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Residual Current and Neutral Monitoring in the Data Center

A White Paper from Raritan

Introduction

Data center outages and unplanned interruptions of service for critical applications are often considered a nightmare by Data Center managers. In some cases, these operations disasters can be easily avoided by setting up a more in-depth power management system; going beyond capacity planning and power metering per phase. Therefore, Residual Current Monitoring, as well as Neutral current monitoring are becoming more important for a safer provisioning and increased granularity of management.

Critical energy supply failures are often due to stray current, insulation errors, overload of the neutral conductor due to harmonics and asymmetrical loads, and potentially EMC factors. From these different causes emerge risks of personal injury, fires, unexplained IT systems failures, and to a lower extent corrosion on lighting and protection systems.

The cost associated with these types of damages is often under estimated as there may be domino effects on the overall health and integrity of the building themselves, impacting the level of redundancy of the data center and its ability to maintain SLAs in the long run. As a worst-case scenario, people getting hurt while handling and manipulating equipment, or permanent health issues resulting from fumes poisoning in case of a fire. These risks must be addressed and controlled.

Electrical standards by essence were made to frame these cases and prevent human injury caused by electrical shock and associated phenomenon's. DIN VDE 0100 series "Low-voltage electrical installations" (IEC 60364 series, base for both NFC and DIN VDE Standards) have been major improvements in preventing these risks. The low-voltage electrical installations standard prescribes extra protection in the form of RCDs "residual current devices disconnects" for all socket outlets in alternating current systems. RCDs will interrupt current distribution automatically and need to be rearmed once the risk has been eradicated. Usual RCDs (based on IEC 61008-1 or 61009-1) can be rearmed by anybody and do not require an electrician.

Residual current may be produced from different sources. It usually flows between a live part and the conductive path to earth. The value of the residual current produced is determined by the rating of the voltage source, the earth resistance and the resistance of what is between the live part and the earth (isolation, human body, material, etc.)

Inside environments like data centers where shielded cables are present, residual current may spread through cable shielding across different parts of the data center if the racks are insufficiently earthed. Depending on the residual current level at the point of insulation error, some issues with upstream protective devices might occur resulting in tripping a protective device and disconnecting the equipment involuntarily.

Why deploy Residual Current Monitoring?

A Residual Current Monitor (RCM) detects current leaking outside its normal circuit path. In power circuits, current normally flows only in the phase and neutral wires. Current flowing in the ground wire (or other path to ground) and through the exposed metal parts within the rack, presenting a significant danger for humans is known as leakage current.

Residual/Leakage current is a safety hazard. It can cause electrocution and fires.

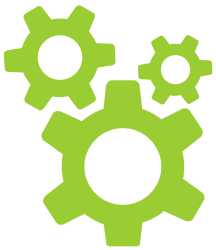
Some European countries require periodic inspection of data centers for these conditions to protect workers and facilities.
This is costly and results in system down time, which is why customers are widely looking to implement efficient means of detection.

RCMs monitor residual currents in electrical installations in real time. They report the level of residual current value and signal when it exceeds a threshold. They comply with DIN EN 62020 (VDE 0663) "Electrical accessories – Residual current monitors for household and similar use (RCMs) (IEC 62020)".

Prevent against electrical shock caused by residual current

Reduce the risk of fire caused by leakage and fault current by alerting in time

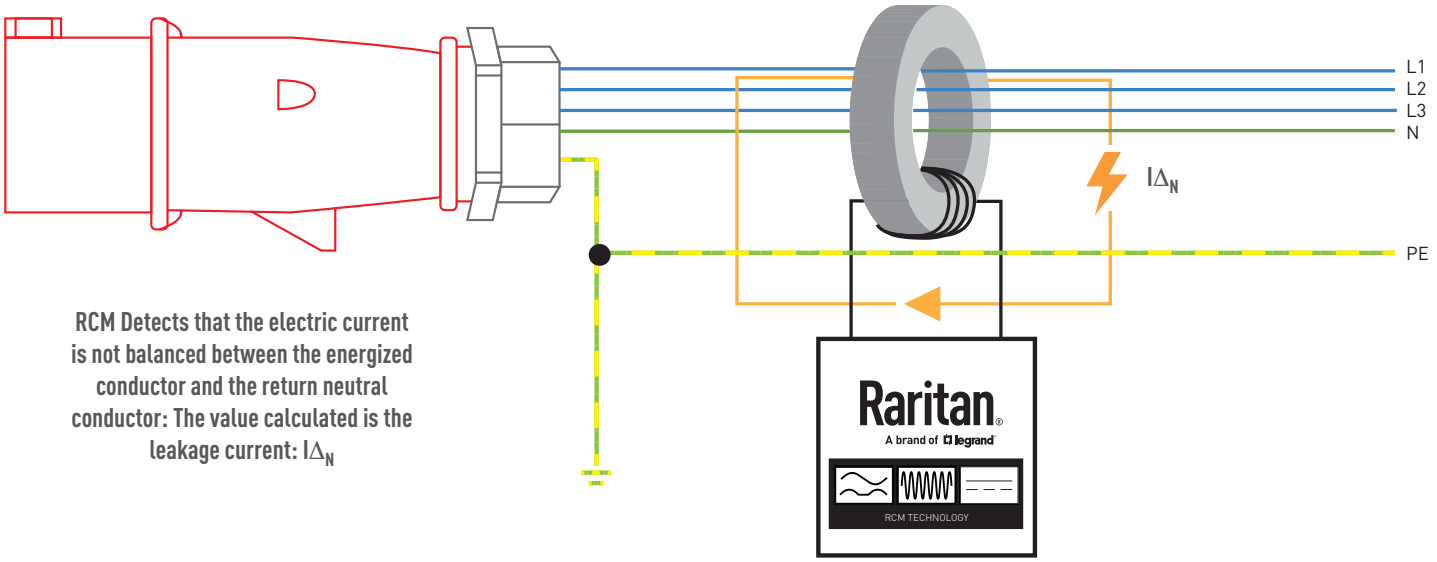
Facilitate preventative maintenance and detect insulation errors



Increase overall performance of the Data Center

How does an RCM operate?

All conductors (phase lines and neutral) are routed through the RCM sensor, which measures the sum of the currents flowing in the conductors. In a leakage-free system, the sum of all currents is zero. When leakage is present, the measured sum equals the leakage current, and this same measured sum always equals the leakage current regardless of how much current is flowing in the load.



RCM Detects that the electric current is not balanced between the energized conductor and the return neutral conductor: The value calculated is the leakage current: $I\Delta_N$

The difference between RCMs and RCDs

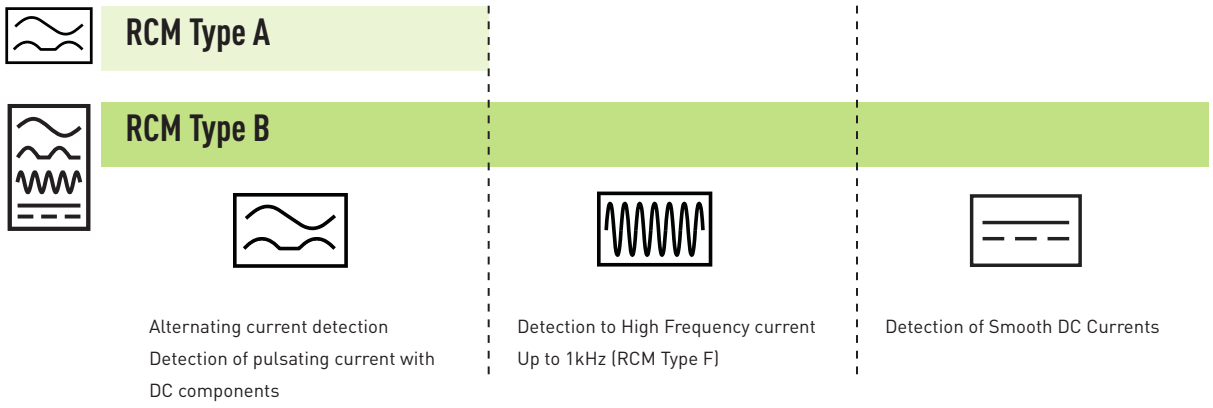
In contrast to RCMs, RCDs (residual current disconnects) act as a circuit breaker to disconnect power when residual current exceeds a predetermined threshold. As disrupting power in a data center is not desirable, it is preferred to use RCMs as they indicate by means of an alarm a fault current for appropriate maintenance. However, RCDs are mostly used when required by local regulatory agencies and can then be used in combination with RCMs.

Differences – Focus on RCM Type A and RCM Type B

Leakage can be AC or DC current or a combination of both. The "Type" of RCM indicates what type of leakage current it can detect.

In a data center environment, the IT equipment (servers, storage, switches, etc...) will in most cases have some level of leakage current. Leakage current is considered acceptable by the IEC-62020 on this type of equipment below 3mA, due to the concentration of electric and electronic components inside servers.
Users will want to apply different levels of granularity for RCM measurement depending on their IT equipment configuration.

In the chart below, we can see that RCM Type A will only provide measurement of the AC current along with pulsating currents with some DC components. This level of readings may be sufficient in some cases, depending on the nature of the equipment
However, Raritan's experience in enterprise type data centers has proven more efficient to use RCM Type B measurements, including smooth DC current and high frequency current detection to the RCM spectrum, hence providing the full visibility on all leakage current types generated by the IT equipment parts.



Accuracy and risk considerations for RCM:

IEC 62020 is a standard used to test RCM accuracy. It defines residual operating current IΔN as the leakage current threshold where the RCM reports an alarm.

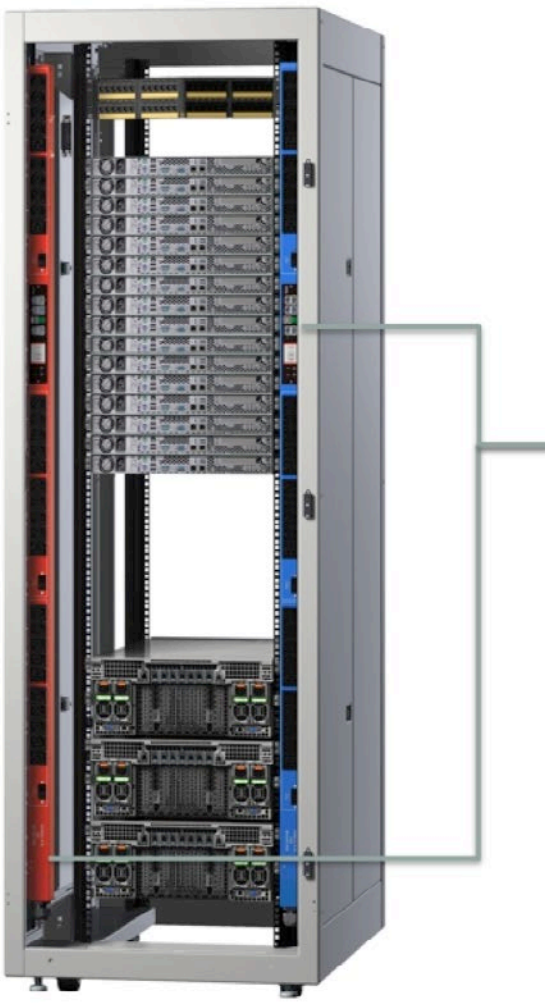
To be IEC 62020 compliant, an RCM must alarm at a leakage current value between ½ the residual operating current and the residual operating current. The alarm resets when the leakage current falls to less than ½ the residual operating current.

For type B RCM, some manufacturers report separate values for the AC and DC portions. At the present state-of-the-art technology, accurate DC sensing is difficult and errors in the sensor can cause false indications. Having a separate DC indicator can be useful in diagnosing sensor problems. However, the residual operating current operating point at which the sensor reports a potential safety issue must always be based on the total AC and DC portions.

Raritan Type A RCM comply with IEC 62020 for adjustable residual operating currents between 6mA and 500mA. Raritan Type B RCM comply for adjustable residual operating currents between 15mA to 300mA. Both RCM Type A and Type B have a measurement range for leakage current between 1mA and 1A.

Why apply Residual Current Monitoring inside the Rack?

These days, RCM solutions are usually used at the branch circuit level, at the outlet or inside the panel protecting the branches.
They can also be used in the sub-distribution or in some buildings at the central earthing point of a TN-S system, the sum of normal device leakage being more important at these locations. Data Center usually only deploy RCM at the outlet level of the power distribution system.



RCM Technology included inside the intelligent PDU at the rack level

Did you Know?

Leading intelligence companies are using RCM data in combination with machine learning algorithms to predict eventual failures of server's power supplies by analyzing the change of RCM data over time.

Residual currents can be detected and reported, and the protective standards met but there is still no scope for quickly localizing and rectifying errors. Therefore, Intelligent rack PDUs can be equipped with integrated RCMs to satisfy a more efficient management.
Here, the residual current is measured at the rack level, per phase and can therefore be reported at an early stage and with accurate location information. Raritan 3-phase PX3 PDUs are available with either a single type B RCM or three separate Type B RCMs – one on each phase line. Using more than one RCM can help locate where the leakage is occurring.

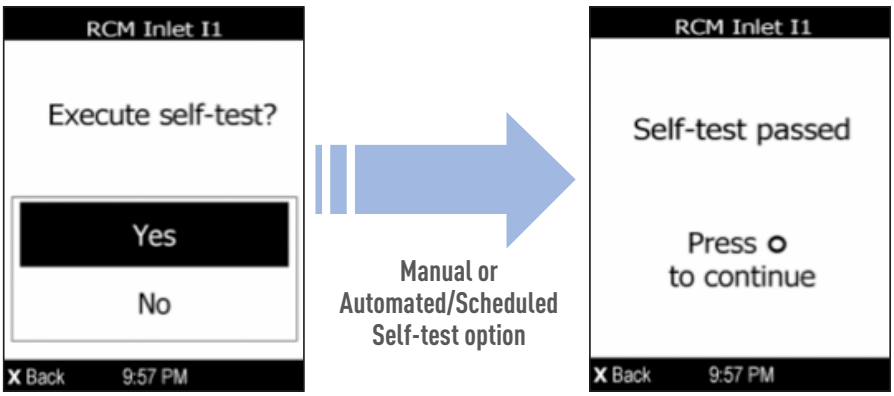
The PX3 intelligent RCM PDUs have configurable threshold values to easily detect RCM conditions and comply with the current standards. All RCM values captured and monitored by Raritan PX3 PDUs can be exported to data center management software (DCIM) or Building Management System (BMS), using SNMP v3, Modbus TCP/RTU, or scripting (JSON RPC/LUA).
In addition to the configurable alerts, users can schedule automated self-tests to ensure accuracy of readings.

Raritan RCM Sensor Patented Self-test function:

Raritan RCM provides a Self-test function that insures the RCM sensor and the PDUs alarming system are functioning properly. This function can remove the need for an electrician to periodically manual test the RCM.

Self-test is an important part of RCM best practices. If an RCM fails or the alert system is improperly configured there will be no indication when a leakage condition occurs. This is known as a false negative. Self-test provides positive feedback that the sensor and alert system are working properly.

The self-test can be performed manually from the PDUs front panel, or it can be scheduled to run automatically using the PDU's event scheduler.



Raritan RCM self-test function turns on a test AC current with an extra wire that runs through the sensor. The circuitry is working properly if it can sense a difference when the test current source is turned on.

Raritan patent (US9411021B2 Granted) covers the full RCM solution, and RCM sensor automatically operating the self-test and sending results to a monitoring system (DCIM) can be achieved easily by leveraging Raritan Xerus Firmware.

In addition, self-test can be operated manually at any time, either locally from the PDU screen, or remotely using the WEB user interface, or from Power IQ DCIM Software. All tests and RCM measurements can be logged and reported to the system of choice, and automated.

Applying best practices for rack power distribution:

IEC 60950-1 safety standard used for IT equipment allows devices to leak up to 3mA and which is considered safe. Equipment can leak more, but the manufacturer must supply a notice to inform the customer of this. In practice, data center rack loads leak less than 3mA. However, this allowable leakage needs to be considered when configuring residual operating current thresholds since the RCM may be measuring the sum of more than one PDUs outlet.

To guarantee accurate and secure alerts, Raritan sets the factory default residual operating current to 30mA.

By the same reasoning, RCM sensors and firmware configurations should not use fixed / non-configurable sensor thresholds, especially not at very low thresholds (like 6 mA for example) as this can cause a lot of meaningless alarms in datacenter applications.

Low thresholds are good for consumer applications where single loads must be monitored but in industrial datacenter applications this is not practical. Ownership of RCM sensor technology to enable configurable thresholds relevant to the application should be a point of consideration for an efficient deployment and day to day management.

Along with RCM, Raritan intelligent PDUs provide the most advanced monitoring and control functionalities, with outlet level metering and switching (remote control with high-end bi stable low consumption latching relays), allowing the user to operate power with more granularity down to the device level.

Combined with Residual Current Monitoring, this offers greater chances to avoid unplanned outages entirely.

Maintaining maximum availability and uptime service levels for data centers and critical servers is the essential duty of modern operators. Depending on the type of data center deployment, it is key to avoid unexpected interruptions caused by residual current resulting in tripping circuit breakers upstream to the rack, along with ensuring that fires and personal injury never happens.

The use of RCMs helps to prevent problems, detect them at an early stage and ensure smooth data center operation. If this monitoring is thorough enough, the time needed to localize and rectify the error can be further reduced and in a best-case scenario, intervention can take place before serious problems arise.

To comply with the IEC 62020 and provide our customers with AC and AC+DC RCM options, Raritan now offers 3 options for Residual Current Monitoring:

RCM Type A : Suffix option: - "M5": Detects AC leakage and is rated down to 6mA (IEC62020) leakage.

RCM Type B Single Channel : Suffix option: - "M11": Single Channel/Phase: Detects AC and DC leakage: 15mA to 300 mA (IEC62020) leakage.

RCM Type B Three Channel : Suffix option: - "M18": Three Channel/Phase: Detects AC and DC leakage and 15mA to 300 mA (IEC62020) leakage on each line.

Raritan PDUs with RCM technology included can be identified with the following sticker:

Key benefits of RCM measurement technology:

- No shutdown of your system (server, IT technology, production machines, machine tools, etc.)
- Higher operational reliability through early detection of possible critical facility's condition
- Significant reduction of operating costs due to optimized maintenance.
- Production interruptions are prevented in contrary to RCDs.
- Easy monitoring of highly available energy distribution facilities.
- Early warning of system errors.
- Localization of single faulty outlets, less effort for troubleshooting.
- Critical residual currents are detected at an early stage, thus increasing fire safety.
- Fulfilment of the security criterion "RCM fault current monitoring" in the data center.

in parallel to residual current monitoring, European standards are also defining the need for Neutral current monitoring, as a mean to Prevent overloading and overheating of the neutral wire.

EN 50600 requirement: 8.2.1 Requirements for neutral current monitoring

The distribution equipment shall be selected to enable measurement of voltage, current, power factor and energy use on all phases present and on the neutral conductor.

Why Monitor the Neutral Conductor?

In modern buildings of information technology and data centers, electrical loads are used (PCs, electronic power supply units, copiers, etc.) which additionally loads the neutral conductor with harmonic currents. Neutral monitoring is a best practice in data centers as harmonic currents can be presents due to the electronic loads. This was recognized in the 1990's when data centers were overloading the neutral lines due to the increasing presence of harmonics generated by various electronic equipment's.

Neutral is not monitored by a circuit breaker and there is no protection on the neutral line itself. The circuit breaker won't trip in case of a Neutral overload, but this condition can create electrical fires due to overheating.

To avoid neutral overload, Raritan PDUs with inlet power meters and all PDUs with RCM sensors monitor and report neutral current.

Raritan Neutral Monitoring Solution:

Raritan Neutral current monitoring sensor is accurate at +/-1%, in a range of 0% to 160% of the PDU rated current.

Neutral metering benefits:
- Overload of the neutral conductor are signaled at an early stage
- Reliability of operation and system safety are considerably improved
- Potential fire hazards and risk of equipment downtime are recognized as they are developing
- Maintenance costs are considerably reduced

Raritan RCM Technical Specification

IEC 62020 Classifications and characteristics

Classification or characteristics	IEC 62020 Clause	
Method of Operation	4.1	Dependent on-line voltage. The RCM only functions if line voltage is present.
Type of Installation	4.2	All Raritan products with flexible line cords and plugs are for mobile installation and corded connection.
Current Paths	4.3	All 1-phase Raritan PDUs contain two current paths RCM. All 3-phase 3W+PE are three current paths RCM. All 3-phase 4W+PE are four current paths RCM
Ability to adjust residual operating current	4.4	Adjustable residual operating current.
Adjustable time delay	4.5	Non- adjustable time-delay
Protection against external influence	4.6	Enclosed-type RCM
Method of Mounting	4.7	Panel board type RCM
Method of Connection	4.8	Not associated with mechanical mounting
Connection of load conductors	4.9	Monitored line is directly connected
Fault indicating means	4.10	Visual, with other output signal
Ability to directly discriminate	4.11	Directionally non-discriminating.
Rated Voltage	5.2.1.1	PDU nameplate rating (UL-60950-1)
Rated Insulation Voltage	5.2.1.2	As specified in UL-60950-1
Rated Current	5.2.2	PDU nameplate rating (UL-60950-1)
Rated residual operating current	5.2.3	Highest setting: 0.5A Type A. 0.3A Type B
Rated residual non-operating current	5.2.4	Highest setting: 0.25A Type A and 0.15A Type B
Rated frequency	5.2.5	47-63Hz
Residual currents with direct current components	5.2.6	Type A and Type B

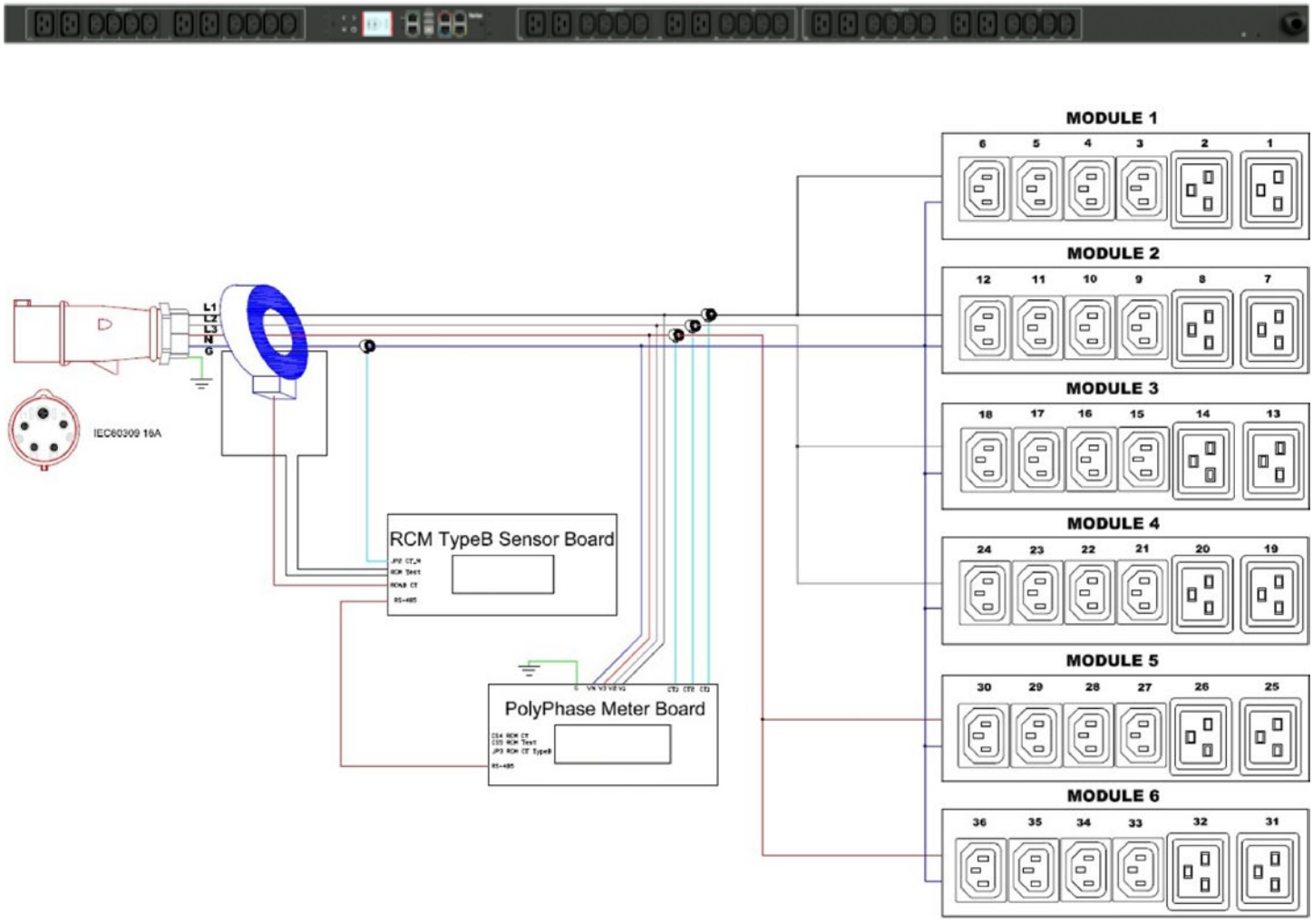
Raritan RCM Technical Specification

Operating characteristics according to IEC62020	Type A or Type B
Rated frequency	42 to 2000Hz
Measuring Range	0mA to 1.0A
Measurement Accuracy	0 to 15%
Rated residual operating current	Type A : 6mA to 500mA (default 30mA) Type B: 15mA to 300mA
Rated residual non-operating current	50% of residual operating current set point
Response time	< 10s (typically 2s)
Hysteresis	Alarm asserts at values >= operating current. De-asserts at values <= 75% operating current

Below 2 examples of RCM Type B options M11 and M18:

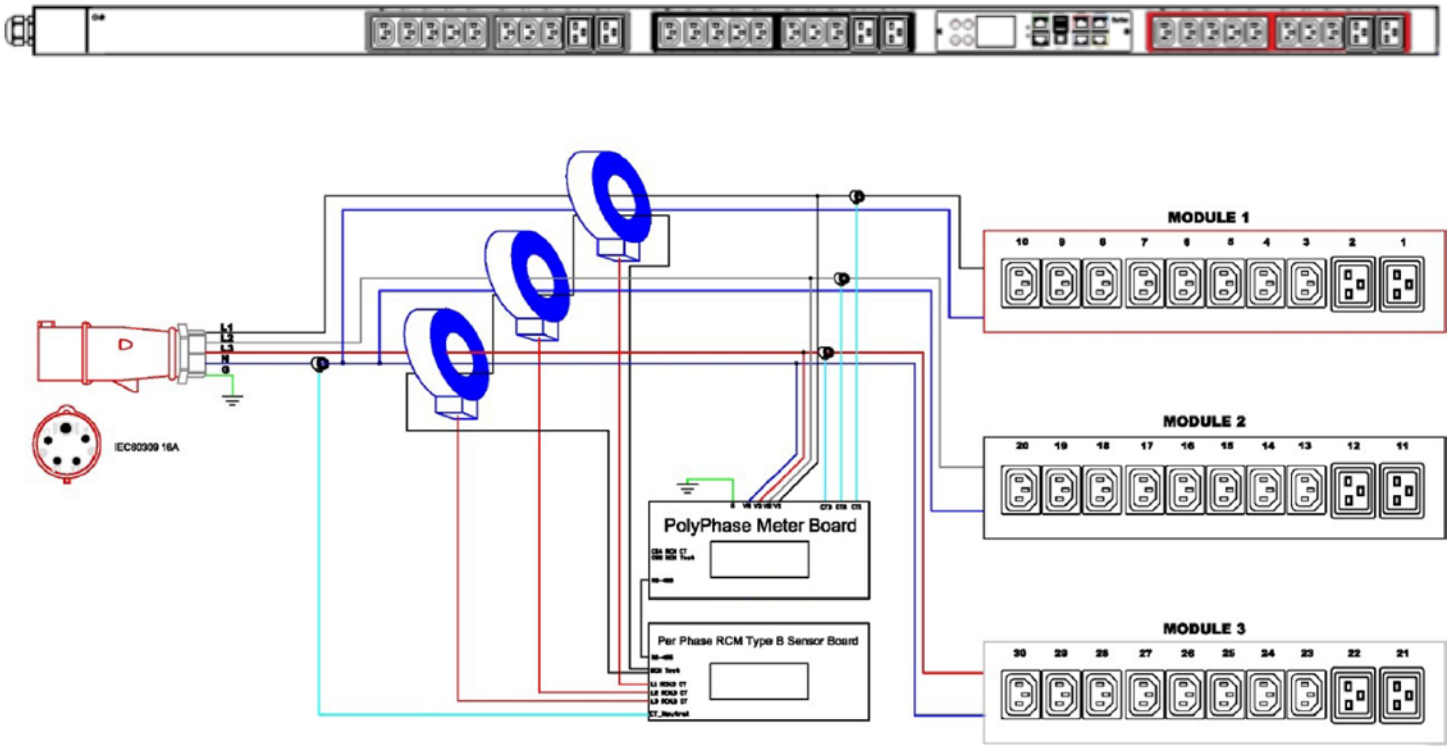
Example 1: Rack PDU PX3-1732-M11: RCB Type B Single Channel

RCM single Channel (Raritan Option M11) reports the total leakage current of all outlets.



Example 2: Rack PDU PX3-1648V-M18P1: RCB Type B Three Channel

RCM Three Channel (Raritan Option M18) has 3 sensors, each sensor reports the leakage current of the outlets on 1 phase. This helps to isolate which outlet bank is causing the leakage



About Raritan

Raritan began developing KVM switches for IT professionals to manage servers remotely in 1985. Today, as a brand of Legrand, we are a leading provider of intelligent rack PDUs. Our solutions increase the reliability and intelligence of data centers in 9 of the top 10 Fortune 500 technology companies. Learn more at Raritan.com