PRODUCT SAFETY and IMPLEMENTATION GUIDE

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kontron

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1.0	Initial issue; Attachment B-1 added	6-Feb-2008

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Disclaimer

Document Applicability

This document is applicable to all Kontron products. It is to be considered as part of any and all documentation (electronic or paper form) relating to hardware, software, and services provided by Kontron.

The safety information and instructions contained in this document must be read and understood by all persons who handle, integrate, maintain, or operate Kontron products prior to performing such activities. They are in addition to any other safety information or instructions provided by other Kontron documentation.

The implementation guidelines are provided to assist users in achieving optimal performance of their Kontron products. Some guidelines are general in nature, however, most set forth provisions which must be complied with in order to ensure proper operation of the Kontron product as well as other system components.

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Explanation of Symbols

Caution, Electric Shock!

This symbol and title warn of hazards due to electrical shocks (> 60V) when touching products or parts of them. Failure to observe the precautions indicated and/or prescribed by the law may endanger your life/health and/or result in damage to your material.

Please refer also to the section “High Voltage Safety Instructions” on the following page.

Warning, ESD Sensitive Device!

This symbol and title inform that electronic boards and their components are sensitive to static electricity. Therefore, care must be taken during all handling operations and inspections of this product, in order to ensure product integrity at all times.

Please read also the section “Special Handling and Unpacking Instructions” on the following page.

Warning!

This symbol and title emphasize points which, if not fully understood and taken into consideration by the reader, may endanger your health and/or result in damage to your material.

Note ...

This symbol and title emphasize aspects the reader should read through carefully for his or her own advantage.

PART 1

Safety

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1. General

1.1 About This Guide

This guide is intended to familiarize users with the safety requirements for Kontron products. Attached to this guide are safety issue documents as appendices which address specific safety subjects. Section 5, part 1, provides a current listing of all available safety issue appendices.

1.2 Safety Issue Clarification

In the event a safety issue is not addressed in this guide or requires further clarification, contact Kontron's Technical Support for assistance before proceeding with any further implementation or operational activities.

2. Compliance

Compliance with the safety information and instructions provided by this guide is required to prevent serious injury to or death of personnel, damage to the involved equipment, or improper operation of the product or system in which the product is installed.

3. Disclaimer

Kontron disclaims any liabiility for damages to personnel or equipment or other losses incurred as a result of non-compliance with the safety information and instructions put forth in this guide.

4. Explanation of Symbols

This section will be supplied in a future revision.

5. Safety Issue Listing

The following table provides a overview of all safety issues addressed in this guide. When a safety issue document is revised, the appropriate entries in this table will be revised to reflect the current status of the document. The respective safety issues are attached as separate documents to this guide and are to be considered as part of this guide and the product documentation.

Table 1: Safety Issue Document Listing

PUB ID	REV	DOI / DOR	SUBJECT / REMARKS
		06.02.2008	As of this date, no applicable safety issues have been added.

PART 2

Implementation

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1. General

1.1 About This Guide

This guide is intended to familiarize users with implementation requirements for Kontron products.

1.2 Topic Clarification

In the event a topic is not addressed in this guide or requires further clarification, contact Kontron's Technical Support for assistance before proceeding with any further implementation activities.

2. Compliance

Failure to comply with the implementation information and instructions provided by this guide can result in damage to the involved equipment, or improper operation of the product or system in which the product is installed.

3. Disclaimer

Kontron disclaims any liabiility for damages to equipment or other losses incurred as a result of non-compliance with the implementation information and instructions put forth in this guide.

4. Implementation Issue Listing

The following table provides a overview of all implementation issues addressed in this guide. When an implementation issue document is revised, the appropriate entries in this table will be revised to reflect the current status of the document. The respective implementation issues are attached as separate documents to this guide and are to be considered as part of this guide and the product documentation.

Table 1: Implementation Issue Document Listing

PUB ID	REV	DOI / DOR	SUBJECT / REMARKS
1021-9142.B-1	1.0	I - 06.02.2008	Thermal (initial issue)

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PART 3

Attachments

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Implementation Issue

B-1

Thermal

Table of Contents

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1. Thermal Considerations

Kontron products are designed to be operated in a wide range of thermal environments. Basic thermal management mechanisms have been incorporated, and, depending on the application requirements, there are configurations available which should satisfy most situations. Still it is necessary for system integrators to be aware of certain concepts and capabilities when projecting overall system thermal management. The following provides more detailed information concerning aspects that must be considered before the product is integrated in an application system.

2. Thermodynamics Terminology

In order to facilitate understanding the factors involved in the thermal considerations being discussed here, the following definitions are provided.

Table 1: Thermodynamics Terminology Definitions

TERM	DEFINITION
Heat	The thermal energy of a body.
Cooling	1. Reduction of the temperature of a body. 2. The transfer of heat (thermal energy) from a body to another body or a fluid (liquid or gas). Cooling is a somewhat relative term when applied to systems which generate heat due to the continuous application of external energy. In general, continuous operation without "cooling" would lead ultimately to the destruction of board components. With cooling, however, board components are allowed to operate within a range of higher temperatures than would otherwise be possible. Cooling in this case means maintaining a working temperature that does not exceed the specified maximum operating level.
Conduction	The cooling of a body by means of direct contact with another body whose temperature is lower. Modern industrial computers employ heat sinks as their primary thermal interface with board/module components. This interface uses conduction to transfer thermal energy to the heat sink. Secondary cooling is then achieved either by conduction or convection.
Convection	The cooling of a body by means of the use of a fluid (liquid or gas) whose temperature is lower. Convectional cooling always requires that some fluid is moved over a body and that the fluid temperature is lower than that of the body to be cooled.
Free or Natural Convection	Free or natural convection relies on the buoyancy of the fluid caused by the transfer of heat from the body to be cooled to the fluid. This results in a very minimal amount of fluid flow which, depending on the temperature of the fluid and the amount of fluid available, may be sufficient to cool the body.
Forced Convection	Forced convection relies on the forceful movement of a fluid across a body caused by the application of external energy. In most cases, the fluid would be ambient air which is forced over the board/module.

Table 1: Thermodynamics Terminology Definitions

TERM	DEFINITION
Radiation	The transfer of heat from a body by means of thermal radiation. Radiation as a means of cooling is not normally feasible with industrial computer systems.
Ambient Air	The air occupying the immediate space surrounding a body to be cooled. For cooling to take place using ambient air, the ambient air must pass over the body to be cooled and the ambient air temperature must be lower than that of the body to be cooled.
Ambient Air Temperature	The temperature of the ambient air surrounding the body to be cooled. When applied to convectional cooling, it is the temperature of the ambient air directly prior to its flowing over the body to be cooled.
Air Flow	Movement of ambient air across a body to be cooled. The flow of ambient air is critical to convectional thermal management in particular if the ambient air is recycled (reflowed over the body to be cooled). Continuous recycling without cooling of the ambient air will quickly lead to overheating. In addition, the cooling effect of air flow in itself is limited. It requires a minimum velocity in order to have any cooling effect at all, and above a given velocity no further increase in real cooling effect is achieved.
Heat Spreader	A mechanism to achieve a rapid transfer of heat away from one body to another.
Heat Sink	A mechanism to achieve a (rapid) transfer of heat away from a body and to act as a transport medium to another body or fluid.
Heat Pipe	A special form of heat spreader which employs both conduction and convection in a discrete body to achieve a rapid transfer of heat from one body to another or to a fluid.
Fan-Less	Fan-less is used to describe a board or module which does not have a cooling fan directly attached to it. It **DOES NOT MEAN** that the board or module does not require some form of additional cooling (e.g. external system fan, air conditioning, conduction cooling, etc).
Passive Heat Sink	The term passive heat sink is used to describe a heat sink which does not have a cooling fan directly attached to it. It **DOES NOT MEAN** that some form of additional cooling is not required. In most cases, forced-convection cooling is required for products with this type of heat sink.
TDP	**T**hermal **D**esign **P**ower (TDP): TDP is determined by the CPU manufacturer and is defined as the typical maximum power consumption that needs to be considered when specifying thermal management (cooling) requirements for a CPU. It is not the maximum power that a CPU may consume.
Housing	An enclosure for system components.
Shelf	A special type of housing which provides an enclosure for system components which can be installed in a chassis (cabinet).
Chassis	A special type of housing which provides an enclosure for shelves. Normally this is an equipment cabinet which is designed to accommodate at least two shelves. The chassis usually provides for interconnection cable routing, air flow routing, and other functions not provided by the shelves.

3. System Environment

Unless otherwise specified, all Kontron products, boards as well as systems, are designed for an immediate environment of ambient-air forced-convection cooling. Kontron supplies operating temperature specifications for all of its products and, for particular products, air-flow-rate verses ambient-air temperature charts to aid in the determination of basic thermal management requirements. Figure 1 is an example of such a chart in a product user guide.

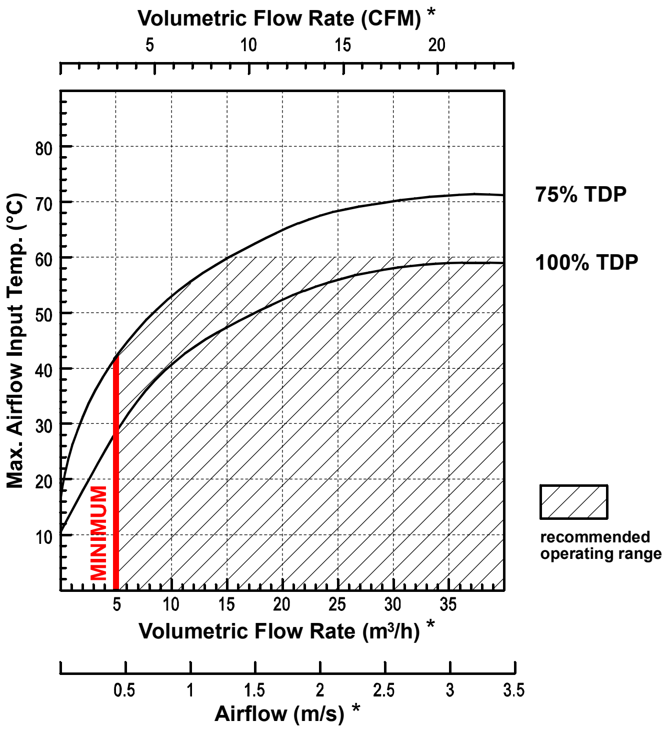
Thermal management, however, is a function of many requirements and restrictions which must be satisfied when designing and implementing a system. Not only the individual components must be considered, the application as well as the immediate and secondary environments also play major roles.

Starting with the packaging of individual components in an open or closed housing, the provision of a cooling medium is the first consideration. If a closed chassis is required, the immediate environment must provide some form of conduction cooling and the components involved must be capable of being cooled conductively. If conductional cooling is to be implemented, a comprehensive empirical thermal design analysis and verification must be performed prior to implementation to ensure safe and proper operation.

If components are packaged in an open chassis, forced-convection cooling may or may not be required. This will depend on the components involved and the capability of the immediate system environment to support adequate free-convection cooling. In most cases, however, a specified minimum amount of ambient-air forced-convection cooling will be necessary.

Application thermal design is and remains the responsibility of the system designer or integrator. Kontron has, however, a vested interest in the successful integration of its products and is ready to provide assistance as required. For further information, please contact Kontron Technical Support: e-mail: support@kontron-modular.com; telephone: +49(8341)803-333.

Figure 1: Sample Airflow Chart



The thermal design power (TDP) curves shown on this chart are representive for an expected maximum load (75% TDP) and a typical maximum load (100% TDP).

The shaded area is the product's operational envelope for the TDPs indicated. Operation of the product outside of the envelope is not permitted.

The recommended maximum operating ambient air temperature is 60°C (as indicated by the shaded area) above which the product should not be operated no matter what the application load is.

This chart indicates that provided sufficient airflow is available the product can be operated at 100% TDP up to almost 60°C ambient air temperature.

* Refer to section 6.8 for further information on airflow measurement.

4. System Standards

Depending of the basic type of product (VME, CPCI, ATCA, AMC, and µTCA) there are standardized specifications for various aspects of thermal management. These range from the basic board layout and components to requirements on system chassis and shelves.

In any event, the mechanical design of a system should take into consideration the applicable specification for the product type involved in order to achieve the best possible compatibility of all system components.

The following table lists basic specifications for various types of products.

Table 2: System Standards

TYPE OF PRODUCT	APPLICABLE SPECIFICATIONS
VME	ANSI/VITA
CPCI	PICMG 2.0
ATCA	PICMG 3.0 CP-TA
AMC	AMC.0 (PICMG)
µTCA	MicroTCA (PICMG)
VME, CPCI, ATCA, AMC, µTCA	IPMI (Intel)
VME, CPCI	ARINC 404A, VITA 30.1, MIL-C-38999, MIL-STD-91403
EQUIPMENT, BUILDINGS	NEBS, ETSI

5. Operational Thermal Management

Operational thermal management not only includes basic maintainenance of operational temperatures, it can also address temporary performance requirements as well as exceptional situations which are not within the foreseen operating envelope. This can range from short term performance increases after which performance is reduced until the system is again with the operational envelope to a longer term operational temperature increase at the cost of reduced performance.

Because no two applications or application environments are the same, system integrators should take full advantage of all of the capabilities provided to insure the maximum reliability, availability, and operational safety. As most applications have a reasonable amount of thermal flexibility, it is normally possible to define a satisfactory operational environment.

In the event of any uncertainties or more stringent requirements, please contact Kontron Support for further assistance.

The following figure illustrates a situation where a system is operated at 40° C and an Airflow of 2 m/s. OP 1 assumes operation at ca. 60% TDP which for this application would be the normal operating load. OP 2, for example, indicates that it would be possible to increase the load to 85% TDP and still be within the permissible operating range.

Figure 2: Operating Range Example

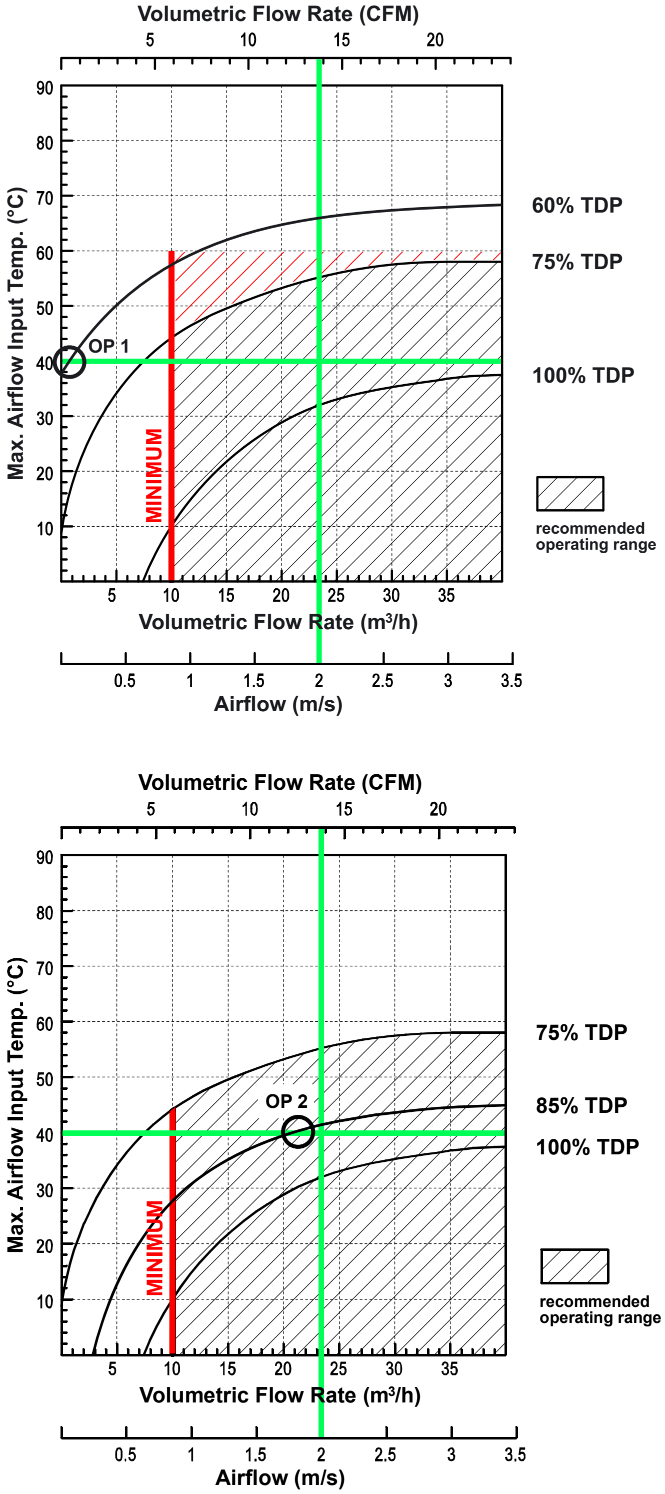


Chart Legend:

OP 1	Operating point 1
60% TDP	normal application operation load
shaded areas	operating range not to be exceeded for TDP indicated
60°C	ambient air temperature above which the product must not be operated
green lines	indicate operation parameters: ambient air temperature and airflow rate
red line	indicates absolute minimum airflow rate required below which the product must not be operated

Chart Legend:

OP 2	Operating point 2
85% TDP	increased application operation load
shaded areas	operating range not to be exceeded for TDP indicated
60°C	ambient air temperature above which the product must not be operated
green lines	indicate operation parameters: ambient air temperature and airflow rate
red line	indicates absolute minimum airflow rate required below which the product must not be operated

6. Specific Recommendations

6.1 Enclosures

6.1.1 Basic Types

Industrial computer enclosures fall into two basic categories:

- closed housing, and
- open housing.

Use of a closed housing requires special consideration with regards to thermal management as the means of transferring heat from internal components to the outside world is restricted and can be quite complex in comparison with an open housing.

In any event, system designers and integrators should contact Kontron Support for further assistance before implementing systems using closed housing.

6.1.2 Closed Housing

As the name implies, this type of enclosure fully encloses its contents and seals it off from the surrounding environment. By design, the operational configuration precludes air flow into or out of the enclosure. Components installed in this type of enclosure must be capable of conduction cooling and the enclosure itself must also be provided with some form of cooling to ensure that the component’s operational temperatures are not exceeded.

Failure to comply with these requirements will result in improper operation of the system and most likely in thermal damage to system components.

6.1.3 Open Housing

Enclosures of this type are basically designed to permit ambient air circulation within the structure. Mechanically they are usually so designed that they support free as well as forced convection. They can range from relative simple designs with open bottom and open top to complex shelves with air channels and push/pull forced airflow.

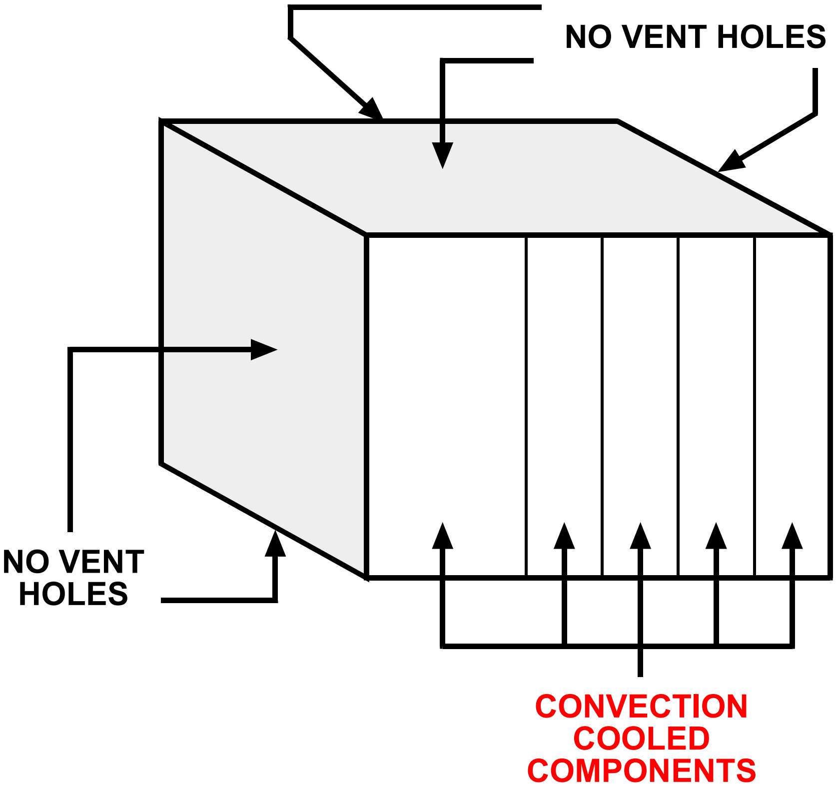
The basic design criteria is, however, that the enclosure must be able to support the thermal energy dissipation requirements of the sum total of all components installed within the structure.

Kontron supplies thermal managment information for all of its products. This includes not only operating temperature ranges, but power dissipation requirements as well as supervision and control information which can be used to support a very comprehensive system thermal management concept.

6.1.4 Housing Examples

The following figures illustrate various type of component enclosures.

Figure 3: Closed Housing, Convection Cooled Components



This type of enclosure configuration does not provide for any form of convection cooling. There are no air ventilation holes and there is no provision for a fan to circulate air.

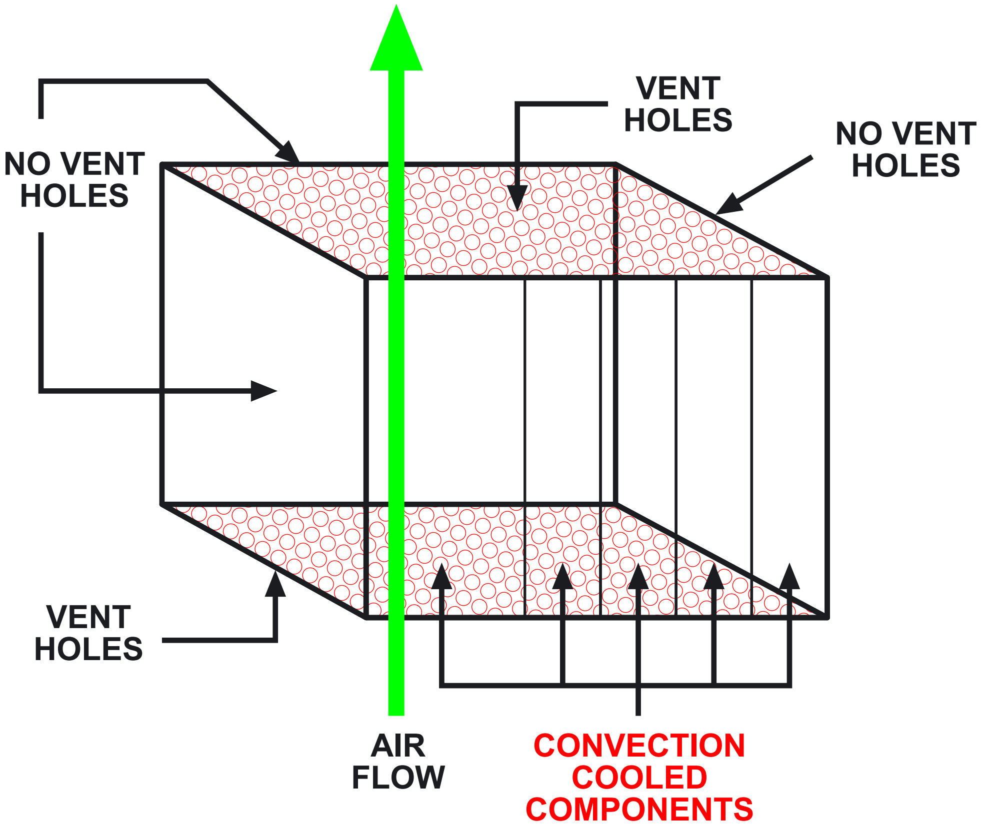
If an application requires this type of enclosure, the system designer or integrator bears the sole responsibility for its functioning and must verify that adequate component cooling is gurananteed before integration in an application.

Warning!

Kontron disclaims any and all liability for damages or improper operation resulting from use of its **convection** cooled products in the configuration indicated in Figure 3 above.

In any event, if such a configuration is required, contact Kontron technical support for assistance **before committing to the implementation** of this type of configuration.

Figure 4: Open Housing, Internal Convection Cooling



This type of enclosure configuration provides for free as well as forced convection cooling. Forced-convection cooling can be achieved by installing a fan or fans underneath the enclosure or on top of it, or if required both underneath and on top.

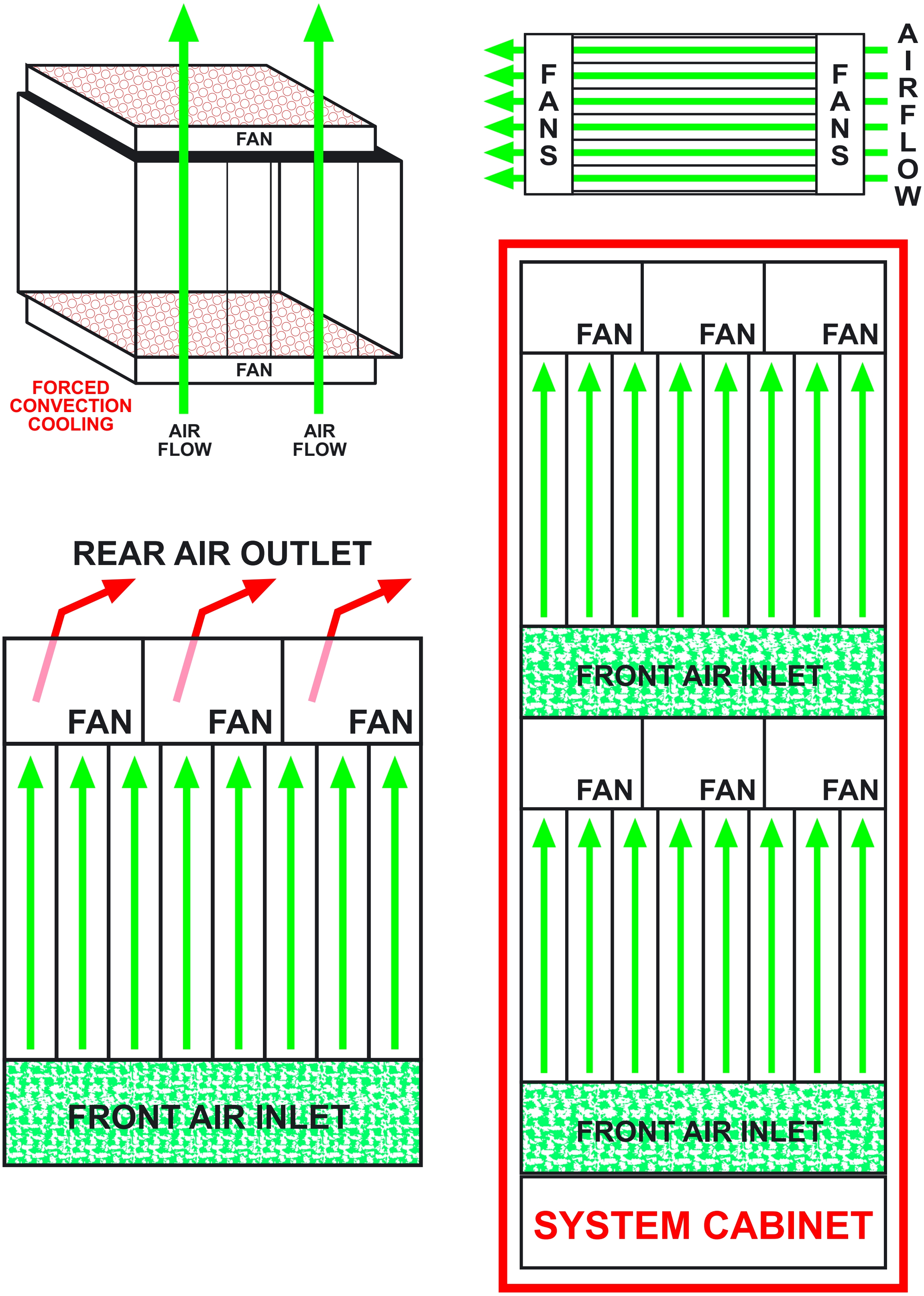
For applications which use this type of enclosure, the system designer or integrator must verify that adequate component cooling is gurarateed before integration in the application. In particular, the ventilation openings or holes must be of sufficient size as not to obstruct air flow through the chassis.

Warning!

Kontron disclaims any and all liability for damages or improper operation resulting from use of its convection cooled products in systems which do not provide for adequate component cooling.

As cooling, in particular in high performance systems, is a critical operational factor, Kontron recommends contacting its technical support for assistance **before committing to the implementation** of this type of configuration.

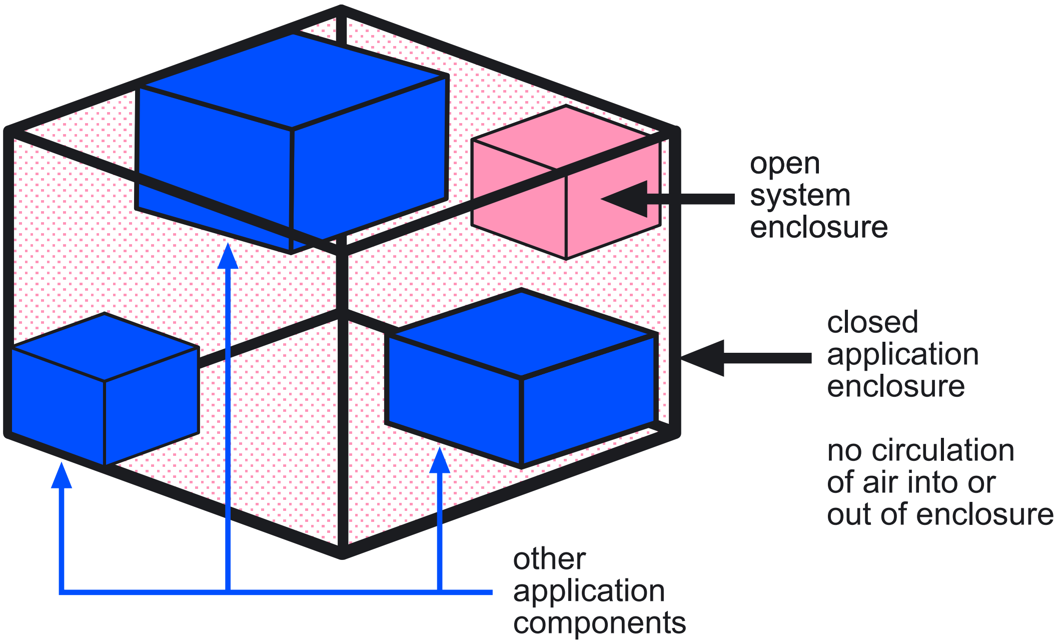
Figure 5: Examples Of Convection Cooling Enclosures



6.1.5 Application Example

With the multitude of possible applcation requirements and system configurations it can be difficult to define a design that will guarantee satisfactory operation. The following figures illustrate a common pitfall and a way to avoid marginal performance.

Figure 6: Typical Application Design Misconception

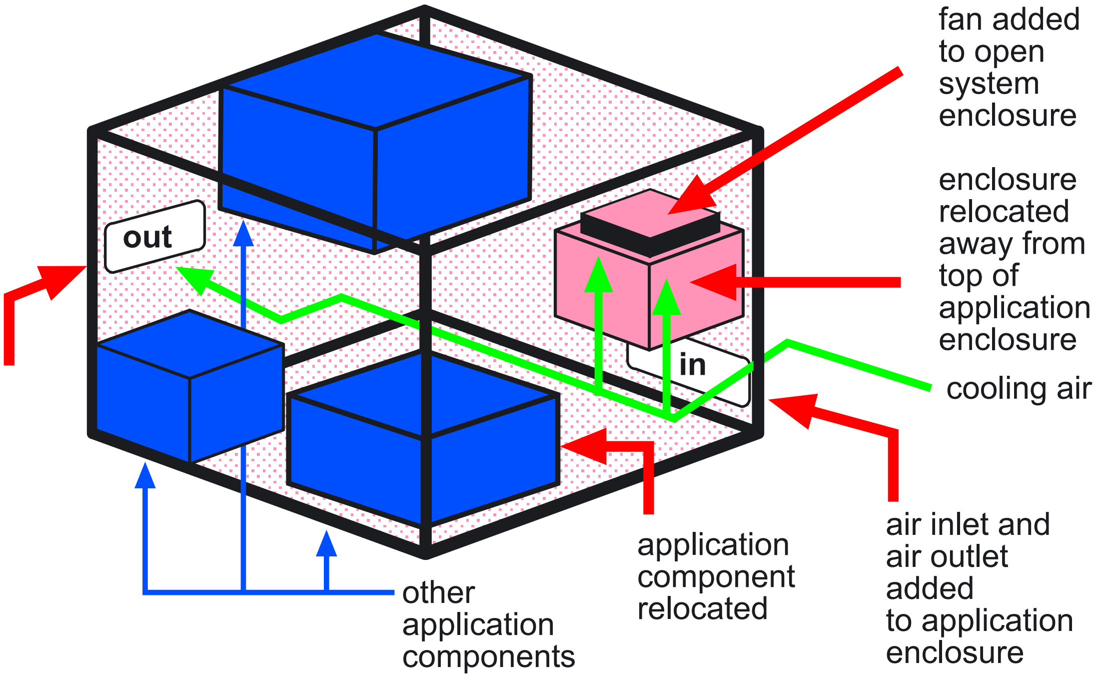


Although the system enclosure is open in the above figure, there is not only practically no possibility of convection cooling (the application enclosure is “sealed” on all sides), there are other heat producing application components installed within enclosure. In addition, the system enclosure is so mounted (at the top of the application housing and no clearance above the housing for air circulation) that any cooling reserve remaining in the application is effectively exhausted.

As this type configuration is demonstrative for many applications, system designers and integrators must pay particular attention to air flow not only in the immediate environment, but also in the secondary environment. In the example above, providing for air flow to the system enclosure would only be the first step. The next would be to provide air flow into and out of the application enclosure. It might even be necessary to provide baffles or ducting in the application enclosure to ensure adequate cooling.

The following figure illustrates one possible solution for the example design.

Figure 7: Thermal Solution for Example Application



As with any proposed solution, it must be verified before committing to implementation. This is and remains the responsibility of the system designer or integrator.

6.2 Temperature Sensing

In many cases, temperature sensing is provided by CPUs and CPU boards which can be monitored either by the application or in some cases by the operating system. Applications can make use of this information either to control the operating temperature of the board or invoke measures to protect the board or system from damage due to overtemperature. Refer to the product documentation for information concerning temperature sensing.

6.3 Fans

When forced convection is required, normally one or more fans are installed in the enclosure. In larger systems, this can also take the form of one or more fan tray(s) with as many fans as there is space available. The physical placement of fans is only restricted by the capability of the fans to provide the necessary forced convection.

Forced convection requirements determines the performance requirements of fans in a system. Often the performance of one fan is not enough or the system configuration is such that one fan cannot fufill the requirements. In some cases it may be desirable to control fan speed to vary the fan performance. In such cases the fan as well as the system must support this function.

As the ambient airflow through a forced-convection system is the most critical component of thermal management, it must be guaranteed that the cooling airflow is sufficient to satisfy system requirements, and that in the event of airflow failure or disturbance the system will detect this and take measures to protect system components from being damaged.

In addition, when implementing fans for forced-convection cooling the following apects must also be considered:

- Fans are mechanical devices and as such are subject to total failure without warning.
- Should not be used in systems which cannot be powered down for fan replacement.
- Fans have resonant frequencies which can affect the operation of hard disk drives which may be installed in the system. Refer to the product data sheets for both the fans as well as the hard disk drives for further information concerning resonant frequencies.

6.4 Air Filters

Normally it is recommended where possible to install air filters in a forced-convection system. Even in relatively “clean” environments, dust can accumulate within a system and decrease the effectiveness of the forced-convection cooling. This can lead to higher operational temperatures within the system and reduce the operational lifetime of system components.

To be effective, placement of air filters must be on the air inlet side of the system preferably at or near the inlet to the card cage itself.

As the filter itself reduces air flow it must also be taken into consideration in the thermal management concept.

Periodically air filters need to be replaced to maintain thermal management efficiency. Replacement interval is a function of the surrounding environment, however, it is recommended to replace them at least once every year.

6.5 IPMI

Intelligent Platform Management Infrastructure (IPMI) is a concept to provide support for active system supervision and control of industrial computer applications. When implemented in hardware and software, it can provide active as well as passive thermal management functions.

Depending of the level of implementation, it can provide support at the board level, the shelf level, and the chassis (cabinet) level. Through the supervision of various thermal aspects, it can, when coupled with appropriate hardware and software, control and manage the complete thermal household of application systems.

Many Kontron products provide comprehensive support of IPMI. In particular, newer CPCI CPU boards as well as ATCA and AMC products support IPMI extensively. For more information concerning IPMI functionality refer to the specific product User Guide and the appropriate application standards (CPCI, ATCA, AMC, MicroTCA).

6.6 Backplanes

Backplanes play a major role in thermal management in as much that they provide the necessary connectivity between individual components, in particular fan control signals and support of the IPMI concept. For this reason, system designers and integrators must verify thermal management requirements against the functionality provided by the backplane.

6.7 Air Flow Routing

The basic product layout determines the possibilities for air flow routing over the product. Blade type products provide the capability to flow air over the entire length and height as well as over the front and rear sides of the board. Alignment of such boards to each other in a shelf is parallel, either vertically or horizontally.

Within the shelf, air flow routing is a function of the mechanical design of the shelf. There are horizontal as well vertical oriented shelves on the market each with its own specific air flow routing over which system designers and integrators have little or no control. One exception to this is the use of slot fillers with baffles to occupy empty slots within a shelf. These fillers ensure that air flows properly to each occupied slot and must be installed to ensure proper cooling. In addition, inter-board cabling within the chassis must not obstruct airflow. In particular, flat-band cables must be routed so as not to block airflow.

Air flow routing external to the shelf is, however, the responsibility of the system designer or integrator. When shelves are built into chassis (cabinets), it must be ensured that there is adequate air inlet as well air outlet capability. This can be a very difficult undertaking if more than one shelf is installed in a chassis or other components are installed which hinder airflow. In particular, outlet air from one shelf should not become the inlet air for another shelf or worse, chassis outlet air recycled to chassis inlet air without some form of temperature conditionining.

As the operational temperatures within a chassis can become quite warm (> 50°C), care must be taken that hot outlet air is not flowed directly over interface cabling at the rear of the shelf. It particular, air flow over cables in excess of 75°C must be avoided.

6.8 Air Flow Measurement

The Airflow charts provided with the product documentation indicate two types of airflow rate:

- Volumetric, expressed in CFM and m^3/h
- Velocity, expressed in m/s

The volumetric flow rate is determined empirically using special test equipment under laboratory conditions. The velocity flow rate is determined mathematically based on the volumetric flow rate results and is provided as an aid to system integrators for verifiying compliance of forced-convection cooling solutions.

In the praxis, a thermal anemometer can be used to measure the airflow velocity in an application chassis. The results provided by such a device should be able to indicate if the airflow is at all adequate according to the Airflow chart. When performing such measurements, the system should be configured as close to the actual application as possible and the airflow measured at various points across the board.

Although the airflow may be in compliance with the Airflow chart, the board temperatures (CPU and board sensors) must be within their specified operating ranges. If not, then the airflow rate must be increased or the ambient-air temperature reduced.

Increasing airflow rate is a function of two things. First, the ability of the forced-convection mechanism (chassis internal or external fans) to supply additional airflow, and second, the routing of air across the board. If the chassis in which the board is installed is too open or does not properly channelize airflow to the board, then increasing airflow will be very difficult if not impossible. Therefore, it is imperative that proper routing of airflow is guaranteed within the chassis.

6.9 Conduction Cooling

Standard industrial computer components do not usually support conduction cooling. In order for system components to be conduction cooled, they must be physically so constructed that conduction cooling is at all possible. In addition, not only the components must be so constructed, the enclosure for such components must also be designed to support conduction cooling.

Blade type products can be provided with special types of heat spreaders and fixtures for mounting with a conduction cooling enclosure. The enclosure itself must, in turn, be provided with some form of cooling. Depending on the surrounding environment, this can be forced convection cooling or a second level of conduction cooling. In either event, the system designer or integrator is resposible for ensuring that the operational temperatures of system components do not exceed their limits.

The enclosures for conduction cooling are usually designed to support more requirements than just conduction cooling. As such enclosures are made to be sealed against the surrounding environment, they offer protection against hostile atmospheres (water, humidity, salt, acid, dust, oil, fungus, etc), and they are also designed to withstand severe shock and vibration.

For those Kontron products suitable for conduction cooling, a physical thermal reference point is provided in the specification for the product as a guide for verifying the application thermal design. The maximum temperature specified for the reference point may not be exceeded during operation.

6.10 High Temperature Operation

As a rule, higher operating temperatures will result in a lower operational life expectancy as well as a lower MTBF. Operation at or near the maximum permissible limits should be avoided where possible. For further information, contact Kontron technical support

6.11 Component Surface Temperatures

System designers and integrators must be aware that system operating temperatures can reach levels where precautions must be taken to ensure that maintenance or operations personnel are protected against burns or secondary injury resulting from contact with the surfaces of system components (heat sinks, front panels, enclosures, handles, metal cabel connectors, etc).