams, dynamic attach/deattach) To exploit these interfaces for connecting application-specific hardware poses some special problems, like long latencies, tough development problems, and cost.

Exploiting the ATA interface – a low-cost alternative

One legacy interface boasting low latencies and high data rates can be found even on the most contemporary motherboards – the ATA interface. ATA is still the mainstream drive interface, so long-term availability could be taken for granted. The most compelling advantage: simplicity. The legacy ATA interface (Parallel ATA) is essentially a modified ISA bus. Hence it should be easy to develop I/O adapter hardware. The hardware/software API is straightforward – a small register file accessible by IO instructions. Serial ATA (SATA) is principally nothing more than two wire pairs to push around register contents between the host adapter and the attached device. Because ATA is essential for booting the system, appropriate support is deeply embedded within the BIOS and the operating systems. Parallel ATA is still supported on new motherboards in small form factors (like Mini-ITX or Nano-ITX), particularly because it is still a mainstream interface for optical drives. Employing ATA as a low-latency embedded interface allows to apply such motherboards instead of typical industrial platforms (like PC/104, EBX, EPIC or PICMG) which are considerably more expensive (Fig. 1 shows an example).

Typical ATA I/O adapters will fit into small CPLDs. Eventually, the application-specific circuitry could find its place within the same CPLD, too (see Fig. 2a). ATA interface adapters can be provided for attachment of widely available I/O hardware, like Opto 22 compatible racks, ISA or PCI I/O cards, and PC/104 modules (as shown in Fig. 2b).

Fig. 1. A low-cost industrial PC based on a Mini-ITX motherboard. 1 - CPLD containing the ATA i/O adapter circuitry; 2 - interface connector; 3 - diagnostic LEDs; 4 - front-panel I/O attachment.

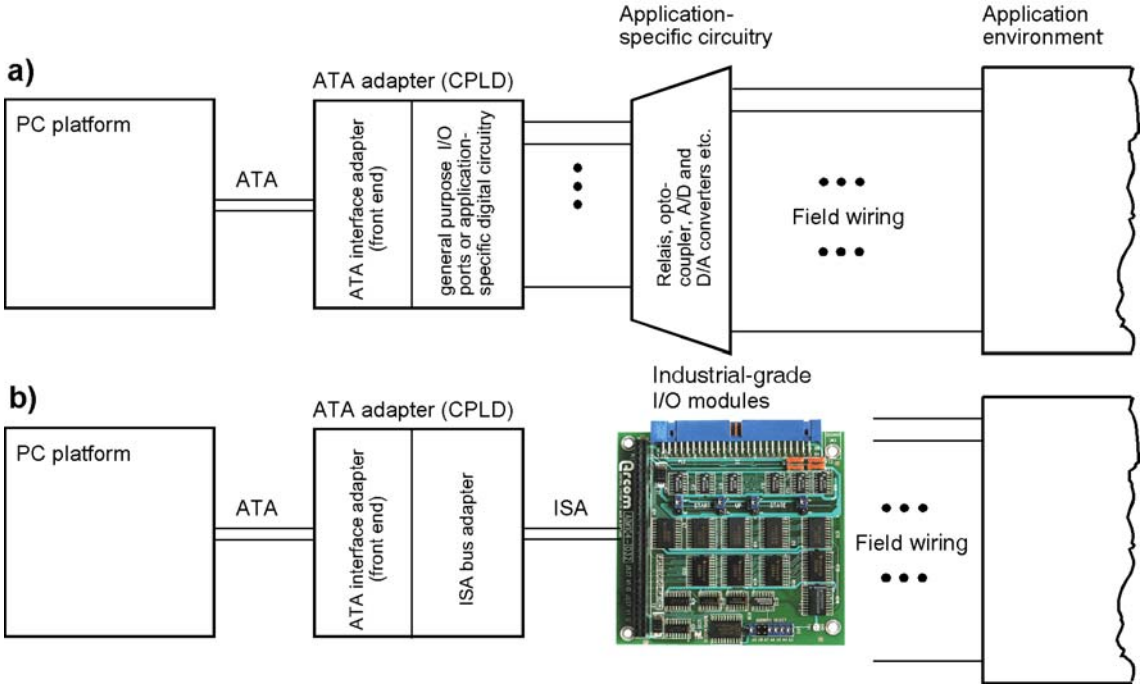

Fig. 2. Typical ATA interface adapter applications. a) The ATA I/O adapter CPLD contains all the necessary digital circuitry (application-specific). b) The ATA I/O adapter CPLD emulates an industry standard interface, so that readily available I/O hardware (PC/104 modules, industrial-grade ISA cards, PCI cards and the like) can be supported by up-to-date low-cost PC platforms based on cheap motherboards (like Mini-ITX).

Reference designs

Based on Xilinx XC9500 CPLDs, some ATA IO adapters have been designed and tested intensively. Porting to other families of programmable ICs should pose no difficulties. The four designs mentioned below fit into Xilinx XC95108 CPLDs, for example. Expect more to come ([6]).

1. Five Universal I/O ports. The I/O ports are similar to the typical I/O ports of well-known microcontroller families (Microchip PIC, Atmel AVR and the like). Under program control, each of the 5 • 8 = 40 I/O lines can be used as an input or as an output.

2. 8255 Emulation. This circuit behaves like an 8255 in mode 0. In addition to the three 8255 I/O ports, two universal ports as described above are provided.

3. ISA interface emulation. The purpose of this circuit is to support ISA I/O cards and, above all, PC/104 I/O modules. Hence the ISA emulation could be restricted to 8-bit I/O cycles and to the support of ISA interrupts.

4. Parallel port emulation. This circuit behaves like an IEEE 1284 Standard Printer Port (SPP) with optional support of the bidirectional (PS/2) mode. In addition to the 17 signal lines of the parallel port, two universal ports as described above are provided.

Related software

ATA interface adapters are to be programmed like the I/O ports of microcontrollers. Under Linux, DOS or in stand-alone programs, ATA I/O hardware can be accessed directly by I/O instructions. It could be not more simple (especially when compared to attempts to program a USB host adapter without system-provided APIs). In Windows, programming via simple port drivers will lead to the usual latencies – like the well-known I/O programming of the parallel port. In this respect, ATA I/O could be seen as a substitute for the good old parallel port which is lacking on nearly all contemporary commercial grade motherboards (at least in small form factors).

References:

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[6] Internet: http://www.controllersandpcs.de/ataio.