SPECIAL FEATURE

Focus on Ruggedized Military Solutions

Innovative Thermal Management in HPEC VPX systems

As the customer demand for putting ever increasing processing power in each High Performance Embedded Computer (HPEC) VPX System, finding new ways for extracting the heat out of each system slot has become essential to reach challenging specifications with very stringent requirements for small size and weight, low power consumption and competitive pricing. Thermal management cannot be considered anymore as an afterthought and designers must introduce new innovative cooling techniques and solutions to achieve performance goals, right at the start at the design phase.

Thierry Wastiaux, Senior Vice President Strategy & Marketing, Interface Concept

Thermal simulation

To maximize the processing power in each slot of a VPX chassis while controlling costs, Interface Concept has developed coupled fluid and thermal simulation models. These numerical models have been assessed through experiment. They are systematically used during the design phase of the products.

These simulations tools allow computing, with good precision, the internal temperature of the components. More importantly, they provide reliable improvement indications when changing the design assumptions. This greatly helps engineers in defining the best cost effective solutions for component placement and design of thermal interfaces (pads, gap fillers, and compound) and heat sink. These simulations are key to design plug-in units able to sustain the long thermal cycle tests beyond the standards, requested by demanding customers. That is the reason why Interface Concept keeps on developing its own simulation tools as well as dedicated thermal measurement benches.

VITA 48.1 cooling

The VITA 48.1 open standard defines the mechanical specifications of air cooled VPX plug-in units. This standard is the basis of cost effective VPX air cooled designs leading to lightweight and cost effective solutions for operating temperature within the [0,55°C] range (AC1 VITA 47 Operating Temperature Class).

Figure 1
IC-INT-VPX3d equipped with standard air cooled mechanical solution

Interface Concept has worked on improving the cooling of VITA 48.1 compliant products to extend the temperature range of operation. The goal is to drive the costs down by avoiding the use of other less cost effective solutions based for instance on the VITA 48.2 conduction cooled or VITA 48.5 Air Flow Through standards when more thermal power dissipation is needed.

Air cooling innovation

A good example of this new approach is the IC-INT-VPX3d single computer board that features an Intel ® Xeon D-1559 processor shown on figure 1 with its standard mechanical solution. The thermal performances of air cooled plug-in units are somehow limited. The limitations are mainly due to forced convection physics. One of the main issues comes from the fact that the air typically flows outside the heat sink as it can be seen on the velocity field picture of figure 2 a). This means that part of the air flow does not participate in the heat exchange. The air kinetic energy provided by the systems (fans, blower…) is simply wasted. This phenomenon is illustrated by the temperature field shown on figure 2 b).

Staying on air cooled VPX products and systems that are usually preferred as they are easier to manage, the classical approach to improve this situation is to move to other solutions as Air flow through (VITA 48.5) or other proprietary similar schemes. However these solutions have some drawbacks. They tend to increase the weight of the products that is not wanted especially on airborne solutions. They also prevent a natural air cooling of the PCB itself where components may be soldered at the bottom side of the plug-in unit. They usually lead to a significant cost increase.

For air cooled designs, Interface Concept has chosen the path to stay on the VITA 48.1 standard and to develop innovative thermal and mechanical solutions. Among the efforts made, the air flow path has been

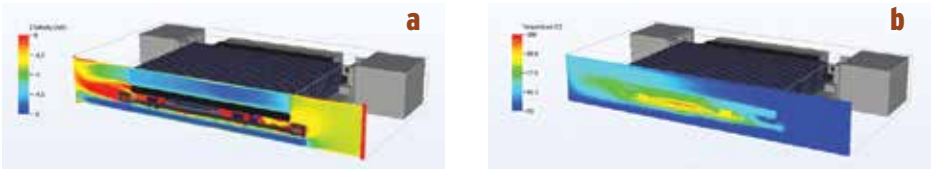

Figure 2
Computed fields across 3U plug-in-unit. a) Transverse velocity. b) Temperature.

optimized. New principles have also been used to greatly improve the efficiency of the heat sink itself. In addition new features have been developed to optimize the thermal contact with the components.

All this effort has led to the design of the enhanced air cooled IC-INT-VPX3d shown on figure 3. The performances of this enhanced plug-in unit compared to the standard one have been tested within a fully instrumented air cooled chassis. By design the Intel® Xeon 1559 processor constantly adapts its operation scheme to stay under the junction temperature limits. When increasing the cooling, the available power of the processor will increase. In term of watts, this power can increase up to a maximum level of 45 W for the Intel® Xeon 1559 processor. This maximum level (Thermal Design Power) represents the average power the processor dissipates when operating at Base Frequency with all core active. At this level, the user gets the maximum performance from the processor.

Figure 3
IC-INT-VPX3d equipped with enhanced air cooled mechanical solution

The results of the test of the compared performances between the standard and the enhanced solution of the IC-INT-VPX3d product are summarized in figure 4 below.

It can be seen that when using a standard air cooled approach and whatever the air flow you are blowing into the chassis, the full 45W TDP of the Xeon D1559 cannot be reached at 70°C ambient temperature (AC3 VITA 47 Operating Temperature Class). So to get the maximum available power from the processor, this standard design can only be used in the AC1 VITA 47 Operating Temperature Class [0,55°C]. The plot shows that with the enhanced Interface Concept design, the full power of the processor is available at 70°C ambient temperature proving the validity of the approach.

This innovative VITA 48.1 thermal design is now used on all the new products as the IC-FEP-VPX3d for instance, that is a plug-in unit featuring a powerful Xilinx® Ultrascale KU115 FPGA for front end processing. Another example is the IC-PPC-VMEb board featuring two T2081 QorIQ® processors the full power of them being available in a legacy VME chassis considerably enhancing the processing power per slot when retrofitting a VME system.

By constantly improving its numerical simulation tools and its experiment benches, Interface Concept keeps on developing new thermal management solutions. Together with industrial and academic partners, the R&D effort is particularly directed towards the topics of conductivity and innovative heat spreading solutions for air cooled and conduction cooled designs.

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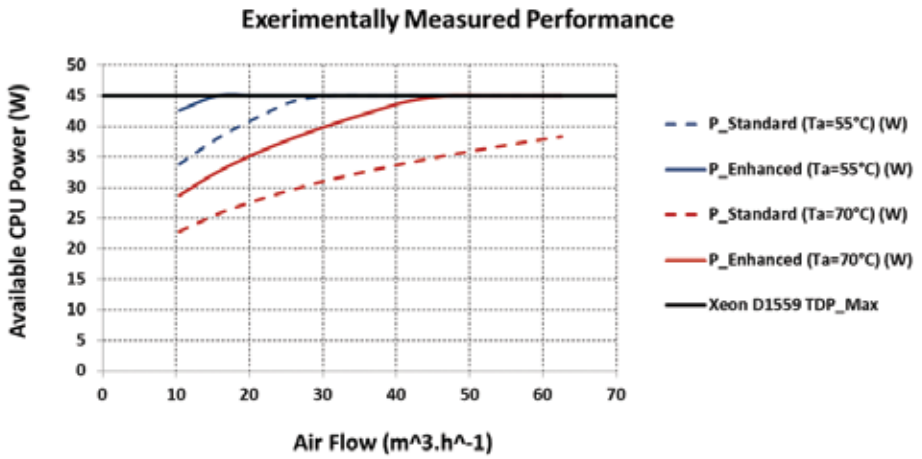

Figure 4
Comparison between standard and enhanced solution tested in the same chassis.