

Liquid cooled ATR chassis



- Conduction cooled ATR
- Independent dual liquid cooled side walls
- Modular design
- Field-proven High Integrity Frame construction
- 100 Watts per slot

BACKGROUND

The Air Transport Rack, ATR, although developed more than 40 years ago, has remained the primary mechanical format of choice for equipment packaging for use in fighting platforms deployed in air, sea and land theatres. Although the mechanical configuration of the ATR has remained essentially unchanged throughout its long operational life, manufacturers have had to respond to the challenges raised by the ever-increasing power requirements of the boards installed in the units, power which eventually has to be removed from the ATR units in the form of heat. Mean Time to Repair, MTTR, and weight saving without compromising the mechanical protection afforded by the rugged construction of the units are further major considerations for the manufacturer.

The ATR does a lot more than provide a mechanical housing for the PCBs it contains. It provides a benign environment in which, if required, COTS commercial grade electronics can operate reliably, thereby significantly reducing costs, cutting development times and minimising the delay from concept to full-scale deployment.

THE ELMA HIF SYSTEM

Elma-Mektron has, over the years, developed an extensive family of patented 'High Integrity Frame, HIF' ATR enclosures, based on a modular design, the heart of which is a high tensile strength frame, precision-machined from aluminium and consisting of a number of interlocking sections that incorporate EMC and hermetic gasket channels, secured together by locking dowel pins. The EMC and environmental sealing is extremely effective, environmental sealing to IP68 are achieved. Once the frame has been constructed

to the required size, outer panels of various designs are then added; this innovative technology combines low mass, excellent thermal efficiency and inherently high levels of manufacturing flexibility with significant cost benefits and reduced lead times. The HIF is typically some 25% - 30% lighter than alternative dip braised designs and it enables application-specific changes to be readily implemented without compromising thermal efficiency or structural strength. The enclosure is typically fitted with a rugged heavy-duty subrack that can be shock and vibration isolated if required. Constructed from high tensile strength extrusions with screwed-down one-piece aluminium card guides, the subrack is configurable for either horizontal or vertical board loading. The ruggedised, powered COTS system enclosures conform to ARINC specifications and offer outstanding versatility for use with VME, VME64 Extensions, VXS, VPX, CompactPCI, VXI, Multibus II, PC, SUNbus and proprietary bus structures. A wide choice of backplanes, I/O connector formats, power options and wiring harnesses are available as either military or commercial grade standard building blocks or custom designs. The enclosures are available in various sizes from ¼ width Short to 1½ width Long and are suitable for horizontal or vertical / top board configurations.

THERMAL MANAGEMENT

The HIF design supports all commonly used methods of cooling: conduction and both direct and indirect convection. The latest development is the introduction of dual redundancy air-liquid heat exchangers that enables up to 1500W to be removed from an ATR with, depending on the liquid used in the heat exchanger, a maximum thermal internal temperature of 85 degrees C.

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Units designed for conduction cooling feature panels with maximised surface areas to improve their efficiency as a heat sink.

CONDUCTION COOLING

Pure conduction cooling has the great merit of simplicity, albeit at the expense of limited thermal performance. The heat generated within the enclosure is conducted from the heat sources on the boards through to the outer surfaces of the enclosure and the heat is then given up to the ambient air. Internal heat pipes can be used to improve the system's efficiency without introducing electro-mechanical moving parts, but conduction cooling, while being the simplest and therefore most reliable method, is also the least efficient, so certain applications may necessitate an external fan to move the ambient air over the enclosure's outer surfaces. A conduction cooled ATR will typically be rated in excess of 25 Watts per slot.

DIRECT FORCED COOLING

Direct forced-air cooling is the most commonly used form of forced-air cooling; ambient air is forced by the use of fans over the heat dissipating electronic hardware. The use of plenum chambers, push-pull fan arrangements and internal baffles will ensure that the airflow is optimised throughout the ATR to best suit the configuration of the boards it contains. Direct cooling is an effective thermal management technique, although the EMC and environmental sealing will necessarily be degraded because of the provision of air entry and exit points. Other potential issues with direct cooling are the possible contamination of the interior of the ATR if the ambient air contains high levels of dust, moisture or salt. While filters can be used to good effect, in extreme conditions they will need to be cleaned or replaced at frequent intervals and there can be a severe reduction in the effectiveness of the cooling system when the filters become contaminated. An indirect air-cooled ATR will be rated at around 500 Watts.

INDIRECT FORCED COOLING

In an indirect forced-air cooling system, the internal and external environments are isolated from each other with the heat being removed via a side-mounted air to air heat exchanger. An internally mounted fan or fan array circulates the air across the active boards and through the internal side of the heat exchanger matrix; an externally mounted fan circulates air across the external part of the matrix, improving the heat transfer characteristics. Internal heat ladders and Peltier cooling devices can be used to improve the removal of heat from observed hot spots such

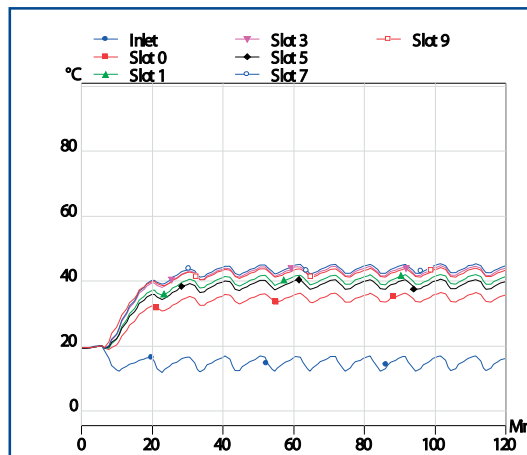
as processors, helping to improve the overall effectiveness of the system. While the indirect system has the obvious benefits of maintaining the isolation of the ATR from the external environment and offers increased thermal capacity, it does have some drawbacks. The ATR footprint is increased and a single system offers no redundancy protection in the event of fan failure in either the internal or the external channels. 40°C for a 100 Watt load is a typical figure for such a system.

LIQUID COOLING

The latest development of the Mektron ATR family is the liquid cooled version, developed from the company's field-proven air-cooled design that is already in service across numerous different fighting platforms. The liquid cooled ATR uses the same HIF construction as the other models in the range, but new side plates, fitted to both sides, provide redundancy, a reduced physical footprint and increased thermal capacity compared with the air cooled version. The side plate assembly consist of precision machined side walls, fluid carrying pipes, configured to avoid sharp bends, thermally conductive inserts and clamping brackets that can quickly be replaced as a complete sub-assembly in the field.

The new liquid cooled version supports a thermal budget of up to 1500W per chassis, enabling the

Load Power 1,000 W
Load Distribution 10 Slots
Average slot load 100 W
Ambient Temperature 19°C
Inlet Coolant Temperature 15°C Nominal
Inlet Coolant: Water @ 3m³ / m per side panel



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latest high performance boards to run well within their operating temperature envelope.

The dual wall modular design is a sophisticated sub-assembly that significantly reduces MTTR; the



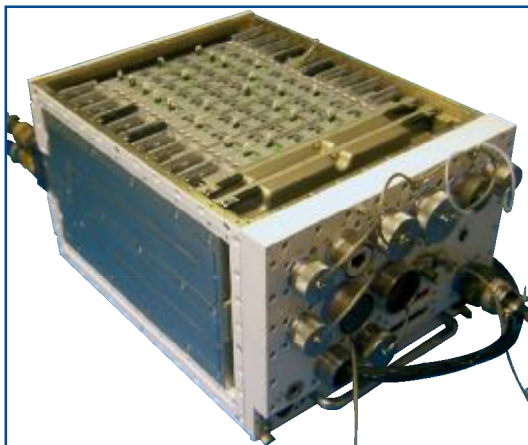
cooling sidewalls are Line Replacement Units, so a swap-out is a very simple process that can be carried out in the field.

Each side plate has its own feed and return, so as they are independent of each other, cooling is still provided in the event of damage to one side; the design also avoids running

pipework across the rear face of the chassis, the area most likely to be damaged if the unit is accidentally dropped.

Rated at around 1500W, the liquid-cooled version gives much more cooling capability than the other versions in the family, enabling full advantage to be taken of the more powerful processors now available.

Three versions using different materials, protective coatings and connectors are available, enabling seawater, aviation fuel or CFCs, ammonia or various alcohols to be used as the cooling fluid



to suit the application. Seawater, typically at a temperature of +15°C, is included as a cooling fluid, because as far as a naval application is concerned it is a free cooling. Although there is no volatile evaporation to assist with the cooling process, it is still cold enough to allow it to be a suitable cooling medium and, of course, the quantity available is unlimited. Similarly, while at first sight it may appear strange to use kerosene as a cooling medium, there are significant advantages for avionic applications. The fuel is already pumped around under pressure, so a dedicated pump is not required, saving weight. The fuel is already at -30°C in the fuel tanks and therefore it must be preheated before it can be burnt in the engine. The heat produced in the ATR, together with the waste heat from avionics and other systems is transferred into the onboard fuel before it is fed to the main propulsion unit, reducing preheat requirements. In closed loop systems with dedicated cooling fluids, the sidewall assemblies are available configured to suit various different refrigerants such as ammonia, carbon dioxide, sulphur dioxide or CFCs.

MTTF and MTTR are critical measures. The optional provision of intelligent flow control in the cooling circuit, in which the flow rates are automatically adjusted to maintain the optimum internal temperature irrespective of load variations and external conditions, ensures maximum life for the housed components. The fact that the two sides are completely independent of each other means that 50% cooling will still be available in the event of damage to one side, extending the in-service operational up time. If either of the cooling side assemblies is damaged, they are Field Service Line Replaceable Units and can easily be swapped out with minimal disassembly required. The liquid cooling side subassemblies are externally mounted onto the structural sidewall of the ATR, so the integrity of the sealed ATR is not compromised when they are removed. As a next-generation evolution of a field-proven design, the liquid cooled ATR combines a significant thermal performance enhancement over previous versions without losing the benefits associated with the well-established design and construction of the enclosure itself.



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