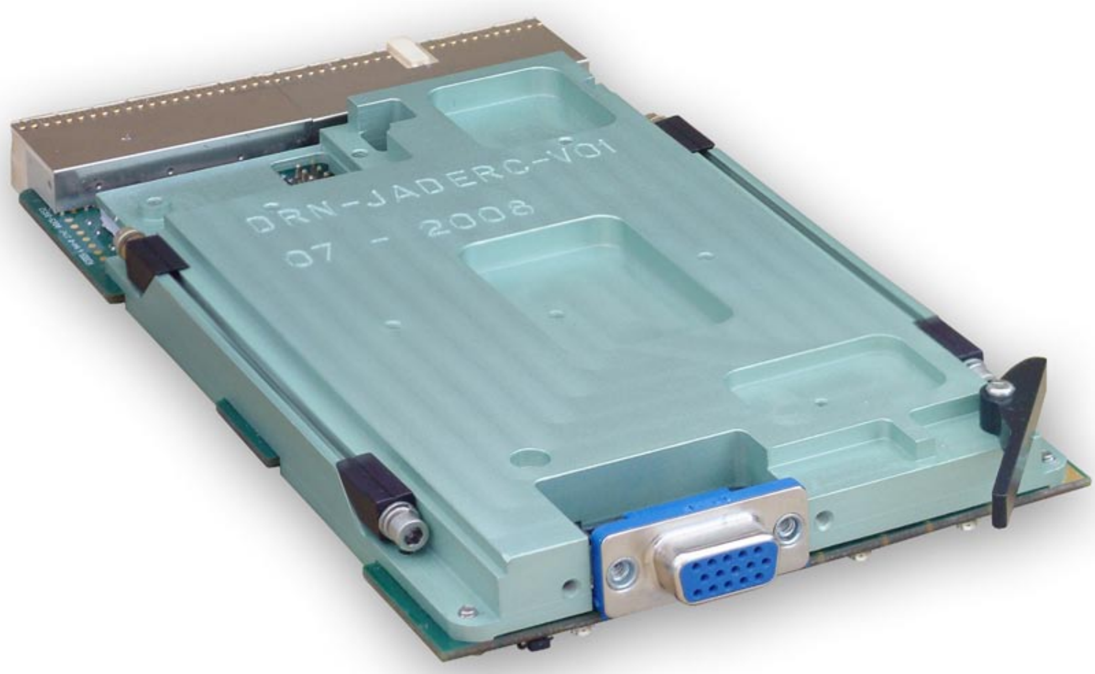
# » Kontron Whitepaper «




## Conduction Cooling Techniques for Rugged Computers

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Conduction cooling for modular embedded computers have been used for many years in applications where air cooling is not appropriate. Standardization efforts in that domain have early helped to maintain interoperability of COTS products. The conduction cooled design techniques are continuously improving to meet the requirements for higher power dissipation and lower price.

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## Why using conduction cooled board computers

Conduction cooled boards have traditionally been employed in applications where heat evacuation with an airflow is impractical. These include situations where there is no air available such as space applications, where the air is not efficient enough to carry all the calories at the right speed. This also includes environments where creating an airflow with moving parts would affect the reliability of the system.

Computers running in harsh environments can often benefit from conduction cooled techniques. Extended board temperature specifications, for example between -40 and 85°C, require optimized thermal performance to lower the temperature difference between the silicon dies and the environment. But also, their reliability is often critical and the high level of shocks and vibrations would prohibit the use of fans.

Another situation where conduction cooling is helpful, is the design of a sealed computer box to avoid exposing the electronics to dust or contaminant, for example kerosene vapours.

## COTS approach to conduction cooled modular computers

COTS mechanical rules for conduction cooled modular board computers in the eurocard form factor were standardized in 1992 by IEEE Std 1101.2-1992 in order to ensure interoperability and common good practices. Thanks to this standard, conduction cooled boards and chassis selected from different vendor catalogues all work together.

This IEEE standard mainly defines the mechanical dimensions and thermal interfaces for eurocards like VMEbus or other form factors such as CompactPCI. It was originally intended to evacuate the heat to the chassis from the bottom of the PCB plugged in module and along the card guides. In that case, the PCB is designed with an embedded conductive layer in order to move the calories toward the PCB edges.

As the thermal dissipation requirements increase, this thermally conductive PCB layer is often replaced with a metal drain, machined from aluminium, which covers the whole top side of the board. And any direct contact of the electronic components is through a thermal paste.

This technique, sometimes called the ruggedizer, not only improves thermal performance, but also helps to sustain a high level of shock and vibration by providing a rigid frame to attach the board at multiple points. It also helps the board vendors to offer the same electronic design in a standard air cooled and conduction cool version. The only penalty to the standard air cooled design being not to place components too close to the card guide area. Figure 1 shows the Kontron PowerEngine7 board running at up to 1 GHz, as an example of the ruggedizer which is compatible with IEEE Std 1101.2.

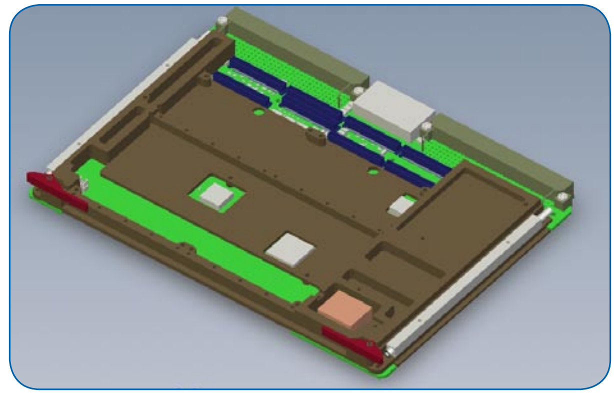

Figure 1: Conduction cooled board computer compatible with IEEE Std 1101.2: PowerEngine7 from Kontron

The wedge lock mechanism along the card guides, defined in the norm, secures the card inside the chassis and applies pressure on the thermal interface between the drain and guide in order to improve the thermal performance.

In addition to IEEE Std 1101.2, other international standards are available to define the conduction cooled practices for modular computers, such as VITA 47 and VITA 20. ANSI/VITA 47-2005[R2007]. These standards normalize the different severity level of environments for air cooled, conduction cooled, liquid cooled and spray cooled boards. Related standards not addressed in this paper, and specifying conduction cooled implementations for Eurocard, are VITA 48 describing VPX VITA 46 mechanical implementations and VITA 57 dealing with FMC mezzanines.

ANSI/VITA 20-2001[R2005] defines the rules for designing conduction cooled PMC mezzanine cards and their associated mother boards. The heat of the daughter cards is propagated to the motherboard through two mandatory thermal bars and two optional thermal ribs, arranged on Figure 2 representing a conduction cooled graphics card, the Kontron XMC-G72. This graphics card, engineered for air cooled and conduction cooled environment, features a state–of-the-art dual display capability based on ATI HD2400 graphics processor.

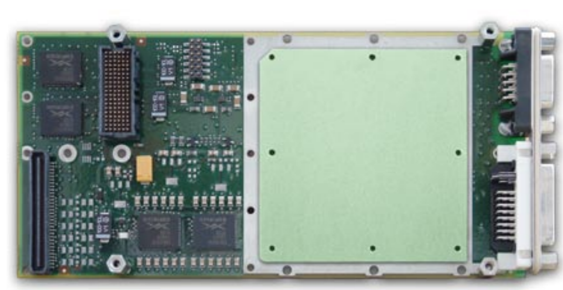

Figure 2: Conduction cooled graphics PMC mezzanine, the Kontron XMC-G72.

## Further refinements for conduction cooled heat drain

To limit the cost of qualifications and inventories, modular boards offered in both air cooled and conduction cooled versions, are sometimes build from a mixed PCB outline allowing both types of cooling. This is illustrated in Figure 3 with the Kontron ITC-320, a single or dual core processor board featuring an Intel® Core™2 Duo, Core™ Duo or Intel® Celeron® M processor in the 3U CompactPCI form factor.

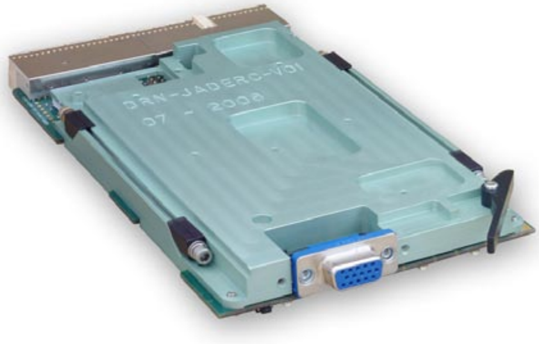

Figure 3: The Kontron ITC-320 Intel® Core™2 Duo processor board

It can also be noted on Figure 3 that half of the wedge lock mechanism is integrated inside the thermal drain. This feature reduces the thermal impedance of the drain to the chassis by increasing the section of the thermal path available to conduct the heat. In other words, it allows to reduce the component keep out area along the sides of the card while increasing the thermal conductivity.

## Extending the thermal performance with heat pipes

For the highest thermal dissipation and thermal density, heat pipes can be very effective in conduction cooled environments. Figure 4 shows the Kontron PowerNode5 processor board which features two 64 bits PowerPC processors running at 1.6 GHz in a conduction cooled environment.

The calories generated by each processor with a significant thermal density are evacuated through two heat pipes towards each side of the board. The first benefit of this is to take advantage of the extraordinary high thermal conductivity of heat pipes as compared to passive metal. The second benefit of these heat pipes is that they provide a floating copper caps to contact the dissipating die with precision, limiting heat losses at the die thermal interface.

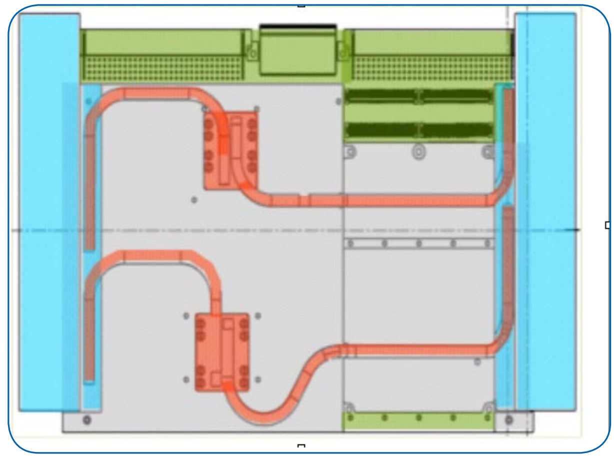

Figure 4: PowerNode5 dual PowerPC processor board running at 1.6 GHz in conduction cooled environment

It should be noted that the heat pipes are arranged in a symmetrical topology from the die, allowing the assembly to be less sensible to gravity or acceleration. Regardless of the card orientation, if one heat pipe becomes less efficient because of acceleration or gravity, the symmetrical heat pipe will compensate through improved thermal performance.

This compensation effect has been clearly validated by testing the equipment in a centrifuge.

Another key feature of the heat pipes is the capability to pre heat a device cooled by a heat pipe up to a temperature that is compliant to its specification before applying the power to the board. When the board is at very low temperature, the heat pipe internal liquid is frozen, hence, it is easier to heat the die with an external device with a good efficiency since the thermal path to the cold wall is blocked.

Note to Readers: Some of the characteristics described in this article are protected through pending patents of Kontron.

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## About Kontron

Kontron designs and manufactures standard-based and custom embedded and communications solutions for OEMs, systems integrators, and application providers in a variety of markets. Kontron engineering and manufacturing facilities, located throughout Europe, North America, and Asia-Pacific, work together with streamlined global sales and support services to help customers reduce their time-to-market and gain a competitive advantage. Kontron's diverse product portfolio includes: boards and mezzanines, Computer-on-Modules, HMIs and displays, systems, and custom capabilities.

Kontron is a Premier member of the Intel® Embedded and Communications Alliance.

The company is a recent three-time VDC Platinum vendor for Embedded Computer Boards. Kontron is listed on the German TecDAX stock exchange under the symbol „KBC".

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