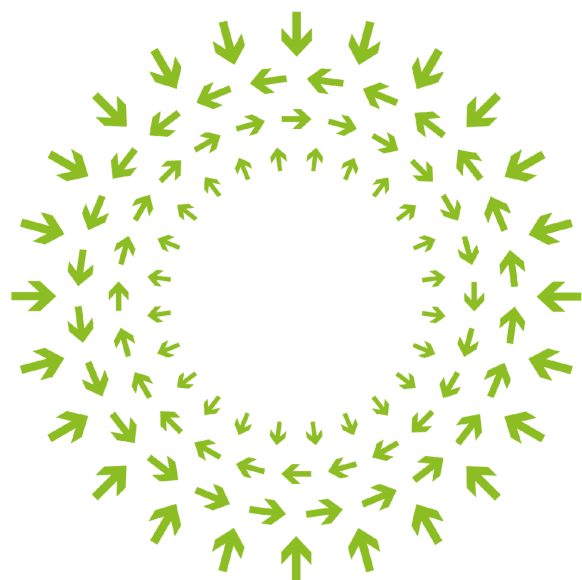




OPEN

Compute Project

Rack Management Controller v1 Specification

Revision 1.2

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2. Compliance with OCP Tenets

2.1 Openness

RM Cv1 utilizes a simple design with flexible interfaces to adapt to many liquid-cooling needs, particularly for AI/ML applications. It contains a DC-SCM 2.0 as a critical component of its functionality and aligns with the Open Systems for AI strategic initiative.

2.2 Efficiency

The design of RM Cv1 maintains a small 1OU form factor and dense panel interfaces to allow more space in the rack and support for many use cases, thus reducing infrastructure costs.

2.3 Impact

With the increasing power densities of our systems, RM Cv1 represents our first scale deployment of a liquid-cooling management device across multiple platforms. It defines how we design, manage, and deploy systems with air-assisted liquid cooling and facility liquid cooling.

2.4 Scale

RM Cv1 is designed to support a wide array of liquid cooling use-cases across different rack designs. The simple architecture is intended to operate robustly at the largest scale across multiple generations.

2.5 Sustainability

RM Cv1 design supports multiple use-cases and platforms. A system can use the same hardware when transitioning to a new liquid-cooling source, or it can be reused in other platforms, which helps reduce the Scope 3 emissions.

3. Change Log

Date	Revision #	Author	Description
29 MAR 2025	0.9	Jeremy Baumgartner, et al.	Initial draft
30 MAR 2025	1.0	Jeremy Baumgartner, et al.	Initial release
16 APR 2025	1.1	Jeremy Baumgartner, et al.	Added details about OpenBMC implementation, References section, and minor corrections.
17 APR 2025	1.2	Jeremy Baumgartner, et al.	Updated license details

4. Scope

This specification describes the design of the Meta Rack Management Controller v1 (RMCv1), which monitors and controls various liquid cooling interfaces across various rack platforms and use cases.

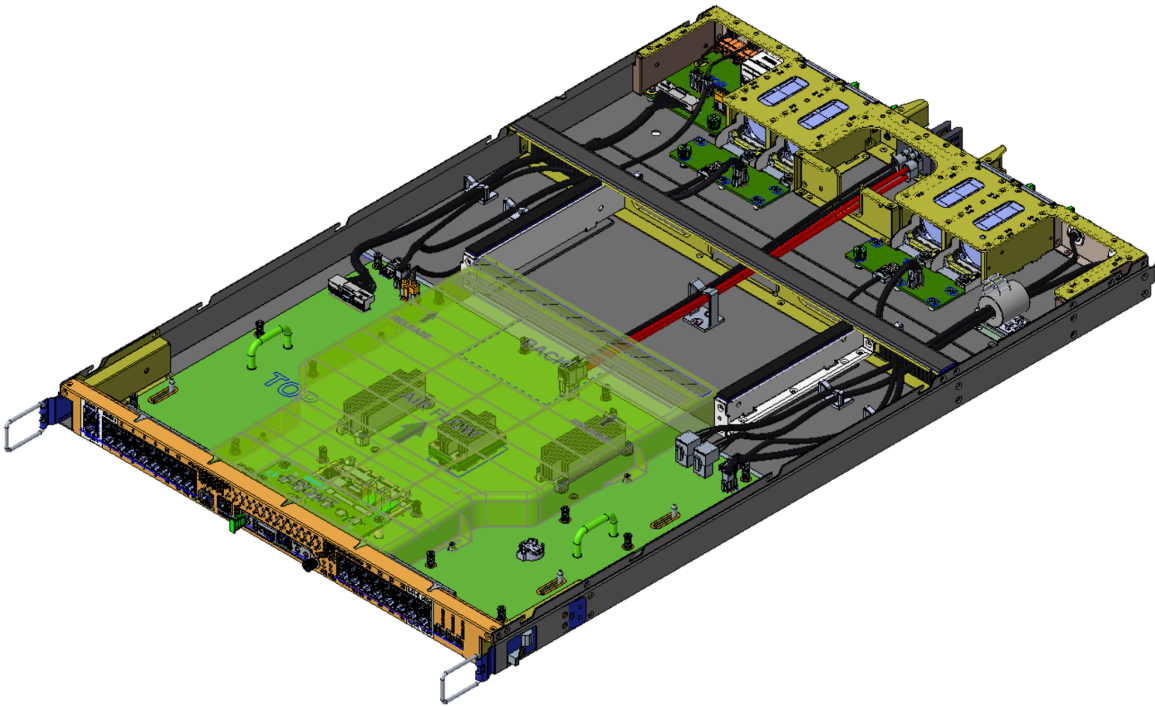
5. Overview

RMCv1 is a 10U device that reads and controls many parts of a liquid-cooled IT rack. It is based on a BMC+CPLD implementation, with interfaces to leak sensors, network, air-assisted liquid cooling (AALC) racks, and facility liquid cooling (FLC).

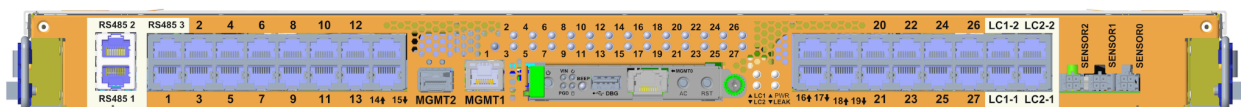
In order to handle the evolving implementations and challenges around liquid cooling, it is necessary to have a rack-level solution for:

- liquid cooling device control
- leak detection
- power state control

Such a design allows flexible, robust, and safe liquid cooling management across multiple AI/ML rack programs.



Overall view of RMCv1 with the top cover removed



Front view of the RMCv1

6. Environmental and Regulatory Compliance

6.1 Environmental

- Gaseous Contamination: Severity Level G1 per ANSI/ISA 71.04-1985
- Ambient operating temperature range: +5°C to +35°C
- Operating and Storage relative humidity: 10% to 90% (non-condensing)
- Storage temperature range: -40°C to +70°C
- Transportation temperature range: -55°C to +85°C (short-term storage)
- Operating altitude with no de-ratings: 6000 feet

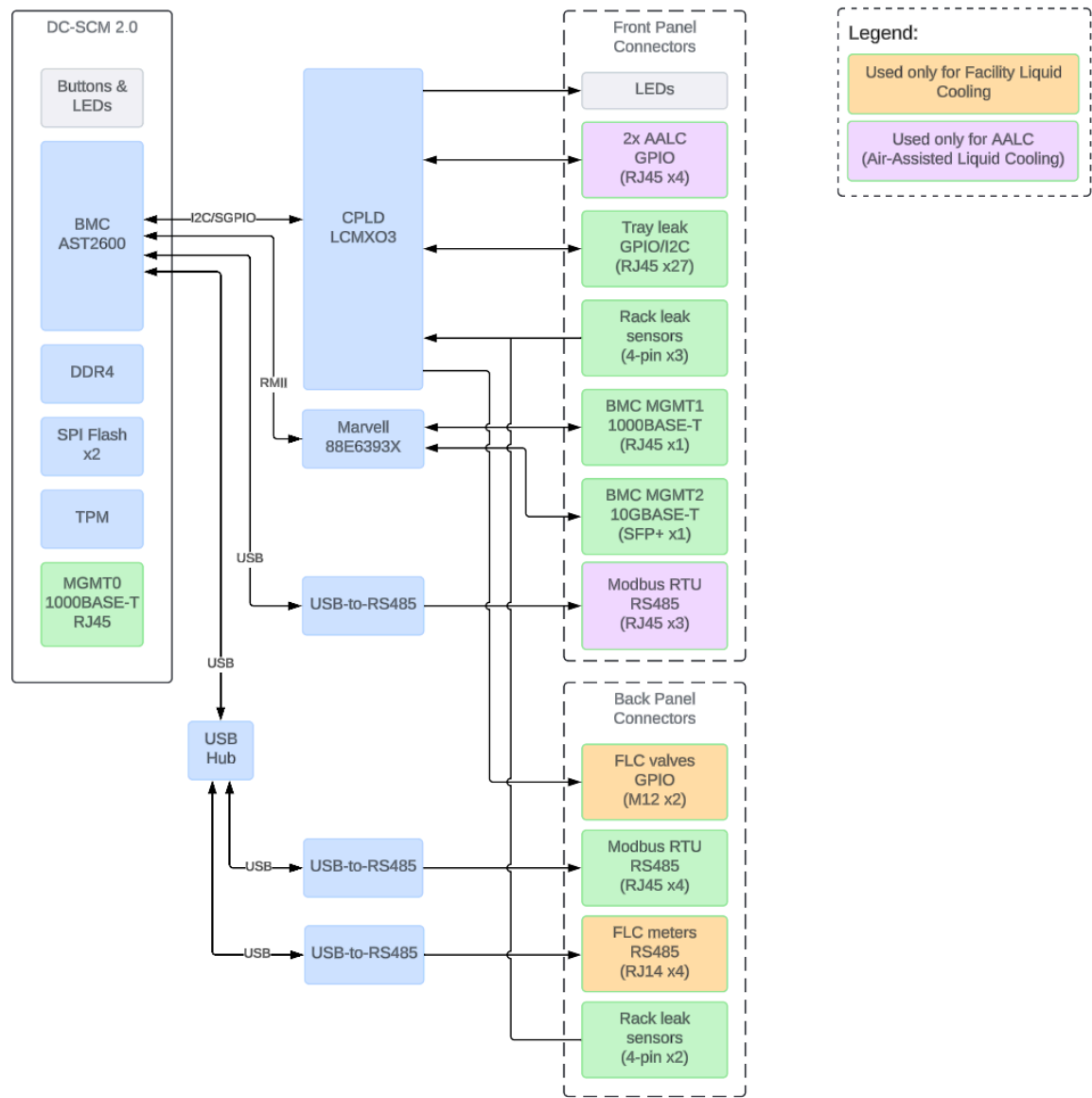
6.2 Regulatory Compliance

- CE and NRTL (UL listed) marks in accordance with the listing and surveillance requirements of the NRTL
- EU Low Voltage Directive (2014/35/EC)
- EU EMC Directive (2014/30/EC)
- EN55032/CISPR32, Class A criteria
- EN55035/CISPR35
- CISPR16
- ANSI C63.4
- EN61000-4-2
- EN61000-4-3
- EN61000-4-4
- EN61000-4-5
- EN61000-4-6
- EN61000-4-11
- FCC CFR47 Part 15, Subpart B, Class A criteria
- RoHS Directive (2015/863/EU)
- WEEE Directive (2012/19/EU)
- REACH regulation (EC 1097/2006)
- US EPA 40 CFR751
- IEC/EN 62368-1, hazard-based performance standard for audio video, and ITE

7. Physical Specifications

7.1 Platform Block Diagram

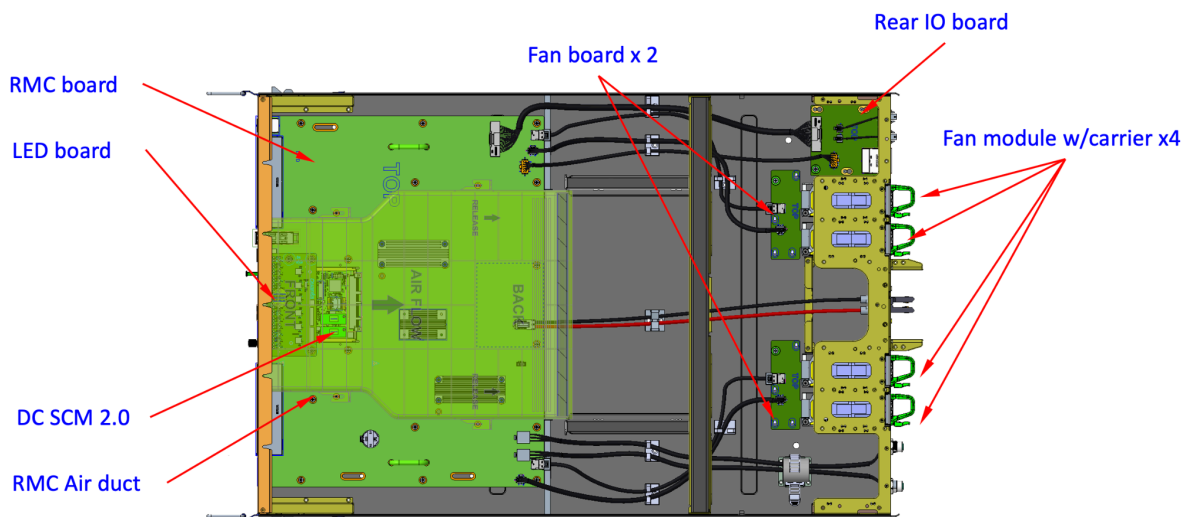
Below is a high-level block diagram of RMCv1:



Block Diagram of RMCv1

Multiple components are integrated within the RMCv1 chassis to provide all functionality. These include:

- DC-SCM 2.0 with BMC
- Mainboard with CPLD
- Rear IO board
- Front LED board
- Fan modules

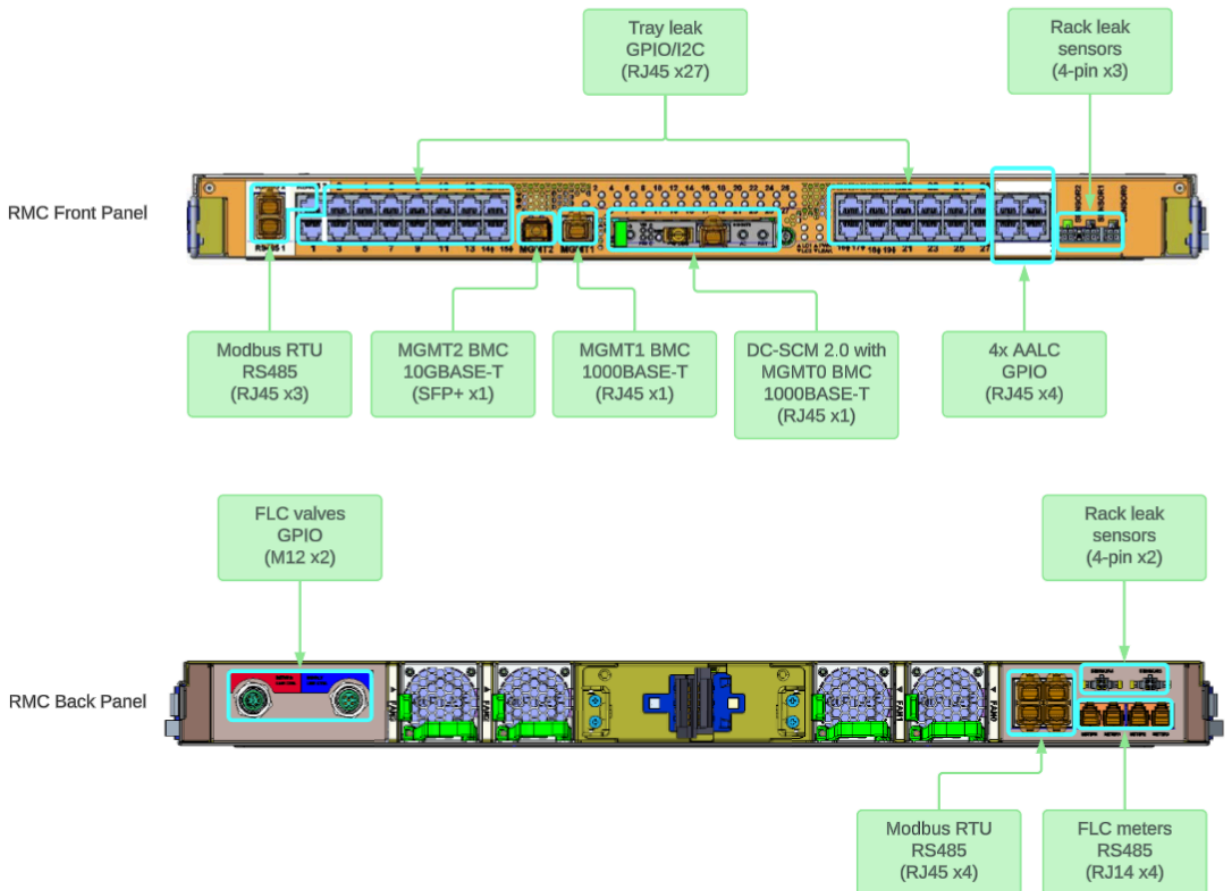


Interior view of RMCv1

There are many interfaces on the RMCv1 front and rear panels to support various liquid-cooling use cases, including:

- 27x leak sensing and control (LSC) RJ45 ports, which connect to each tray in the rack and handle leak reporting and power control (see *Catalina Compute Tray Specification* [1] for more details on this use case)
- 7x Modbus RTU RS485 RJ45 ports, which can connect to any supported Modbus device such as AALC, PSU, or BBU
- 4x AALC GPIO RJ45 ports, which connect to any number of AALCs to control and monitor
- 1x 1000BASE-T RJ45 Ethernet port on the DC-SCM 2.0 for management
- 1x 1000BASE-T RJ45 Ethernet port on the RMC for management
- 1x 10GBASE-T SFP+ Ethernet port on the RMC for management
- 5x leak sensor 4-pin ports, which can be used for any rack-level leak detection such as in the drip tray or around the liquid manifolds

- 2x FLC valve control GPIO M12 ports, which control and feedback signals for FLC liquid valves
- 4x FLC meter RS485 RJ14 ports, which read telemetry from FLC liquid meters

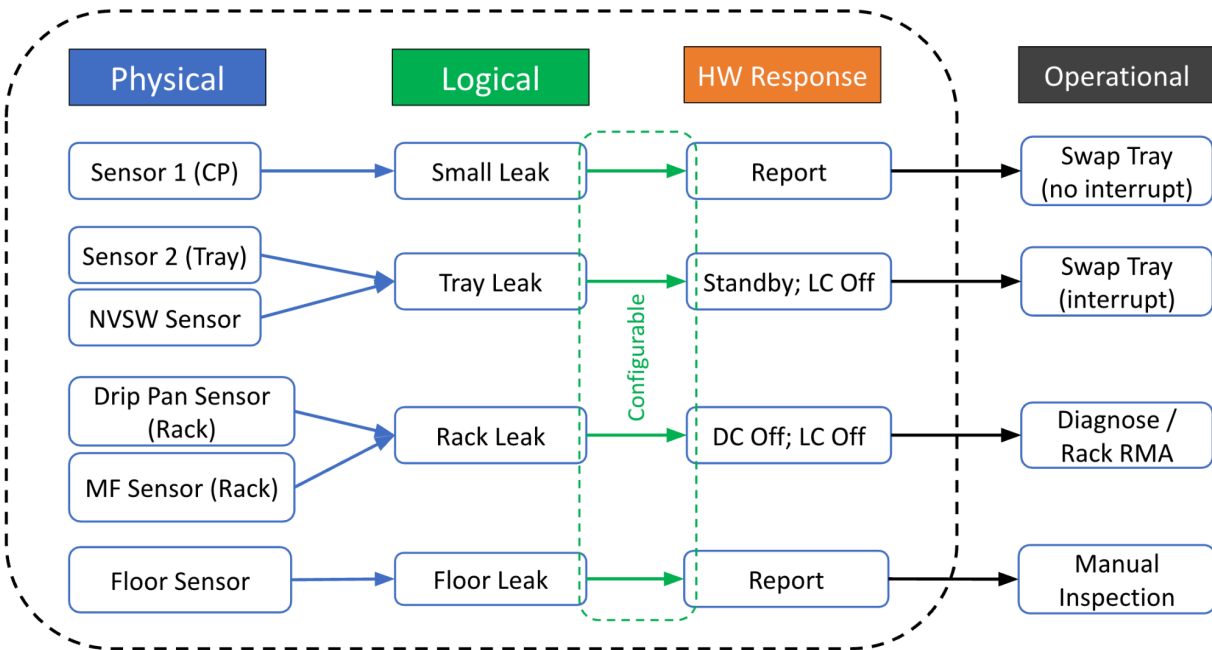


Interfaces of RMCv1

7.2 Mainboard

The mainboard contains most of the devices and interfaces within RMCv1. At its core is the CPLD, a Lattice Semiconductor MachXO3 device that performs the main functionality of RMCv1. The CPLD code enables a state machine for all leak sensing, power state control, liquid cooling control, presence detection, BMC reporting, and other interfaces. It operates independently of the BMC, and can take action regardless of BMC state.

Below is an example of the leak detection and response flow handled by the CPLD firmware:



In the Physical category, we have various leak sensors located throughout the rack, such as around the cooling cold plates, the base of individual trays, the base of the rack's drip tray, the liquid manifold, and the floor.

In the Logical category, we map each sensor signal to a logical group, such as Small leak, Tray leak, Rack leak, or Floor leak.

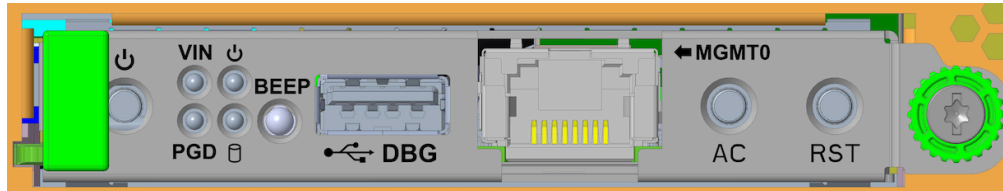
In the Hardware Response category, we assign a severity (and thus an action) for each logical group. In this case, for Small leaks, RMCv1 simply reports/logs an alert, but takes no further action. For Tray leaks, RMCv1 reports/logs the alert, powers off all trays, and stops liquid flow in order to preserve hardware and human safety. For Rack leaks, the same actions are taken as Tray leaks, but the entire rack is also powered off at the PSU/BBU level (no busbar power). For Floor leaks, RMCv1 reports/logs the alert and datacenter personnel will be dispatched to inspect the area.

7.3 DC-SCM 2.0

The SCM follows the DC-SCM v2.0 specification, with pinout exceptions permitted to include features not covered in the base specification.

The system uses an ASPEED AST2600 BMC for baseboard management with the following connectivity:

- Single x16 8Gb DDR4 DRAM memory interface
- NCSI/RMII network interface
- I²C™ management of all system sensors for power, thermal, and environment
- RJ45 for management network access



Front View of the DC-SCM in the RMCv1

The BMC is capable of recovering any firmware in the system regardless of the state of the host system. The SCM contains removable TPM2.0 for the BMC through SPI interface, a SPI flash for BIOS, and a removable board storage module (BSM) containing all the BMC non-volatile storage.

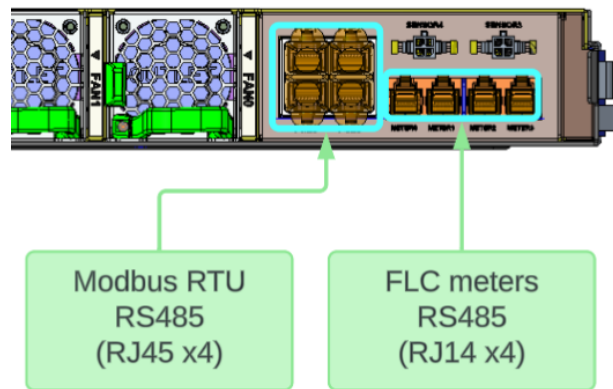
The DC-SCM follows the DC-SCM 2.0 specification. The front panel of it has the following:

- Power-on pushbutton
- Power LED
- HDD LED
- Fault/ID LED
- USB 3.0 OCP debug port
- SCM voltage status LED
- SCM power good status LED
- AC power hard-cycle pushbutton
- Reset pushbutton
- RJ45 Management Port

7.4 Rear IO Board

The Rear IO Board contains interfaces for:

- 4x Modbus RTU (for reading and controlling various devices, including AALCs, PSUs, and BBUs)
- 4x FLC meters (for reading liquid telemetry in the facility)



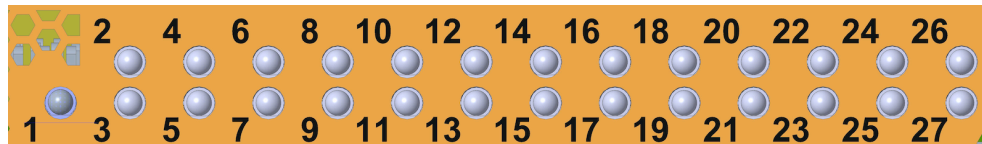
Rear IO board interfaces

7.5 LED Board

The LED board provides a controller and 27x blue/amber LEDs in order to indicate the presence and leak state for each tray.

The LED behavior is as follows:

- Blue: Good (no leak)
- Amber: Leak detected
- Off: Tray not present

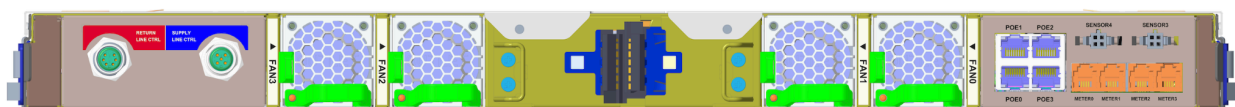


Front view of the LEDs on the LED board

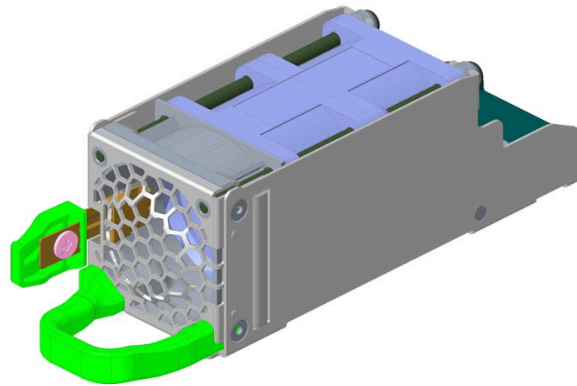
7.6 Fans

RMCv1 is completely air-cooled since components are relatively low-power. This also removes dependency on the liquid-cooling system that it must monitor and control.

There are four (4) fan modules on the rear of the chassis that pull air from the cold aisle to the hot aisle. They are hot-swappable with N+1 redundancy.



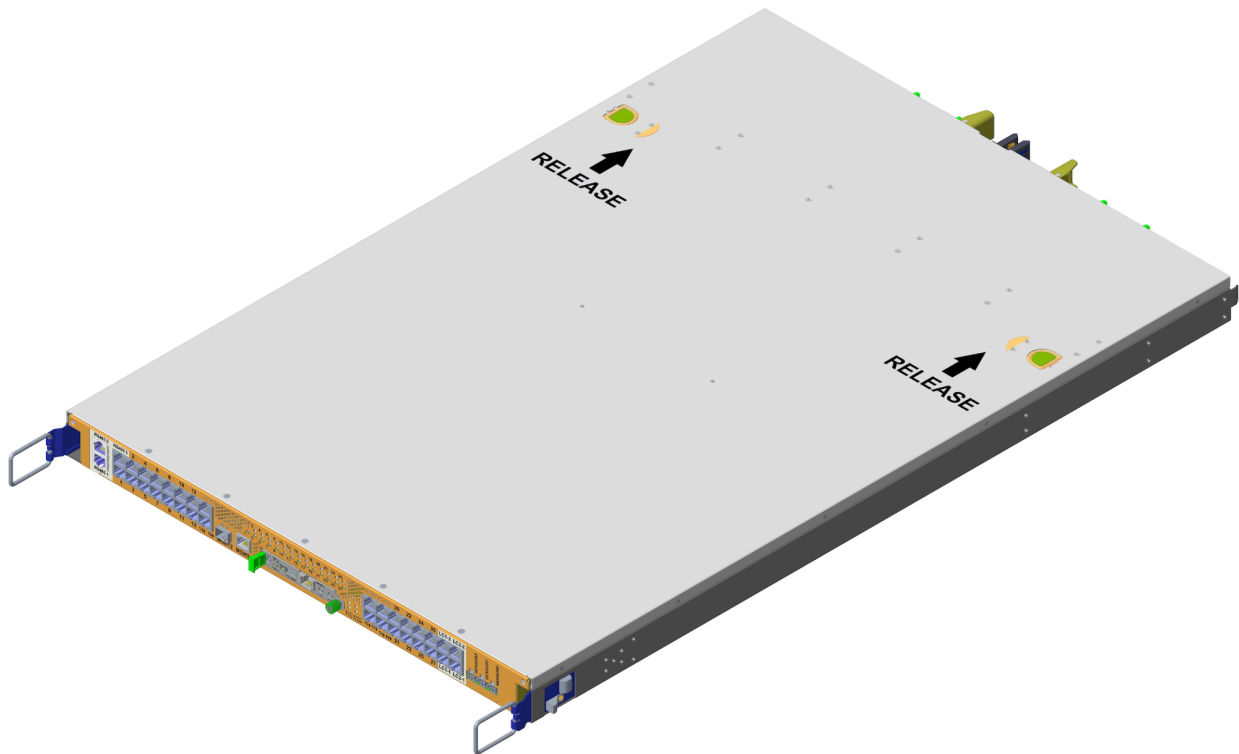
Rear view of the RMC with four fan modules



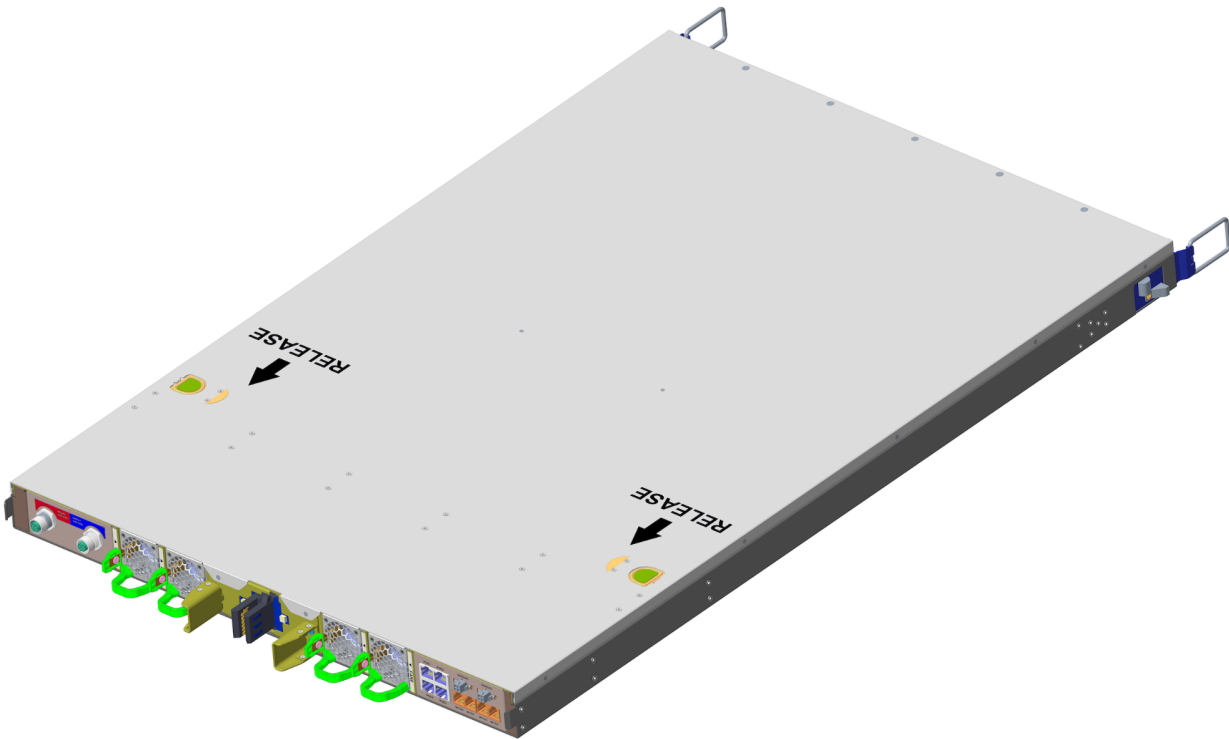
Angled view of the RMC fan module

7.7 Mechanical

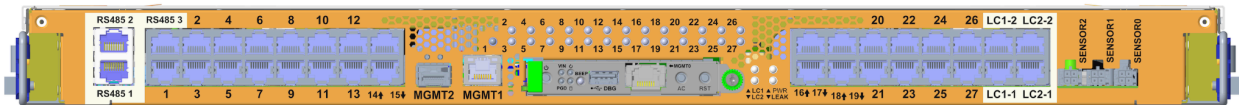
The RMC design is a 10U chassis. The front of the chassis has latch grab handles, connectors, LEDs, and the DC-SCM 2.0. The rear of the chassis has 4x fan modules, connectors, and the bus bar power connector.



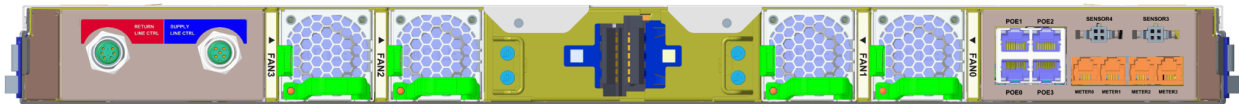
Angled front view



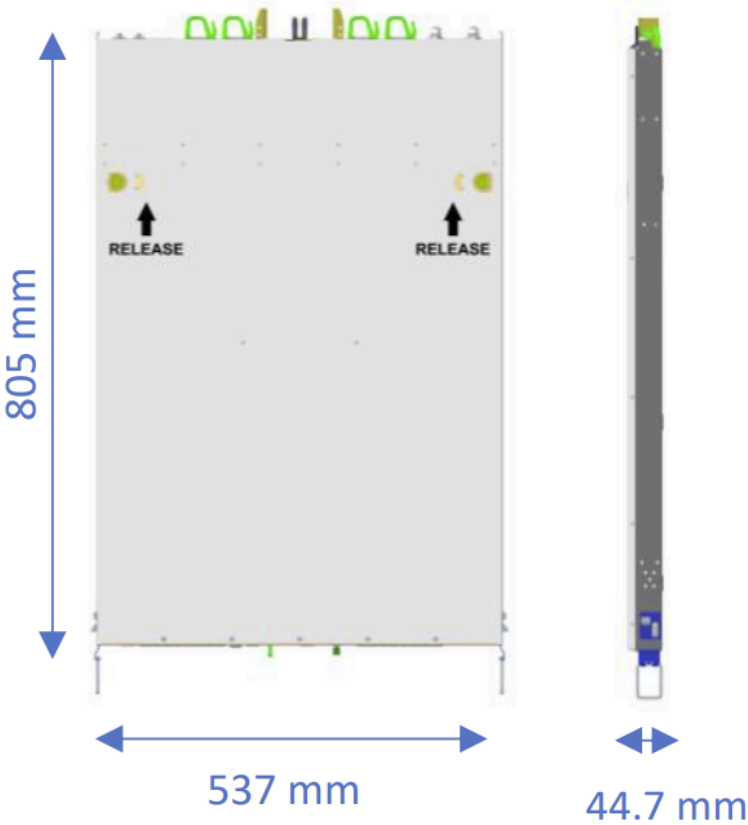
Angled rear view



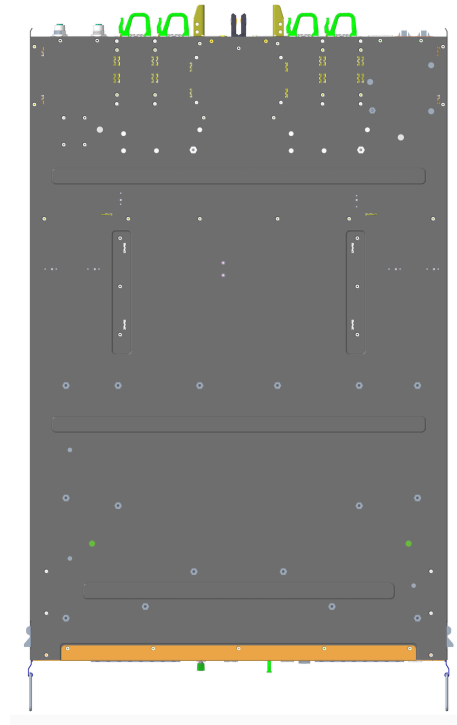
Front view



Rear view



RMC chassis dimensions (top view and side view)



Bottom view

7.8 Rack Compatibility

RMCv1 is designed to be installed in an Open Rack V3 (ORv3) HPR rack. [2]

8. Electrical Requirements

RMCv1 is electrically compliant with ORv3 HPR specifications. [2]

8.1 Input Voltage

RMCv1 is compliant with the ORv3 HPR specification for 51VDC input voltage. The system will operate normally with an input voltage tolerance range between 46V and 52V.

RMCv1 runs purely in the standby power domain of the rack. So if the busbar is powered, then RMCv1 is powered, which maximizes its availability in order to control high level leak sensing and power state handling at all times.

- High-speed signals
 - RMI from BMC to Ethernet switch
 - 10Gb Ethernet from Ethernet switch to SFP+
 - 1Gb Ethernet from Ethernet switch to RJ45
 - Clocks
- Low-speed signals
 - Modbus RTU RS485
 - I²C™ and SPI for management, sensors, I/O expanders, and other components
 - USB 3.0 for debug connection
 - UART
 - GPIO
 - SGPIO
 - JTAG

10.2 Cables

Various signal and power cables are used to connect components within RMCv1. This is done to provide placement flexibility for the boards, reduce the mainboard size, and provide easier serviceability.

Internal cables include:

- 2x fan power cables
- 2x fan signal cables
- Rear IO board power cable
- Rear IO board MCIO cable
- M12 panel mount connector cable
- Busbar power cable

11. System Firmware

RMCv1 uses Linux Foundation OpenBMC, an open-source firmware stack for the BMC on the SCM. Link to the repository:
<https://github.com/openbmc/openbmc/tree/c64869176cb2a4e502edab28491eccda0ca30095/meta-facebook/meta-ventura>

This firmware supports any Redfish commands that are already supported by Linux Foundation OpenBMC.

RMCv1 contains other components with firmware, including:

- RMCv1 mainboard CPLD
- DC-SCM CPLD

- Ethernet switch configuration file

12. Hardware Management

12.1 BMC

This system uses an ASPEED AST2600 BMC with one 8Gb x16 DDR4 SDRAM and 65MB flash for various platform management services.

The BMC resides on the SCM board, which follows the DC-SCM v2.0 specification (with board pinout exceptions).

12.2 Remote Upgradeability

The system is capable of remotely upgrading the BMC, VRs, CPLDs, and FRU EEPROMs. The BMC can access each device, update code from BMC to the device, and verify the code.

The BMC is capable of recovering the SCM CPLD from image corruption or an accidental erase. The BMC does not rely on proper operation of the SCM CPLD for booting or to be accessible remotely.

12.3 Sensors

The BMC has access to all analog sensors directly or through host management. Below is a list of all sensors:

```
SCM_P12V_VOLT_V
SCM_P5V_VOLT_V
SCM_P3V3_VOLT_V
SCM_P2V5_VOLT_V
SCM_P1V8_VOLT_V
SCM_PGPPA_VOLT_V
SCM_P1V2_VOLT_V
SCM_P3V_BAT_VOLT_V
SCM_P1V0_VOLT_V
SCM_TEMP_C
RMC_BRICK_CURR_A
RMC_BRICK_TEMP_C
RMC_BRICK_INPUT_VOLT_V
RMC_BRICK_OUTPUT_VOLT_V
RMC_HSC_TEMP_C
RMC_HSC_CURR_A (LTC4287 0x88)
RMC_HSC_PWR_W (LTC4287 0x88)
RMC_HSC_VIN_VOLT_V (LTC4287 0x88)
```

```
RMC_HSC_VOUT_VOLT_V (LTC4287 0x88)
RMC_M12_P24V_CURR_A (INA230 0x80)
RMC_M12_P24V_PWR_W (INA230 0x80)
RMC_M12_P24V_VOLT_V (INA230 0x80)
RMC_RJ14_P24V_CURR_A (INA230 0x8A)
RMC_RJ14_P24V_PWR_W (INA230 0x8A)
RMC_RJ14_P24V_VOLT_V (INA230 0x8A)
RMC_MEDUSA_POSITIVE_VDROP_V (INA238 0x86)
RMC_MEDUSA_RETURN_VDROP_V (INA238 0x82)
RMC_TEMP_C (TMP75 0x9E)
FCB_0_FAN0_PWM
FCB_0_FAN1_PWM
FCB_1_FAN2_PWM
FCB_1_FAN3_PWM
FCB_0_FAN_0_CURR_A
FCB_0_FAN_0_VOLT_V
FCB_0_FAN_1_CURR_A
FCB_0_FAN_1_VOLT_V
FCB_1_FAN_2_CURR_A
FCB_1_FAN_2_VOLT_V
FCB_1_FAN_3_CURR_A
FCB_1_FAN_3_VOLT_V
FCB_0_FAN0_TACH_IL_SPEED_RPM
FCB_0_FAN0_TACH_OL_SPEED_RPM
FCB_0_FAN1_TACH_IL_SPEED_RPM
FCB_0_FAN1_TACH_OL_SPEED_RPM
FCB_1_FAN2_TACH_IL_SPEED_RPM
FCB_1_FAN2_TACH_OL_SPEED_RPM
FCB_1_FAN3_TACH_IL_SPEED_RPM
FCB_1_FAN3_TACH_OL_SPEED_RPM
```

13. Security

RMCv1 includes the following security features:

- SCM with Linux Foundation BMC
 - Verified boot with signed firmware

14. References

[1] “Catalina Compute Tray Specification”, 2025, version 1.31.

[2] “ORv3 High Power Specification”, 2024, [link](#).

Appendix A - Checklist for IC approval of this Specification (to be completed by contributor(s) of this Spec)

Complete all the checklist items in the table with links to the section where it is described in this spec or an external document .

Item	Status	Link to detailed explanation
Has this contribution been presented to an OCP Project group during a project call or engineering workshop?	Yes	If “No”, please state the reason.
Approval by Project Leads		If “No”, please state the reason.
Is this contribution entered into the OCP Contribution Portal?		If “No”, please state the reason.
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