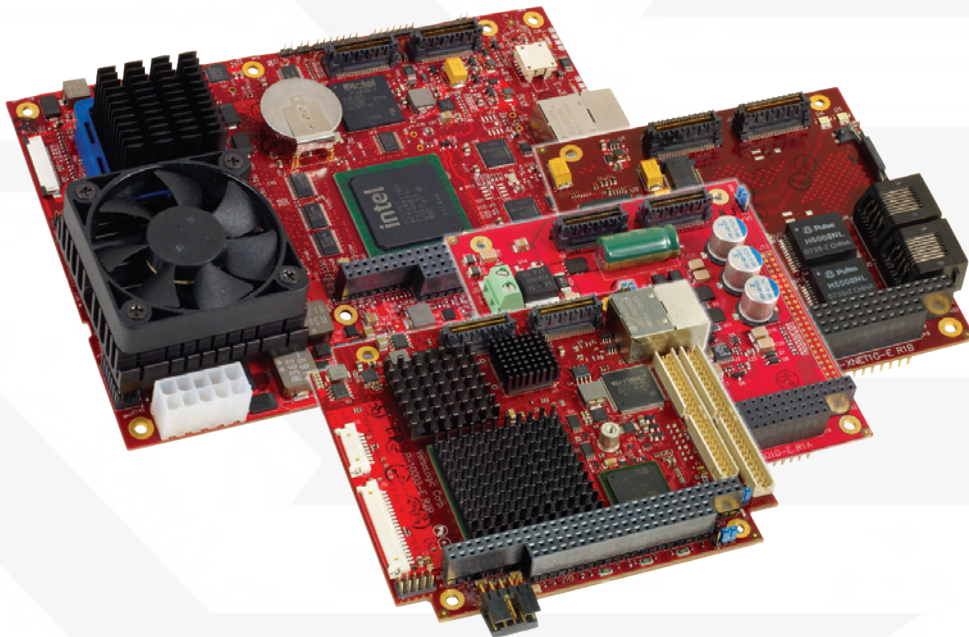


WHITE PAPER

Increasing Bandwidth and Connectivity in Small Form Factor, High-Performance Embedded Applications: The I/O-Centric, High-Speed SUMIT Interconnect Standard

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White Paper: Increasing Bandwidth and Connectivity in Small Form Factor, High-Performance Embedded Applications: The I/O-Centric, High-Speed SUMIT Interconnect Standard

Introduction: Defining the Problem

Designers of high-performance embedded systems need to incorporate growing numbers and types of I/O in smaller and smaller off-the-shelf and semi-custom boards, while keeping their design platforms flexible enough to accommodate a variety of designs, including some that must maintain compatibility with legacy I/O.

Demand for processing performance and higher bandwidth is increasing while space and power constraints are getting tighter. Many applications now require faster throughput associated with the PCI Express bus, and primarily address either newer video (HDMI) and/or high-speed Ethernet applications.

This is especially true in video-intensive situational awareness military applications that utilize picture-in-picture and mapping overlays, as well as in video- and 3D-intensive medical applications, such as virtual colonoscopy, MRIs, CT scans, and digital mammography. Demands for connectivity and communications capability in these applications are growing, such as in systems used in the Department of Defense's Global Information Grid, which requires a robust networked force for improved information sharing, or in medical networks that give patients access to the digital data of test results.

Table 1 - Comparative bus speeds

Bus Type	Maximum Bandwidth
PCI Express x1	250 MB/s (500 MB/s) (bi-directional)
SATA	150 Mbps
PCI	133 Mbps
Gigabit Ethernet	125 Mbps
IDE (ATA 100)	100 Mbps
USB 2.0	60 Mbps
IEEE 1394 (Firewire)	50 Mbps
ISA	16.67 Mbps

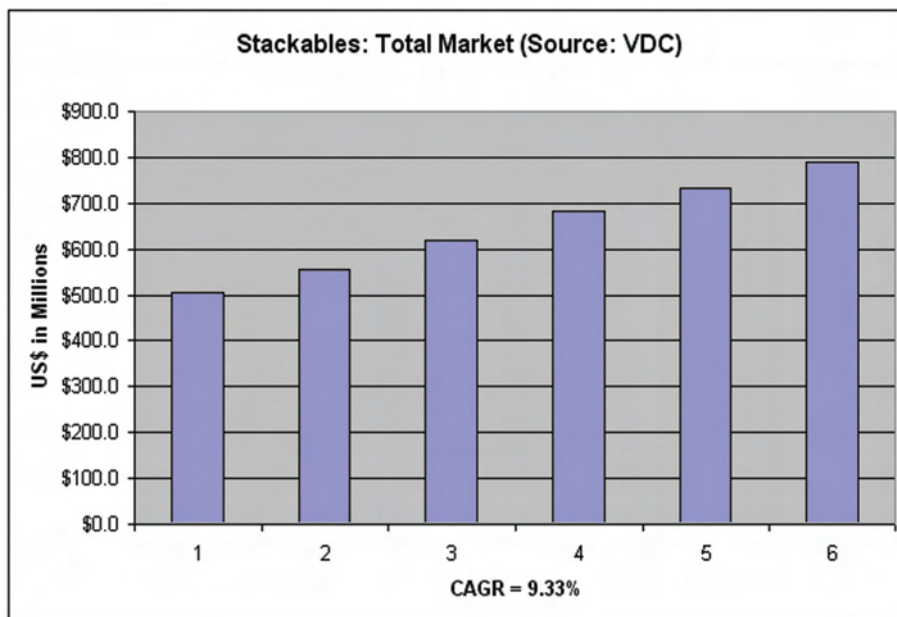


Figure 1: Stackables Total Market 2007 - 2012 (Source: VDC)

Developers of both medical and military applications are looking for a small footprint, compact modular size, and the ability to use the multitude of existing expansion modules available today. They want to be backward-compatible with legacy devices in the installed base, while still supporting a hardware environment that will accommodate very high speed devices.

Although space, power, bandwidth and performance issues are being addressed in semiconductor electronics at the CPU and chipset level, designing boards with new 45-nm technologies such as Intel's Atom processor has still been a challenge. This challenge is caused primarily by mechanical and connector issues, as well as the sheer number of buses that must now be accommodated to cope with the proliferation of I/O, including PCI Express, Universal Serial Bus (USB), Serial Peripheral Interface (SPI), Low Pin Count (LPC), System Management Bus (SMBus), and ExpressCard.

Form Factors and Interfaces

Over the last few years, high-speed serial buses, or switch fabrics,

have replaced older, slower, and cumbersome parallel interfaces in embedded designs. Most of them have not lasted. Meanwhile, most microprocessors, primarily Intel silicon, have adopted the PCI Express bus. PCI Express is a serial bus which allows data to be sent in two directions at the same time, doubling the effective bandwidth. Each PCI Express lane (port) provides more bandwidth than the original 133 MBytes/s PCI parallel bus. PCI Express typically provides throughput of up to 250 Mbytes/s per lane, (500 MBytes/s per lane bidirectional) in version 2.0, and up to 1 GBytes/s per lane (bidirectional) in version 3.0. It is used both as a motherboard-level interconnect and as an expansion card interface for add-in boards.

In medical and military applications, higher bandwidth is needed for manipulating data and for Ethernet-based communications, as more and more systems and subsystems become networked and requirements for high-speed, multiple Gigabit Ethernet connectivity increases. According to industry researchers VDC Research Group (VDC), PCI Express is emerging as the dominant high-speed serial

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interconnect in the stackable module space. VDC also finds that the largest vertical markets for all stackables include industrial automation and control, instrumentation, medical, and military/aerospace/defense.

Existing solutions have included a growing array of small board form factors and interfaces. As I/O has proliferated, designers are faced with two choices. The first is to build larger-footprint single-board computers (SBCs) with more integrated I/O, such as Embedded Board eXpandable (EBX) boards, at 8 x 5.75" (203.2 x 146.05 mm). The second is to construct taller, stacked-board systems based on stackable architectures such as Embedded Platform for Industrial Computing (EPIC), at 4.5 x 6.5" (115 x 165 mm), or PC/104, at 3.6 x 3.8" (90 x 96 mm), which enable I/O modules to be stacked on top of an SBC and can accommodate these expansion needs.

VDC has said that stackable board architectures such as PC/104, EPIC or EBX are attractive to OEMs and integrators facing these challenges, since expansion boards can be added vertically to preserve a small footprint. VDC expects a compound annual growth rate of 9.33% for shipments of all stackable modules between 2007 and 2012.

Today, many designs begin with the I/O, not with the CPU. Since the I/O drives the bus requirements, and then the CPU requirements, it makes sense for the designer to start with the most unique I/O and work back to a standard CPU. Although the form factor of an SBC is tied to its mechanicals – how the board is mounted in the system and its cabling attachments – the interfaces are important because of data throughput and how easy it is to attach I/O.

At the same time, the strong drive toward smaller board sizes and the flexibility needed for a platform to serve multiple uses means that a taller,

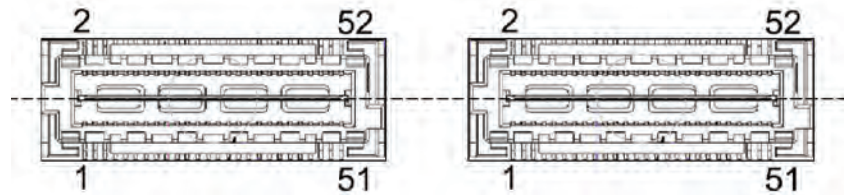


Figure 2: SUMIT A and B connectors

stackable platform is more likely than a larger-footprint SBC with everything on it.

The SUMIT Solution

Instead of assigning one connector per bus, and instead of defining yet another board form factor for next-generation, low-power, high-performance, small board-based systems, it makes more sense to separate the interconnect standard from the form factor standard, and design a new interface that integrates and consolidates both high- and low-speed serial and legacy buses. Keeping the same form factors, and

updating only the interfaces, lets form factor standards and interface standards evolve separately. When a new form factor becomes available, it can support all of those interfaces, which helps minimize revisions to the specifications and increases the design platform's longevity.

The Stackable Unified Module Interconnect Technology (SUMIT) from the Small Form Factor Special Interest Group (SFF-SIG) does exactly that. The interconnect technology chosen for the open standard SUMIT interface accommodates multiple high- and low-speed buses in a single high-speed connector (SUMIT-A

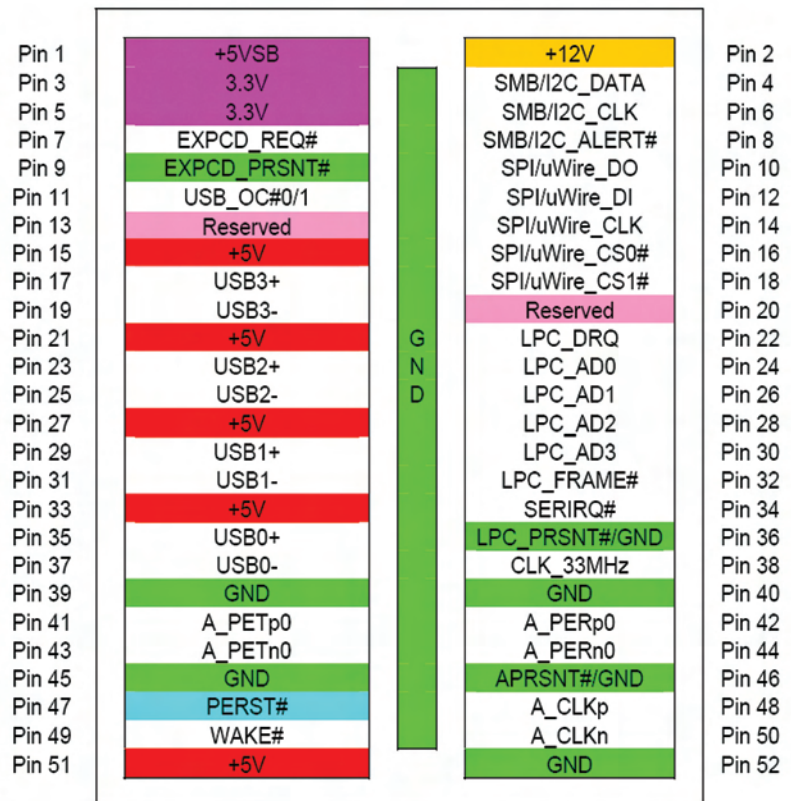


Figure 3: SUMIT-A connector pin assignments

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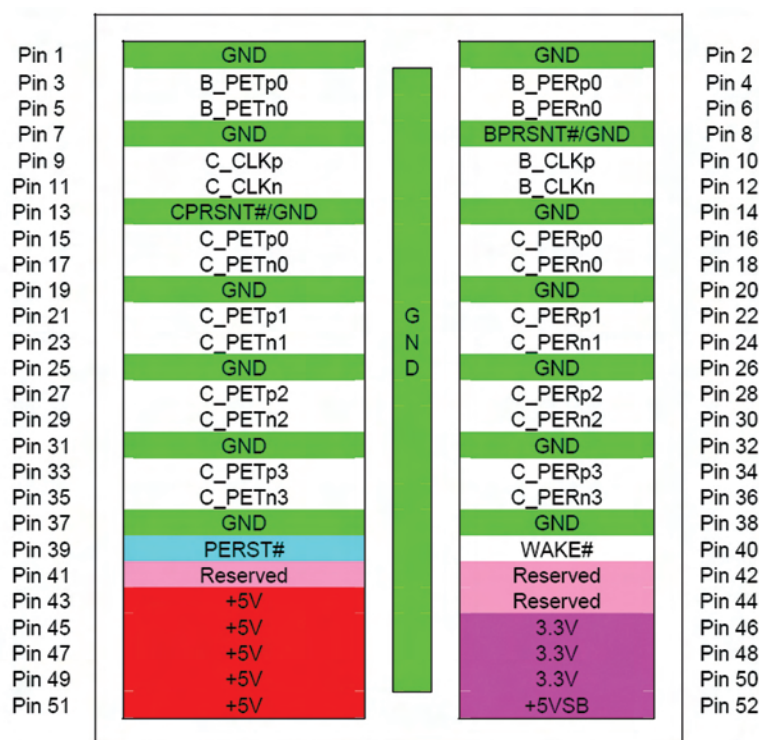


Figure 4: SUMIT-B connectors pin assignments

connector), using less board space than previous solutions. The SUMIT-A connector supports several buses, including PCI Express, USB, LPC, SPI, SMBus, and ExpressCard. An optional second connector (SUMIT-B), with the identical size and pin count, supports additional PCI Express lanes for more channels or higher bandwidth. Either or both connectors can be used on a board. Another optional connector offers support for legacy ISA devices. The specification is designed to optimize cost per pin, pin density, and signal integrity. It provides the basis for a stackable, I/O-centric, multi-board solution via an expansion approach that is independent of any particular board form factor. It is also designed to be processor-independent, since it focuses on bus and interconnect technology rather than on a particular processor.

The SUMIT interface specification defines the two different connectors, their respective pin assignments, and their relative placement on the board.

Because it does not define a specific board size, the SUMIT connectors can be implemented across multiple board form factors, such as PC/104 and EBX in standard and semi-custom SBCs. A board built to this specification can use only the SUMIT connectors, in which case it is a COM. Or a SUMIT-Board can also include pin headers for other I/O such as IDE, Ethernet, or GPIO, in which case it is a hybrid SBC/COM. By using two smaller, separate connectors instead of one large connector, the maximum amount of I/O bandwidth is balanced with the minimum amount of board space. An expansion or add-on board built with only a single SUMIT connector can plug directly into other processor or expansion cards populated with both SUMIT connectors, reducing overall system cost.

The SUMIT-A connector's more space-efficient, low-speed buses are the same ones integrated into many of today's processor chipsets. They can help designers who want to migrate to

low-speed I/O – used for tasks such as low-rate data acquisition or switching relays on and off – to these buses to replace the bulky ISA bus. SUMIT connectors can also co-exist with ISA connectors, since ISA occupies a different location on the board.

SUMIT Technical Description

The connectors chosen for the SUMIT interface play a critical role in meeting the specification's goals. The SUMIT interconnect system has several requirements for connectors that implement the interface. They must be able to handle the high-frequency signals required by PCI Express and USB, and must be available off-the-shelf as a standard product. They must have closely-spaced, fine-pitch pins in order to minimize the board space consumed.

The SUMIT specification's connectors are based on the Samtec QFS/QMS Micro High Speed Connector series. The Samtec connector is a one-bank terminal assembly that provides a ground blade in the center of the connector body. The QFS connector measures only 0.88 x 0.32" (22.35 x 8.13 mm). It features a unified internal ground interface for improved routing characteristics, and for efficient use of all 52 pins.

Both the A and B SUMIT connectors are 52-pin, high-density (0.634 mm-pitch) connectors. In addition to the high- and low-speed buses, they also contain +12V, +5V, +5V standby, +3V, grounds, and other control and status signals. Center ground blades provide impedance, EMI, and DC ground return.

The SUMIT-A connector contains one PCI Express x1 lane, four USB 2.0 ports, an LPC bus for expansion serial ports and other legacy I/O, an SPI port, an ExpressCard port, and a general-purpose Inter-Integrated Circuit (I²C) bus that is usually connected to the SMBus for use with x86 chipsets.

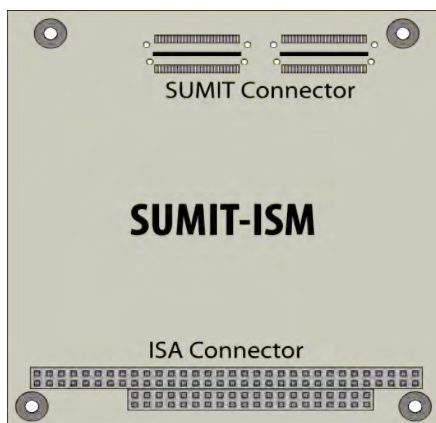



Figure 5: SUMIT-ISM board diagram, showing relative positions of SUMIT-A and SUMIT-B connectors, ISA connector, and mounting holes

The SUMIT-B connector contains one PCI Express x1 lane and one PCI Express x4 lane, as well as additional power, ground, and control signals. The PCI Express x4 lane can be split into four x1 lanes. SUMIT supports PCI Express 1.0 and 2.0, with speeds of up to 500 MBytes/s per lane (bi-directional).

With a variety of bus signals on the SUMIT interface, multiple types of I/O cards can be combined in a stack, giving the flexibility of both high- and low-speed functions. The SUMIT-A connector supports low-speed applications, similar to ISA speeds, via the LPC bus, as well as a USB expansion scheme.

The SUMIT specification defines the relative placement of the A and B connectors to each other on the board in order to ensure proper routing as signals are passed from one connector to another up through the stack of cards, as well as to ensure mechanical compatibility.

A separate SUMIT specification, SUMIT-ISM (Industry Standard Module), uses the SUMIT stackable architecture on a PC/104 sized, 3.6 x 3.8" (90 x 96 mm), module. The specification for the location of the SUMIT connectors is such that the original PC/104 (ISA) connector can be used along with SUMIT on the same board. This makes it easy to migrate from systems with

PC/104 ISA expansion modules, to a system with mixed SUMIT and PC/104 expansion stack. The SUMIT interconnect is currently specified for EBX, EPIC, and PC/104-sized CPU and expansions boards. 

About the SFF-SIG

The Small Form Factor Special Interest Group (SFF-SIG), formed in September 2007, is focused on open standards for small form factors. The group's purpose is to develop, adopt, and promote circuit board specifications and related technologies that will help electronics equipment manufacturers and integrators reduce the overall size of their next-generation systems. The SFF-SIG's philosophy is to embrace the latest technologies, as well as maintain legacy compatibility and enable transition solutions to next-generation interfaces.

In April 2008, the SFF-SIG introduced the SUMIT interface specification aimed at next-generation, low-power, expandable SBCs. With its blend of high- and low-speed buses, SUMIT can be added to a variety of board form factors, and is flexible and compact enough to meet a broad range of application requirements. Unifying the expansion interfaces of many SBC form factors can help consolidate I/O ecosystems and thereby improve I/O economies of scale.

About VersaLogic

VersaLogic Corp. has been designing and manufacturing small form factor off-the-shelf and semi-custom boards for embedded designers of high-performance systems for more than 30 years. The company is committed to superior product quality, outstanding pre- and post-sales support, and guaranteed long-term product availability. VersaLogic is active on the boards and working groups of a number of standards bodies including the PC/104 Consortium, PICMG and the SFF-SIG. VersaLogic has received the coveted Platinum level vendor rating from VDC Research Group, Inc., for five consecutive years. The company is ISO 9001:2008 certified and was one of the first companies in North America to be registered to the 2008 standard.

VersaLogic's new SUMIT product series demonstrates the company's commitment to the compact, stackable SUMIT interface that integrates and consolidates both high- and low-speed serial and legacy buses. VersaLogic's SUMIT-enabled products bring the next generation of high- and low-speed interfaces to popular off-the-shelf form factors including PC/104, EBX, and EPIC. For more information on the new SUMIT series from VersaLogic, please visit www.VersaLogic.com/SUMIT.

For More Information

SFF-SIG:

www.sff-sig.org

About SUMIT:

www.sff-sig.org/sumit.html

SUMIT Specification Revision 1.3:

www.sff-sig.org/sumit_spec_v13.pdf

