CompactPCI Serial reaches out into Space

Always reliable. Always ahead.

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Recently, the US-based Internet service supplier OneWeb ordered 900 satellites to provide global Internet broadband service. Knowing that this volume is more than half of the total 1400 satellites already in orbit, and the costs for sending one up into space is about 100 Million, you need to start thinking about new computer technologies that could help to manage this mass of satellites that need to be produced every year.

The commercialization of aerospace, like this OneWeb project, progresses and increases the pressure on established companies to develop competitive products for this market. One possible option is to count on standards in order to save time and cost during development, and also during project life-cycle.

Taking an existing standard and adapting it to the requirements for space was also the solution a group of global players in space like Airbus, Thales Alenia, and others went for. They decided to go with a rather new and powerful, and already industry-proven with its predecessor versions, standard: CompactPCI Serial. Using a standard like this also helps to contribute to the obsolescence problem of avionics hardware, as well as to significantly reduce complexity and costs for hardware/software.

The new technical PICMG sub-committee “Space CompactPCI Serial” is now extending the current CompactPCI Serial specification by a sub-standard covering the specific requirements for space applications. Players in this working group are, in addition to Airbus and the initiating companies STI Spacetech, SYSGO and TTTech, also Amphenol FCI, EKF, Elma Electronic, ERNI, Fastwel, Harting, HEITEC, Intel, Keysight, Pentair and Positronic, with MEN Micro acting in a consultative role, having already been strongly involved in the development of the CompactPCI PlusIO and CompactPCI Serial standard.

Availability and Open Interfaces for Space Applications

Even if VPX was – with the exception of completely customized solutions – for a long time the only standard for embedded systems in space, CompactPCI also has a long history in space applications. Famous examples are the “Curiosity” Mars rover for satellite control, or being implemented for scientific tasks in the ISS. Even the CompactPCI Serial base specification has the mechanical and conduction cooling technologies needed for space already defined and in place.

In addition, compared to VPX, the flexible CompactPCI Serial standard offers an easier and cost-optimized development.

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Fig. 1: A typical application for Space CompactPCI Serial is e.g. the implementation of the platform and the payload controller onboard satellites

Space CompactPCI Serial is therefore the most logical choice for implementing high-tech solutions for a highly sophisticated market, while both re-using and evolving proven industrial technologies, while also reaching significant cost reductions. At the same time, some unused features have been removed to make the standard more streamlined, and other properties have been added to optimize the standard for use cases.

The two main changes in the extension of the CompactPCI Serial specification are the definition of a dual star architecture for increased availability, and allowing the integration of different communication protocols common in space applications for both – the dual-star and the full-mesh network (which was formerly restricted to Ethernet only).

The CompactPCI Serial basic specification defines a single star architecture, while Space CompactPCI Serial now doubles these interconnects in a symmetrical way, so if one CPU fails, the functionality of the complete system will not be affected. Having this increase in availability was essential for use in space, especially since you cannot simply exchange a CPU card installed in a satellite in orbit.

In addition to the system slot (A) on the left side of the system, a second system slot (B) on the right side of the system uses the same routing method. All seven peripheral slots are connected to both system slots, and both system slots are connected to each other. All together, these links build a fully meshed interconnectivity network. The full-mesh network is not restricted to any particular protocol, and may be used for physical interconnection standards like Ethernet, SpaceWire, TTEthernet, EtherSpace etc…

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Parallel to the full-mesh network, both system slots can be connected to any of the peripheral boards by means of eight specific differential links. These links could be also used for any protocol, depending on the application and the individual boards. This dual star architecture is intended to be used in high availability solutions.

The result is a parallel and flexible usage of the full-mesh Ethernet network via the backplane, as well as the dual-star architecture via PCI-Express or any other protocol.

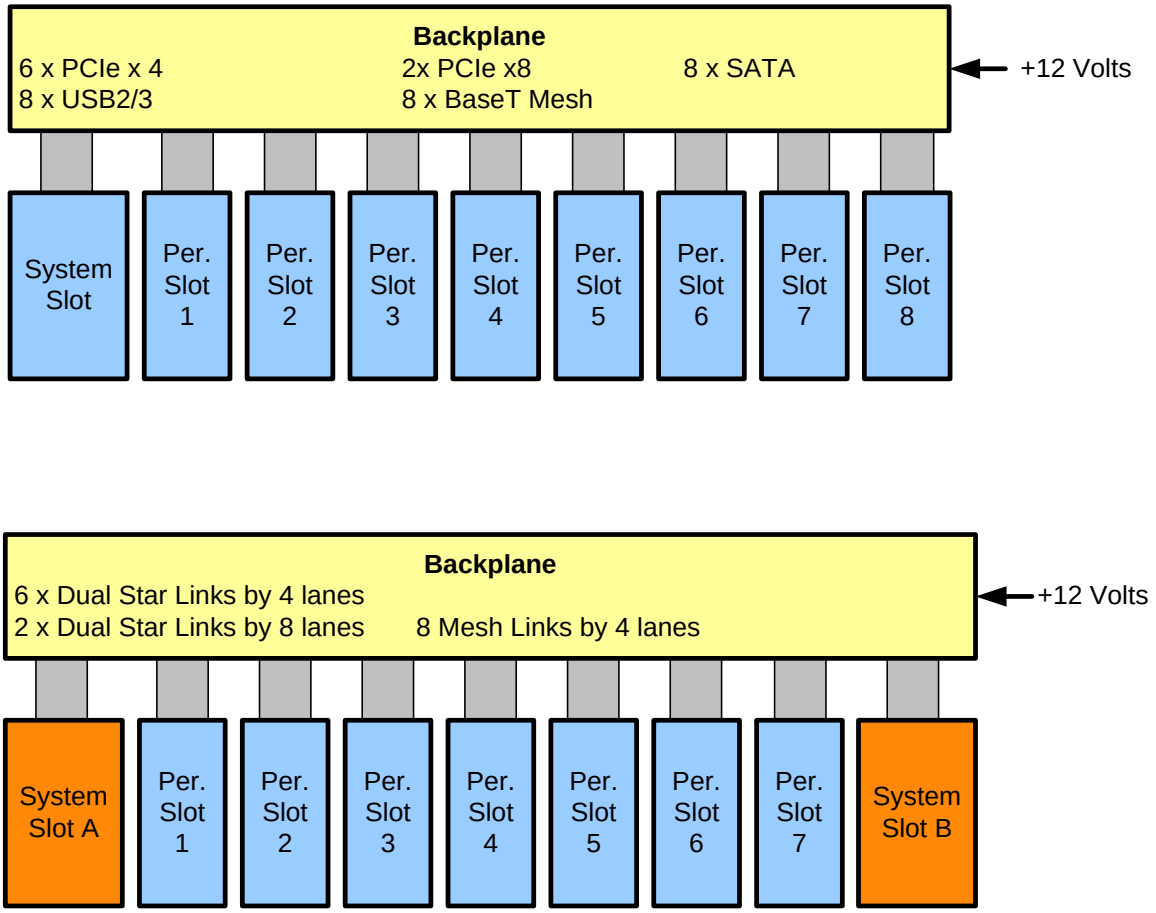

Fig. 2: Space CompactPCI Serial defines a second system slot, forming a dual star architecture for PCI-Express.

In addition to that, the specification defines a utility connector, which can be controlled and configured via an open management bus. It takes over the hot-plug functionality, as it was used for CompactPCI Serial, and allows single cards within a system to be switched on and off. Hot-plug functionality is indeed not necessary for satellites in the orbit, but is extremely useful during integration on ground and for test systems, which can be still realized via PCI-Express and with common CompactPCI Serial cards.

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As Space CompactPCI Serial is intended to be used in a conduction cooled environment, the board to board pitch is defined to 5HP (= 25,4 mm) to allow a conduction cooling frame for each boards. To make the standard specification easier, the pitch will remain the same, also if the boards will not need a conduction cooling frame (e.g. for testing systems on ground), which would just require a 4HP pitch. At the moment, members of the working group are already working on specific standard backplanes for Space CompactPCI Serial.

The high-speed backplane interconnects, and the connectors are intended to support data rates of 12.5 Gbit/s per differential pair. The accelerated bandwidth of the full mesh is 400 Gbit/s. Additionally the dual star interconnect simultaneously supports a 1 Tbit/s throughput rate.

Infrastructure signals allow a comfortable and flexible system management. In addition to a I²C bus, CAN bus is also supported. The power supply is 12 Volts only. Optionally, a 5 Volt standby voltage could be used to support suspend modes or sleep modes. Power rails can be a single plane, or every board could be supplied and controlled individually. The power supply and the system management are not a part of the Space CompactPCI Serial specification.

The harsh environments in space and especially the vacuum conditions require high demands for the connectors. The material must not outgas, as some outgassed materials can deposit on the sensitive lenses in the satellites. A correspondent outgassing test had already confirmed the qualification of the connectors used for Space CompactPCI Serial. However, other mechanical or environmental measures, like SEU-resistance are not defined in the standard specification, as this always depends on the customer's requirements, and the boards design within the application and end system.

The working group just finished the specification recently and will plan to bring it into the PICMG ballot during the second quarter of 2017.

Space CompactPCI Serial allows the use of established industrial technology in space. This permits the cost-effective use of the latest technology also for space applications. The open standard guarantees the interoperability of different boards from different suppliers, and helps re-use solutions from mission to mission.

Keep an eye out for this new great standard, which open the doors for highly available and reliable applications, not just in space!