New Challenges, New Opportunities, New Frontiers

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Since their introduction in 1991, the PC/104 standard based systems have been widely adopted in various applications, on transport, in industrial control and in defense systems. Unmanned aircraft control, on-board vehicle control and navigation systems, personal communicators, add-on cardsfor customer specific boards – all this makes far from the full listof the most popular PC/104 based products applications. Many system developers choose this form-factor due to its advantages, as low weight,compact size, ease of application development and modification, mechanical reliability of both connectors and the whole system.

To achieve the highest reliability, best flexibility and performance characteristics of a system, developers can use a number of standard of-the-shelf boards available from many manufacturers. PC/104 board manufacturers consortium established 14 years ago unites 78 manufacturers allover the world now specializing on development of various products forPC/104 standard.

According to the Electronics Trend Publications data, the global PC/104 boards market amounts to around 170 millionUS dollars per year. Statistics shows, the largest volumes of produced PC/104 boards are used in industrial and in defense systems, 50% and20% respectively. Functionally PC/104 boards are divided into two, practically identical by the sales volume segments: CPU (or processor) boards and input-output boards.

As the reliability of the wholesystem depends on the reliability of its components directly, the system development and selection of each component should be done thoroughly and with great care to details.

Customers' demand for functionality and reliability of PC/104 systems very often require additional efforts from boards developers and specific engineering solutions for their realization. Below we will discuss main solutions that bring more processing power, improve reliability, widen operational temperature range and, therefore, expand the PC/104 products application area.Also, we are going to draw your attention to some novelties.

Extreme Temperatures and Computing Performance
Many applications require PC/104 system's operability within a wide temperature range that often exceeds the operating range provided for the components by its manufacturers.

To considerably increase reliability and to widenoperating temperature range, one can choose a more robust version of acertain component type; for example, use tantalum capacitors insteadof wet foil electrolytic ones. There is no such opportunity for othercomponents, such as high performance CPUs, chipsets, and memory. Therefore, when developing a board for tough operating conditions, the keytasks are thermal effects analysis, building the board in the way to provide its operability even in worst working conditions, and, finally,thoroughly and comprehensively test the product within the whole operating temperature range at the stage of outgoing inspection.

Due to the boards' small size and far from ideal heat dissipation conditions inside the closed cabinet, special attention should be paid to the thermal stability and functionality not only at low operating temperatures, but especially at high ambient temperatures.

Forced air -cooling is not always acceptable in these systems because of their very compact size and hence ineffectiveness of air cooling, as well as due to low durability of cooling fans compared to the one processor boards have. For instance, MTBF of an average fan does not exceed 20,000hours only, but PC/104 processor board itself should have MTBF well exceeding 100,000 hours.

In their effort to cope with low heat dissipation capability of PC/104 systems many processor board manufacturers use low heat emitting CPUs, such as Pentium III operating at 300…600 MHz with reduced power consumption. However, these processors haverelatively low performance comparing to what is needed for modern applications. Moreover, Intel recently announced the phase out of ultra low voltage Pentium III processors, so it is risky to count on what is left on suppliers' stocks.

It is more reasonable to use low voltage versions of Intel Pentium M family processors. These CPUs are manufactured using special technology and have almost double advantage infrequency-to-TDP ratio compared to their congeners.

Even though developers selected a low thermal power processor for their application, they still have to solve the task of heat dissipation from CPU and GMCH. Only few companies in the world offer PC/104 Plus processor boards with CPUs 1GHz and up. They use various solutions for heat dissipation like heat pipes, low profile fans and some others.

According to the common practice used by all PC/104 processor boards manufacturers, the CPU is located on the PCI and ISA connectors' side. These connectors and the expansion board placed on top of computing one prevent effective heat dissipation from CPU. It is done differently at Fastwel PC/104 Plus processor boards. They are designed to be either the top or the bottom one in the stack of PC/104 Plus cards and the CPUitself is placed on the opposite side of the PC/104 Plus connector. Thus, the task of heat sinking is significantly simplified since everyone can use the opportunity of drawing heat from the CPU and GMCH chip via a heat conductive plate. In such case the contact area is much bigger and the overall resistance for heat transmission is much lower thanin those boards where heat pipes are used to bring the heat power along the board surface to the sides of PC/104 enclosure. Provision of alow heat-resistance thermal bridge between CPU and system chassis allows using of the whole PC/104 cabinet as a large heatsink.

Thissolution gives advantages in size, weight, price and overall system design. It also allows to use high performance

processors operating atfrequencies of up to 2 GHz with 533 MHz front side bus. For applications with high data exchange between CPU, memory and I/O the limitationin the system bus can be crucial; that is why the system bus frequencyincrease from 400 to 533 MHz can give a 30% benefit in certain systemperformance

Shock, Vibration and Harsh Environment Resistance
Systems used in transportation or industrial environment are very often exposed to permanent vibration load. In these applications,PC/104 architecture itself is a very good choice due to reliable fastening, small size and low weight of PCBs, as well as to PCI and ISA connectors reliability. However, for many applications there is never toomuch reliability. The most trivial way to increase reliability is soldering normally socketed components. The use of a soldered CPU is quite a routine technology, whereas soldering DRAM chips leads to parallelcircuitry routing, and requires addition of several conducting PCB layers. Moreover, soldered DRAM chips providing 1 GB of memory take about 15% of the PC/104-Plus board usable surface area. In overall – soldering of components considerably complicates design and manufacturing,but drastically improves shock and vibration resistance. For exampleFastwel's CPC1600 withstands vibration level right up to 5G within frequency range 10 to 500 Hz, whereas SBCs with SODIMM memory usually stand the tests at 2G.

There is one more "side effect" of having all the components soldered. Efficiency of additional damp-proof boardcoating increases while more components are soldered, bringing down the risk of short-circuit caused not only by the condensed moisture, butalso by salty mist, metallic particles or corrosion.

Expansion Interfaces and Data Input-Output
At the earliest stage PC/104 cards were equipped only with ISA connector for extension modules plugging. At that time the number "104" corresponded to the number of contacts between the connected modules. In 1997 the PC/104 consortium has approved new PC/104-Plus specification introducing an additional 120-contact connector provided for PCI interface extension modules. Unlike the PCI bus standard connector having 124 contacts, the PC/104-Plus PCIbus does not support 64-bit data transfer. A PC/104-Plus compatible systems are designed to support up to four extension cards via this bus. Maximum theoretic bandwidth of the PCI bus within the PC/104 architecture amounts to 132 MB/s, while the real throughput does not exceed 55 MB/s.

The main applications using PCI bus within PC/104 segment are: extension boards with Ethernet controllers, video capture modules, digital signal processing boards and other applications requiring high speed data exchange rate for the CPU.

However for manymodern applications the bandwidth capacity of the 32-bit PCI bus is not enough. For example, many graphics cards require 500 MB/s and even more. Video-encoding and recording tasks need more capacity. One channel MPEG-2 video compression solution using the Philips Semiconductors SAA6752 chip requires ~8 MB/s. Hence, ~5 video channels use the whole bandwidth capacity of the PCI bus. Another example - 32-bit PCI bus cannot provide enough bandwidth to implement full speed Gigabyte Ethernet interface.

The most bandwidth demanding applications can berealized by means of PCI Express bus. Being serial, PCI Express has acarrier frequency of 2.5 GHz and can provide up to 2.5 Gb/s per one x1 lane with option to combine lanes in various configurations like x4, x8 and x16.

PCI Express bus is now actively promoted by a number of companies led by Intel as a universal bus for interconnection of components within a board as well as modules within a computing system. Due to its flexibility and scalability, PCI Express bus is able tofit the system developers' requirements for up to the middle of the next decade.

In addition to the high throughput, among the advantages of PCI Express are: lower signal delay values; improved data burst transfer protocol and option to set processing priority for data packages (Quality-of-Service).

At the physical level one PCI Express channel is realized as two pairs of low voltage differential signal lines at 2.5 GHz. This feature brings significant advantage for size-constrained boards like PC/104. Less routing means less interconnectlayers in PCB and more space for additional components or interfacesplacement on the board.

This is why silicon manufacturers and embedded boards developers will switch to PCI Express technology, evenfor applications that do not require such high bandwidth of the bus. In summary PCI Express simplifies wiring and saves PCB space; this in return allows to reduce costs or to add functionality. Thus utilizing PCI-Express lanes available from the ICH (south bridge) Fastwel CPC1600has on-board GEthernet controller providing two full speed GEthernetchannels.

PCI Express can provide advantages not only for on-board data transfer, but for board-to-board connection as well. As an example, most of modern Intel server boards do not have PCI slots any more, most expansion boards shall work via PCI Express interfaces. Froma global perspective the move from PCI to PCI Express interface lookslike a logical step in overall shift from parallel interfaces to serial ones in the industry. Thus, USB is replacing LPT, and SATA is overcoming EIDE.

PICMG consortium developing standards for passive backplane embedded systems has recently announced several specifications in which the PCI bus is replaced by one or another serial bus, suchas PCI Express, Infiniband, RapidIO, and others. Therefore appearanceof a high-speed serial interface as a data exchange interface in popular PC/104 standard is natural and its appearance is just a matter of time.

The nearest "neighbor" to PC/104 standard, the EPIC standard (Single board computers manufactured according to EPIC standard can accommodate PC/104 modules through the same ISA and PCI connectors),has recently received the pre-released version of EPIC-Express specification. In this version of the EPIC-Express specification, PCI bus isreplaced by PCI Express bus with 4 (10 Gb/s – one bank of connectors)or 12 (three bank of connectors) PCI-Express lanes.

This solution is quite logical, because the bus used for data exchange (PCI) isreplaced by a faster one (PCI-Express), while a low speed ISA bus, traditionally used for simple I/O tasks and for signaling is kept unchanged.

This idea has inspired Fastwel developers to create CPC1700, the first PC/104 SBC with PCI Express bus. Actually, it is a modification of Fastwel's CPC1600 PC/104-Plus CPU board, in which the PCI connector is replaced by a four lane PCI-Express one, which can be set up as four x1 lanes or grouped as 1 x4 lanes.

Both EPIC-Expressand Fastwel's PC/104 Express computing boards are compatible with that majority of ISA based application cards developed by PC/104 consortium member companies and by myriad of designers who do their proprietary application boards with data transfer through ISA bus.

Thus,the embedded system developers can now use new compact boards equipped with high performance CPU and high-speed serial data exchange interfaces. Security video processing (downsteaming, encoding, packetizing and storing), image capturing and recognition in surveillance systems,target capturing and tracking in defense applications – just to name afew possible applications for such high performance computing boardslike CPC1600/1700 and boards to be manufactured according to EPIC-Express standard.

These new products open new horizons in development of modern high-performance solutions for robotics, security,transportation, avionics and defense systems.

In his current role Alexander Buravlev drives strategic sales opportunities for Fastwel. Before Fastwel Alexander worked for Intel Corp. developing projects and pushing sales of Intel IA-32, network processors and otherwireline and wireless silicons as well as system solutions in telecomunication and industrial market segments.

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