PC/104 OneBank™ - Small News

One new smaller Samtec® stackable connector gives the PC/104 Consortium® a giant leap upwards, downwards and fast forward

Longevity for anything electronics is difficult, as progress is often confused with fundamental changes and nowhere is this more apparent than in the Mobile phone industry where each generation of device is different in size and shape and in some cases in-compatible with previous peripherals and charging devices.

When Rick Lehrbaum and his Team of Electronics Board Designers/Engineers @ Ambro in 1987 was burning the candles in search of a way to create an modular form-factor of electronics boards that could be bespoken into anything the ever demanding Systems Engineers required and based on the dominance influence of the Personal Computer (PC) on a desk, I am sure at least one of them had been given Lego® bricks as a child, like me!. They would never have chosen to STACK the boards, rather than use the conventional concept of using a backplane to route the inter-module functions for the 8-bit ISA-PC Parallel Bus. It took another five (5) years for this idea to become the PC/104 ® and standardize by the 'chosen' twelve (12) Members of the PC/104 Consortium.

The following sixteen (16) years this initial concept of a stackable x86 Shared-Bus architecture was sufficient for the even the most demanding embedded solutions and is still – Year 2015 - widely used and supported by the PC/104 Consortium, but the good people of Intel had decided that 'Shared and Parallel Bus-system' (One day, I hope, they might understand that shared memory for MultiCore CPUs is not a good route either for building scalable systems) was not the future for connecting CPUs with I/O.

This was one of Intel's *"Apple iPhone Moments"* in the name of a major improvement and the PCI Express Lane is composed of two differential signaling pairs, with one pair for receiving data and the other for transmitting and totally NOT compatible with Parallel Bus and each lane is composed of four (4) wires. Keep that number in mind…

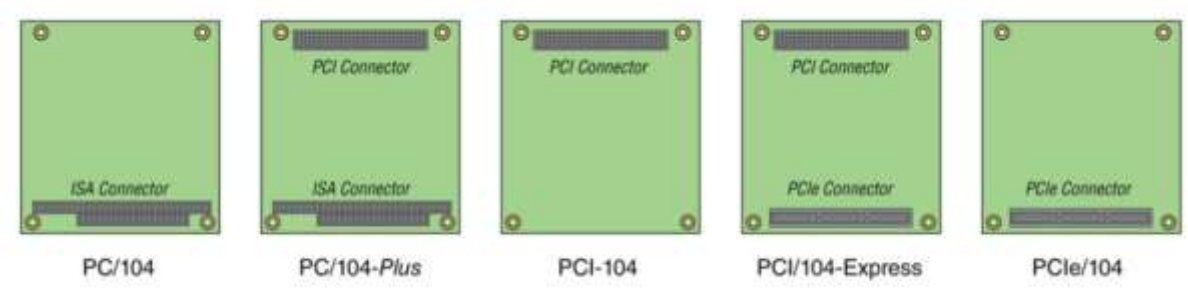

Figure 1: Five versions of PC/104 track the PC's evolution.

The Intel-driven PCI Express Bus was born in Year 2003, but it took, yes, you guessed it! – four - years before the PC/104 Consortium could introduce this to the PC/104 community, as the *PCIe/104-Express™ and the PCIe/104™* (the names alone gives away why it was so hard… ☺) and in the name of comprised, for upgradability and compatibility, the new standard had two large connectors, one for the 'Shared-Bus' of PCI and the other for providing the 20x lanes (that is 80x signal pins + lots of GND!) of PCI Express that Intel/AMD provided and 16x of these lanes were kind of allocated to the

CPU<>Graphics Processor, so only four (4) lanes were useful for 'Custom' I/O cards, the backbone of the PC/104 success. The innovation of Intel's PCI Express effectively made the PC/104 less attractive, as limited number of I/O Modules could be added to the stack without introducing a another switch-chip to provide 16x lanes into more 4x or 1x lanes.

Lucky, the "Powers-to-Be" at Intel/AMD, also saw the ironic of removing the bulky 'Shared Parallel Bus' and replace it with a complicated 16x lanes interface between the two essential components, the CPU and GPU (Graphics Processing Unit), was not a major step forward for Man-kind, so in Year 2009 the arrival of a number of 'Integrated' devices arrived, the first step of "SoC" (System-on-Chip) revolution and the beginning of Internet-of-Things.

The PC/104 Consortium got out quickly with a modification to the PCI/104-Express and PCIe/104 and in the in haste called it "Type 2", that got multiple four (4) lanes PCI Express, rather than a single sixteen (16) lanes. Although not really 100% compatible (a bit of Plug & Prey required..) with the quickly rename old and initial type, now "Type 1", no potential for damaging of boards, but mainly a compatibility and frustration issue. At least it was now possible to design a CPU + GPU board on a single PCB and have an almost infinitive number of I/O Modules on the now less congested PCIe/104 "Type 2" connector – and remember, they are INDENTICAL and COMPATIBLE connectors.

Now, either fast forward to Year 2010 – or backwards, depending on your vantage point – and yours truly got interested in the PC/104 Stackable Concept. I have 'soft-spot' for anything with four, being it pets, vehicles, chairs, Lego® bricks or inter-processor communication on semiconductors to build Multiprocessing solutions. Sundance Multiprocessor Technology Ltd. jumped into the heaven of "Type 2" with both feet, creating a very versatile PC/104 Platform that combined a Dual Core PowerPC 440 CPU @ 350MHz, running Linux, an endless array of standard interfaces, like USB, SATA, RS232 and long-distance fibre interfaces, combining with 108x LV-TTL I/O that could interface to "Sandwich" daughter modules to provide the DAQ interfaces and routing four (4) lanes PCI Express interfaces to the lovely stackable PCIe/104 connector for adding even MORE of these 'Beasts' to a PC/104 stack. The core technology was/is the Xilinx Virtex-5 FPGA family with integrated PCI Express end-point lanes and lots of spare logic/fabric for the user to add "Application IP-Core Accelerators" for doing FFT or image pre-processing/compression, etc.

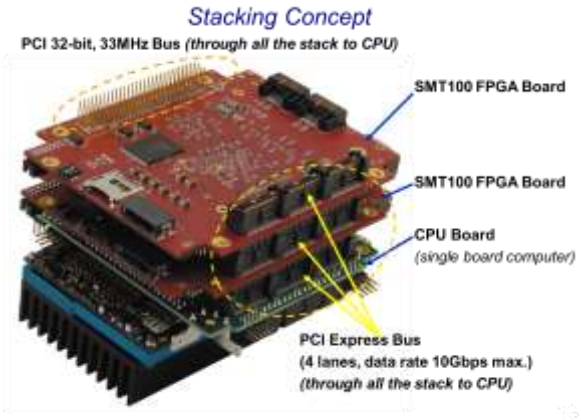

Figure 2: A PC/104 SBC CPU Board with two FPGA Boards stacked

Had Sundance and many others had the foresight to predict the demise of PowerPC for Embedded processing, then lots of tears could have been saved – see *Where art thou, PowerPC?* - but rather than leaving the PC/104 Bandwagon with the tail behind our legs, we decided to become more active in the PC/104 Consortium and focused on making the PCIe/104 concept even better.

Figure 3 Dual Core PowerPC integrated into a Virtex-5 FPGA on a PCIe/104 Module

The initial focus was to push the Samtec Q2™ connector and the pin-out defined by the PC/104 Consortium with multiple GNDs and see if we could validate and double the original Gen 1 speed (2.5GHz) to the higher speed of Gen 2 (5GHz) and for completeness, then we also tested the Gen 3 (8GHz)

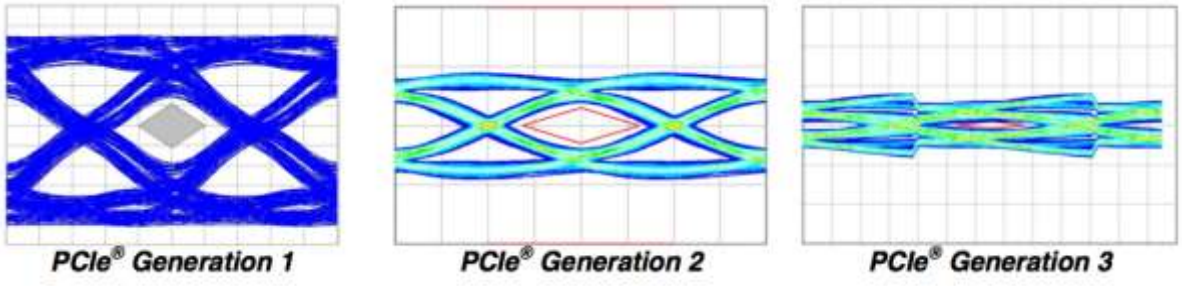

Figure 4 - The Samtec Q2 connectors are capable of 8GHz PCIe Gen 3 speeds as shown in these eye diagrams. See full test specification here

To our delight and slightly surprise, then we could stack up to 10x PC/104 board and still produce acceptable eye-diagrams, so in early Year 2013, revision 2.10 of the PCIe/104 Express was introduced and a few vendors has got CPU Controllers that support Gen 2 now and the Sundance SMT105 FPGA Module, with the integrated FPGA, is also Gen 2 hardware enabled.

A revised version of SMT105 was introduced in late Year 2014 that offered an "Open-FPGA" and full hardware compatibility with a VITA57.1 FMC-LPC Daughter-card and with free Linux drivers.

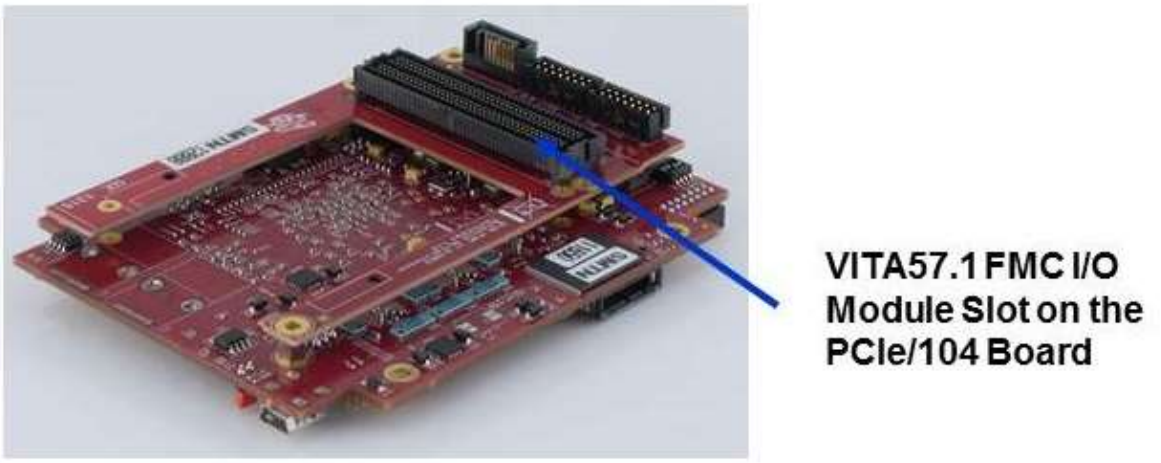

Figure 5 SMT105 PCIe/104 FPGAs Module gets more I/O options with VITA57.1 FMC Add-on Module

The significant of the "Open-FPGA" concept might not seem important, but historical, all vendors of FPGA boards has chosen to integrate some proprietary IP-Cores to protect the huge investments in developing VHDL solutions for Embedded Application – see *FPGAs: Tough to program, but key for embedded computing* - but the latest firmware/software for SMT105 is generated exclusive with IP-Cores available from and compatible with Xilinx ISE Design Suite and support for Linux reduce cost and more suitable for low-cost, bespoke and turn-key systems.

What next then?? Surely PCIe/104 and PCI/104-Express, with the future proofing of the 'need-for-speed' in terms of verification of PCI Express, Gen3 would make everybody happy?? Well, as well as speed, the other important aspects of a four-legged Embedded System chair is cost, size and legacy compatibility. The Samtec Q2 connector has 156x contacts, takes 463mm^2 of PCB 'Real-Estate' and is in the region of USD15.00, whereas a single PCI Express Lane only require 4 (four.. – the magic number) contacts and adding a single I/O Module to a Host PC/104 SBC should then be possible with a 20 mm^2 connector and cost approx. $5 each.

Sure, but the last leg of the chair, legacy-compatibility, also needed to be resolved. We wanted the new and smaller connector to be compatible with the current connector.

The most difficult questions sometimes has answer right in front of you and the solution was to get Samtec involved and 'cook' and 'shrink' the current PCIe/104 connector from having three (3) banks to only having one (1) bank and reduce the area 260% to 172mm^2 and cost with 50% to a typical price of USD7.00 each. It looked easy, but to maintain the robust stack-able design that PC/104 is associated with and famous for, the efforts by Samtec involved a few iterations and then it all had to go through the vigour's of the PC/104 Consortium strict procedures.

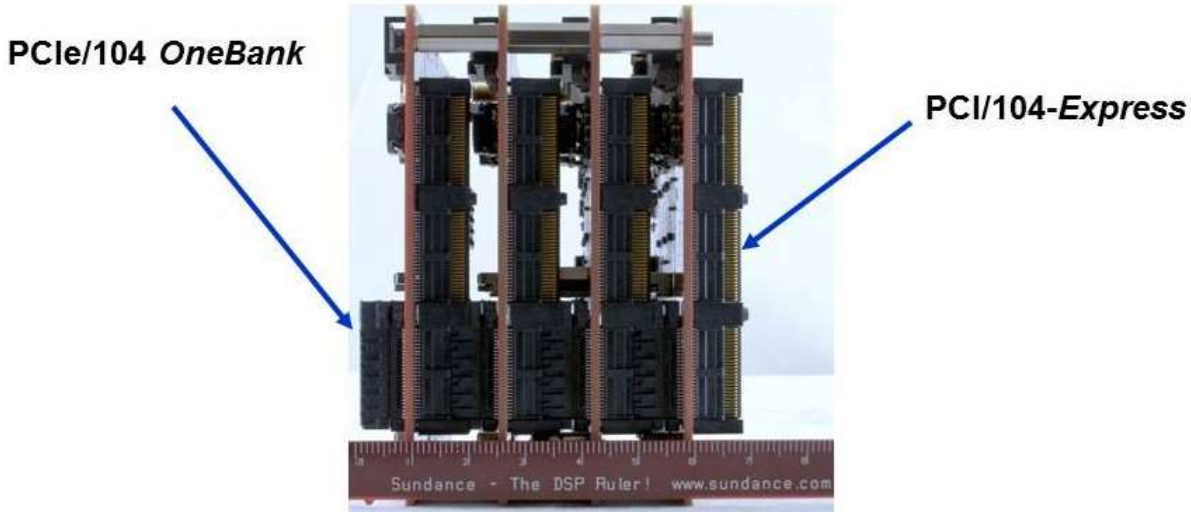

Figure 6 Stack of combination of PCIe/104 OneBank and PCIe/104

The relative easy part was to give the new arrival a name to be remembered by for the next 20+ years and it was obviously going to be "OneBank", as it clearly describes what it is. The OneBank variations are now part of the PCIe/104™ and PCI/104-Express™ specification, revision 3.0 and approved by the Members of the PC/104 Consortium and were released on 22nd January 2015 and can be downloaded from ….

Wait a minute?? All this efforts for the benefits of PC/104 boards only??

Nope, the OneBank has other potential form factors to be added to that will provide a local, fast and in-expensive PCI Express expansion capability, like below example (see Fig. xx) of a Backplane-Bus-based PXI-Express or OpenVPX board that might be fitted with a high-end CPU or large FPGA that has more PCI Express Lane than a single Backplane-Slot and finding 172mm^2 would enable a OneBank board to be added for I/O interfaces or more DSP Processing.

Take an Intel Server board, an EBX-Express™ or an EPIC-Express™ SBC board that will or might have a Xeon-class or AMD Opteron CPU that has up to 80x PCI Express and adding a small OneBank connector would give it instant, low-cost and stackable I/O expansion and with careful placement of the connector, then PC/104 OneBank could provide a cable-less expansion option.

1. About EMC2
2.

Multi-Stack OneBank Mezzanine Standard Ideal for COM, PC/104, SMARC, VME, More

http://www.victorianschool.co.uk/great%20victorians%20science.html

Electronics is adopting the mantra of city-planners: If you can't move outwards, move up. Instead of skyscrapers, the PCI /104 Consortium have created OneBank, a small form factor stackable connector/mezzanine that allows boards to be stacked to boost applications, but in a format that saves board real estate on the original board.

By: TBD Author.

There are five versions of PC/104 and two base board flavors, so the last thing one might desire is another PC/104 variant. Yet those five versions (Figure 1) track the evolution of the PC industry from ISA to PCI Express and each maintains dedicated followers and tech-savvy vendors. Collectively, PC/104 remains one of the most popular small form factor standards ever deployed.

Market pressures are increasing the per-board density on PC/104 single-board computers (SBC) and demanding lower prices of the already cost-effective SBC. As well, PC/104 is being considered a candidate to become a mezzanine module on other boards such as COM Express, CompactPCI, SMARC, VME, VPX and others.

To save cost, board real estate, and plan for future mezzanine flexibility, the PC/104 Consortium created and recently approved *PC/104 OneBank*. OneBank is compatible with existing PCI Express (PCIe) PC/104 versions and offers the following benefits to designers and users:

- speed scales up to PCIe Gen 3,
- increases board real estate on existing PC/104 SBC and stack board layouts,
- makes way for PC/104-compatible small form factor (SFF) mezzanines used with other industry standard formats,
- remains stackable just like PC/104,
- saves BOM costs,
- and has the potential for increased ruggedness.

From Three to OneBank

At the request of the PC/104 Consortium, connector company Samtec evaluated the feasibility of removing two of three "banks" from the PCI/104-Express and PCIe/104 "Q1" connector (P/N ASP-142781-03, QMS, 22mm). This is a 66 percent reduction in the connector itself, and saves board real estate and cost. OneBank PC/104 boards are equipped with a much smaller but equally powerful inter-board connector.

The premise of OneBank is that the conventional 16-lane QMS connector is often under-used in an era when a GPU (graphics processing unit) or DSPs (digital signal processors) are integrated, rather

than being plug-on stack boards. In practice, many of the bus lanes are redundant; rarely are all 16 available lanes used. Reducing the number of available lanes to four (PCIe x4) with only one bank of the connector is made up by the fact that two thirds of the previously occupied connector space is now freed on the board. Looked at from the PCB, there's an additional 10 percent total board space freed up for components and routing. Figure 2 shows how much space is saved for components or other I/O connectors.

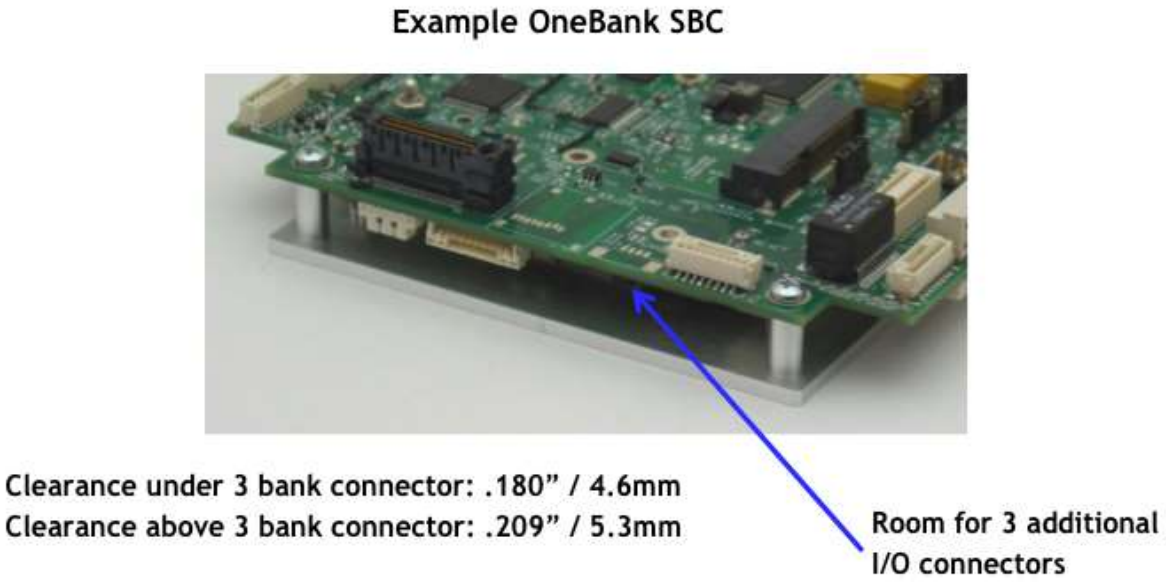

Figure 2: The smaller Q2 OneBank connector (top board, at left) frees up additional real estate for other things. (Courtesy: Diamond Systems.)

In applications where a OneBank board will be used with other PC/104 type boards, compatibility was closely considered—both electrically and mechanically. As shown in the Figure 3 stack-up, the new Samtec OneBank "Q2" connector maintains the same 15.24mm stacking height as the original three bank Q1, and can even mate onto a Q1 as indicated. In that case, the new Q2 connects with the left-most bank of Q1 (refer to Figure 1, PCIe/104 connector).

Also, the OneBank connector maintains 52 pins, supports x1 and x4 PCIe, and the Consortium reserved six pins for future expansion such as SATA-based mass storage (Figure 4). Plugging a x16 PCIe/104 Express board into a x4 OneBank-equipped board will cause no electrical damage—they won't work—and vendors will clearly specify whether their boards will work either or both 3- or 1-bank systems.

Figure 3: PCI/104 OneBank stack-up maintains the familiar PC/104 ecosystem 15.24mm height. (Courtesy: Sundance Multiprocessing.)

Figure 4: The OneBank connector supports PCIe x4 and maps well with legacy PC/104 boards such as the PCIe/104 shown here (left- and right-most columns).

Price and Performance

The drive for smaller form factors in computing equipment has led to a need to utilize all of the available board space to make sure all desired features and functions are included, but not at the cost of 'bulking up' the design. There must also be no performance penalties, so the platform and the connector architecture must continue to provide high-speed interfaces, which can be used and reused for future designs, but at a price point that is sensitive to market needs.

The lower cost Samtec Q2 OneBank connector shown in Figure 4 offers the following connectivity within a footprint of 23.71 mm x 7.26 mm (approximately 172 mm^2).

- 4 PCIe x1 lanes
- 2 USB 2.0 ports
- SMBus
- ATX power and control signals: +5V standby, PS on, Power Good
- +5V, +3.3V, Ground

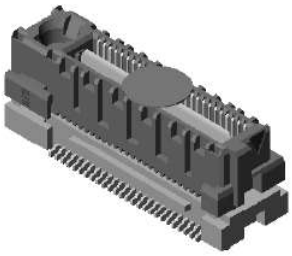

Figure 4: OneBank top connector (shown with pick-and-place tab).

This tall order has been met with the OneBank, shown on a PCIe/104-sized PCB in Figure 5. The specification delivers a high-speed, three-bank, stackable PCI Express connector for both up and down stacking (on the top and bottom of the mainboard), while retaining the stackable PCI connector for backward compatibility to PCI-104, PC/104-Plus and PCI/104 peripheral modules as shown in Figure 1.

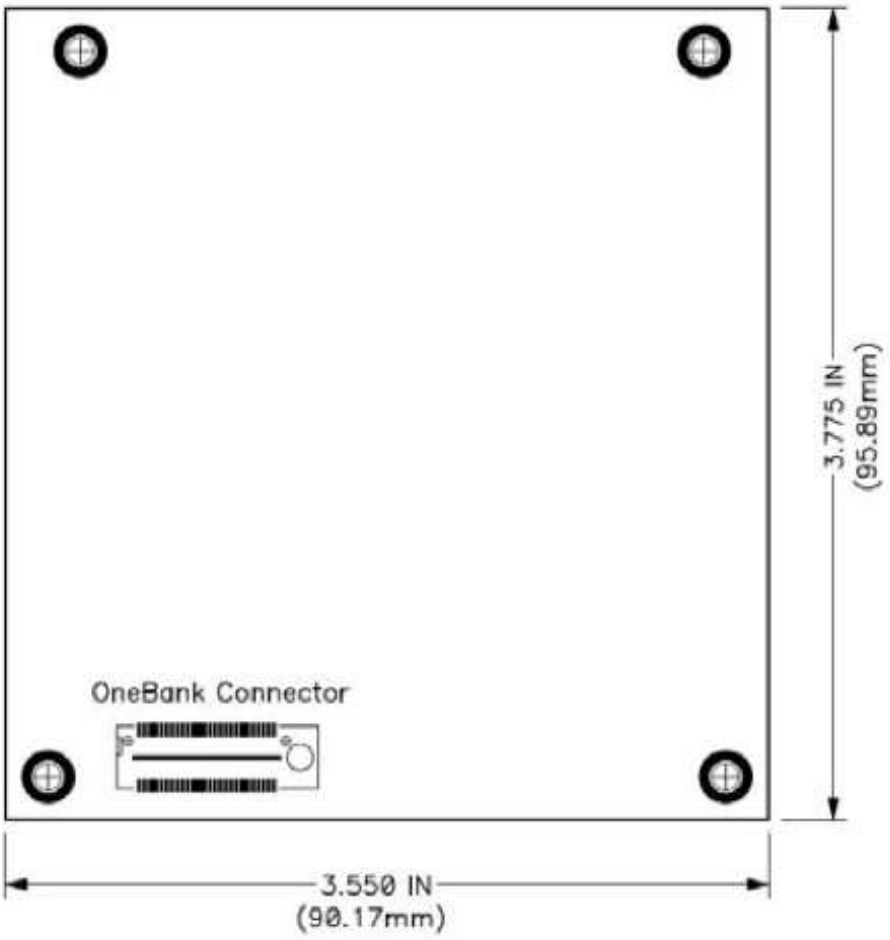

Figure 5: The OneBank connector consumes a mere 172 mm^2 or roughly 2 percent of the total available board real estate.

As well as freeing up valuable board space to allow the designer to add other on-board functionality, OneBank also saves the bill of materials, as the cost of the connector is reduced, possibly by as much as half (understandably, no vendors would provide actual price details). Considering that the volume of boards can be in the thousands, even small savings can translate into cost-efficiency passed on to the developer using the OneBank boards.

Mezzanines for other SBCs

OneBank enjoys the familiar software and configuration interfaces of the well-established PCI infrastructure, but also looks to new designs, where multiple boards, either accelerator boards or I/O boards can be stacked to fit into constrained areas or to fit more functionality into a conventional space, such as a 1U rack.

To meet the performance requirements of today's computing and similar to the original Samtec Q1 connector, the new OneBank connector was validated for high speed LVDS serial data rates. Eye diagrams provided by PC/104 vendor testing confirms that OneBank is capable of running at PCIe Gen 3 8GHz rates (Figure 6). It should be noted that few PC/104-style boards

The OneBank /OneBank Plus offers designers a flexible means to plug in boards onto PCI/104 or plug into other formats, such as a VPX board, using the familiar PCI Express architecture, software and configuration interfaces. It has been adopted to meet the increased functionality with a need for efficient use of available space, or with a view to reducing that form factor.

The aim of OneBank is to meet design demands for compact form factors without sacrificing performance, flexible design and compatibility with legacy products.

Parking Lot

But technology further evolves and high-density Intel- , Freescale- and ARM-based MCU/SoCs pack so many peripherals on chip that the need for multi-lane PCI Express stacking options has greatly diminished. That is, separate I/O and graphics boards (with x16 PCI Express) aren't as necessary as only three years ago.

It is worth noting that ISA bus backward compatibility can be achieved easily by using a PCI-to-ISA bridge peripheral module if required.

There are two versions available. A full size PCI-104 board with a 22mm single bank PCI Express expansion connector is the PCIe/104 OneBank, or OneBank. A PCI-104 board with the smaller, 15mm single bank connector is the PCI/104-Express OneBank, or OneBank Plus. Both are mechanically and electrically- compatible with the PC/104 architecture.

Both OneBank and OneBank Plus share the same feature set and pin assignments. These are four x1 PCI Express links, two USB 2.0 ATX power and control signals and 3.3, 5 and 12V SMBus. They also share the location and pin-out as PCI-104 and PC/104-Plus for retrofitting and compatibility.

OneBank (or PCI/104-Express) and OneBank Plus (or PCIe/104) incorporate four x1 PCI Express links and options for either a single x16 Link, or two x8 links, or two x4 PCI Express links. This provides designers with options to connect to standard PCI Express device chips. For example, the x16 link could use next-generation graphics chips, 1Gbit or 10Gbit Ethernet chips, or a PCI Express switch.

Feature	Type 1	Type 2	OneBank
USB 2.0	2	2	2
SMB	1	1	1
PCIe x1	4	4	4
Power	+3.3V, +5V, +12V	+3.3V, +5V, +12V	+3.3V, +5V
ATX Control	Yes	Yes	Yes
PCIe x4		2	
PCIe x16*	1		
USB 3.0		2	
SATA		2	
LPC		1	
RTC Battery		1	

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