Rack Layout and Thermal Profiling

Introduction

Every minute of every day, new projects are placed on the desks of test engineers with the expectation they develop measurement systems that not only meet specification requirements and release deadlines but also offer high quality and reliability. In an ideal world, engineers have the time and resources to perform in-depth research, modeling, and simulation to produce perfect systems. Unfortunately, real-world project schedules do not typically permit the time and resources to develop perfect systems. In a System Integration Study performed by Control Engineering in August of 2014, only 67 percent of system projects were completed on time and within budget. In a world of tight release schedules and demanding project timelines, it is important to consider the aspects of a measurement system that can impact the quality of measurements, which, in turn, can increase risk to schedule, cost, and performance. These aspects range from the instrumentation selected to the quality of the connections and cables to the implementation of the measurement methodology. An overlooked area, however, is the impact thermals can have on measurement quality and measurement system reliability.

This paper equips you with the knowledge to learn more about your design to avoid risk. Learn how thermals impact measurement quality, see basic design approaches, and explore thermal modeling tools for designing a rack measurement system.

Importance of Thermals in Rack Designs

In a generic measurement system, thermals can develop in many ways; however, in a rack-mount measurement system, heat generation within the rack and heat exchange to the environment around the rack are the primary sources of thermal changes that can impact a measurement.

You should be concerned with thermals for several reasons:

- **Good design practices**—Being aware of the implications of thermals and designing your system to account for them is a good design practice. By knowing how thermals may impact your system, you won't allow thermals to become a major contributing variable in your measurements. Keep in mind that operating instruments outside of their specified temperature ranges may have an impact on the quality and life expectancy of that instrument, which is also a reason to maintain good thermal designs for your equipment.
- **System uncertainty**—Thermals will always exist and are difficult to eliminate completely. Therefore, by better understanding what they are, you are better positioned to account for them in your system uncertainty and can more accurately account for them in your measurement derivations and measurement results.
- **System stability**—Stability is important for a good measurement system. If variability is observed, often it is difficult to determine the root cause and/or how to address it. Thermal changes in a system can lead to false results in testing because of this variability. Minimize this risk by controlling the thermals in your system.

Product quality—Products require certain thermal environments to ensure optimal performance, specifically during adjustments. Minimizing the impact of system thermals on product performance can improve the overall product quality.

Thermals and Instrumentation

Thermals should receive significant consideration with respect to instrumentation. Instruments specify certain temperature adherence requirements to meet specifications. Most instruments experience temperature drift, and measurement results will vary if the temperature is unstable or is beyond the adherence requirements. To truly understand and trust the measurement results from a test solution, you should understand and know this impact.

For example, take a look at some related industries such as telecom and IT that have developed best practices for recommended and allowable temperature ranges, which most device manufacturers follow. Some devices still have their own specifications, so the design objective here is to meet those individual device specifications as well as the industry best practices. The primary concerns in these industries include long-term reliability, system uptime, and a lower total cost of ownership (TCO), which are very relevant to automated test. Likewise, automated test engineers should also consider the potential impacts that relate to rack systems and thermals.

The impacts of thermal mismanagement in these industries all tie to a higher cost of operation. For example, if the cooling system fails, the rising temperatures put stress on the rest of the system, resulting in reduced equipment lifetime. If the temperature is too high, IT systems can experience computation errors at the CPU level, resulting in application errors. Redundant cooling systems can be implemented, but increase the TCO. Most importantly, downtime because of auto-shutdown results in loss of service and any downtime translates to loss of money.

National and International Standards

In regard to national standards, Network Equipment-Building System (NEBS) and the American Society for Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), have established guidelines and best practices for telecom and IT equipment, respectively.

Whereas ASHRAE is an organization that focuses on best practices across a breadth of areas, NEBS is a more focused effort, specifically for telecom equipment. ASHRAE may reference NEBS for some of its guidelines related to enclosures and rack-mount equipment, but ASHRAE best practices appear to be more comprehensive for all aspects of the enclosure designs.

Although these national standards are not directly applicable to test and measurement certification, they follow many of the same principles and guidelines for rack design and performance that are relevant for automated test.

International standards that the International Electrotechnical Commission (IEC) creates relate to the thermal aspects of enclosures. Manufacturers of enclosures mostly refer to these for either designing or testing the enclosures or for providing usage guidance to customers.

- IEC 61587-1 specifies environmental, testing, and safety requirements for empty enclosures (that is, cabinets, racks, subracks, and chassis) in indoor conditions.
- IEC 62194-1 provides methods for evaluating the thermal performance of empty enclosures under indoor and outdoor conditions.

The design objectives for the telecom and IT industries are similar to the test and measurement industry, but the primary focus areas and challenges are somewhat different. Design objectives in test and measurement focus more on meeting individual device specifications, because there is no universal standard for test and measurement equipment racks, though best practices from various companies in the industry exist. The primary focus is to ensure that each instrument, as well as the device under test (DUT), maintains alignment to its specifications. This comes even before long-term reliability or uptime, because those types of considerations become more relevant at much higher temperatures, while loss of required accuracy can occur at relatively lower temperatures.

In terms of challenges, automated test systems have some added constraints. One is that test racks are usually used in environments occupied by moving humans or in uncontrolled production facilities all around the world. This does add randomness in the overall thermal profile of the room/location, unlike unoccupied server rooms with stationary objects.

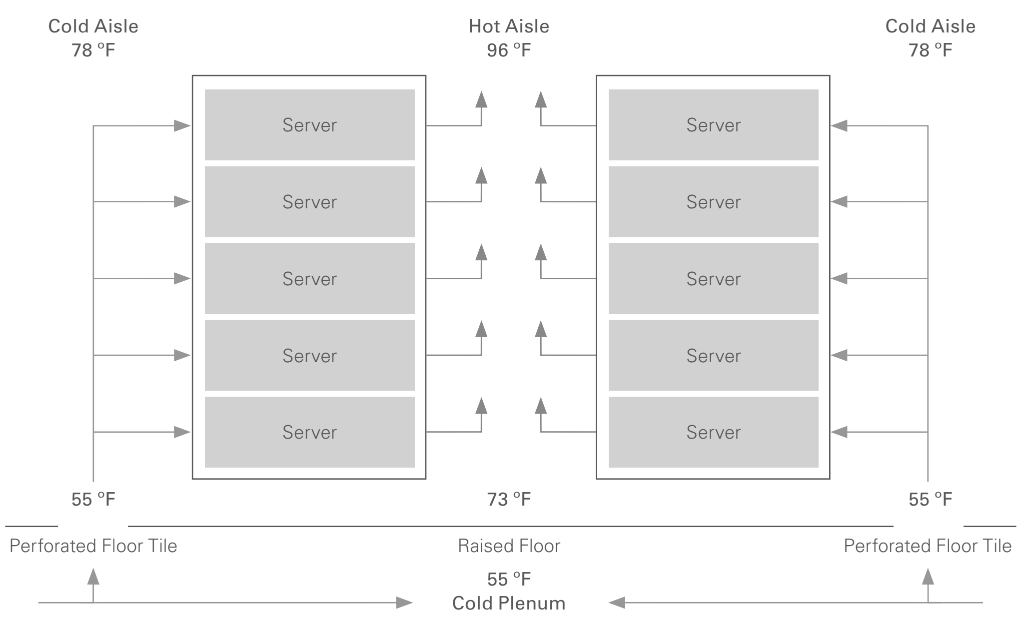

FIG 1 | Server rooms/facilities have controlled environments, unlike test systems, which are placed into uncontrolled, chaotic environments.

Impact of Thermals on the DUT, Test System, or Test Results

The first and most fundamental impact is on the accuracy of your instruments and DUTs. If you can't ensure the correct ambient temperature for any of your instruments, its accuracy would have to be derated.

For example, your calibration could be invalid if the ambient temperature changed enough between adjustment and verification to change the instrument or DUT accuracy. This might also result in false failures or false passes in manufacturing. The best way to manage this risk is to account for thermal offsets in your measurement uncertainty calculations.

Even if the temperature is within the specified range of operation, you might notice some difference in data from different test stations. The same is true for data collected in development rather than data collected in a production environment, with changes in ambient temperatures around the test station being the primary cause for variations.

Most instruments follow the ambient temperature closely, albeit with an offset. This means that even a slight change in ambient temperature can translate into a change in the instrument's temperature, which creates a rising potential for variation in data across test stations.

As a difference in temperature may result in data variation across development and production, it can also happen across verification and validation and test development. Usually, verification and validation is performed on a benchtop setup in an office setting, whereas test development is done using a rack-mounted test station in a controlled environment. This results in a totally different environment for the instruments, even if the instruments and subsequent test system are the same. Some instruments even have alternate measurement specifications for certain temperature ranges, so it's important you use the applicable specifications in your design and measurement calculations.

In addition, none of the previously discussed environments perfectly model the production manufacturing environment, so being conservative in your design to address the potential of these environments is recommended if no known environmental information can be applied. For example, the figure below compares environments by looking at room ambient temperature data over a period of a few hours at the front-top of a test station in an office cube area, as well as in a controlled environment.

The controlled environment is a small room with dedicated air conditioning, so you see the thermostat turning on and off more clearly with sharper temperature changes; this temperature is maintained around 23 °C to 25 °C. The office cube area is slightly warmer, though more stable.

The slight increase in both temperatures is the start of a workday (far right of chart); when people arrive, the temperature increases from body heat and doors opening. Note that the temperature for office cube areas can vary with time of year, location, floor, and other factors. In contrast, the controlled environment temperature is fairly constant throughout the year because of a dedicated air conditioner. In light of all these facts, you should always keep track of the ambient temperature while conducting verification and validation or developing tests and collecting data. This helps in data analysis if differences are seen across verification and validation data and test data.

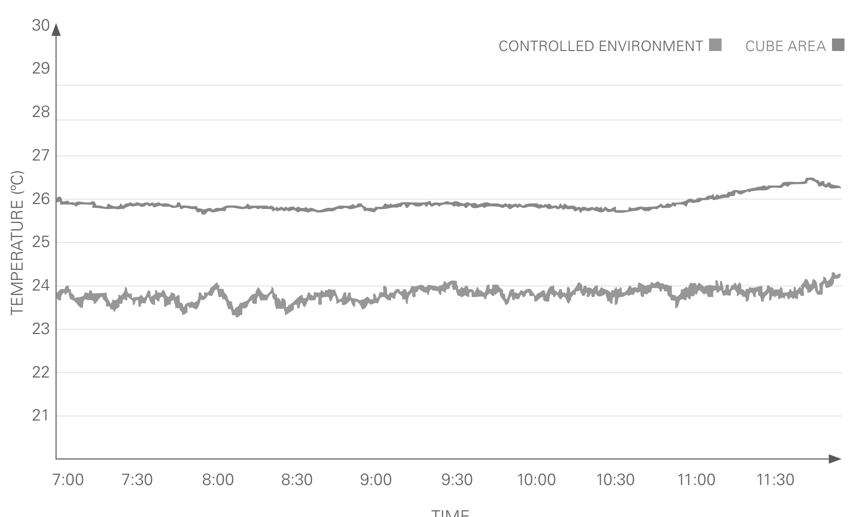

FIG 2 | Room ambient temperature

Thermal Profile of Rack-Mounted Systems

When thinking about the heat distribution in any system, there is a temptation to oversimplify it. The most common simplification involves the perspective of "cold at the bottom, hot at the top." You might also think that the temperature gradient is uniform across the rack, but in most cases, these simplifications are not exactly true.

In a real system, a number of variables contribute to the thermal profile, and as such, the thermal distribution varies. If an infrared thermometer gun or thermocouples were applied appropriately to a system, you would see characteristics like local heat zones and nonuniform temperature gradients in the horizontal or vertical axis of the rack system. This is because you are not dealing with just hot and cold air in isolation of everything else; the thermal profile depends on the rack layout, fan speeds of individual devices, location of inlet and outlet vents, power dissipation of each device in the system, and the airflow forced by the combination of all fans in the system.

This is important because it means that the top of the rack may not necessarily be the point needing the most attention, which is directly counterintuitive to one of the most common oversimplifications regarding thermals. A thorough evaluation is required to understand the unique thermal profile of each system and address areas of concern.

The following example helps explain how thermals can behave in a typical rack-mounted test system.

FIG 3 The common assumption of an even distribution of cold at bottom to hot at top will deliver bad results.

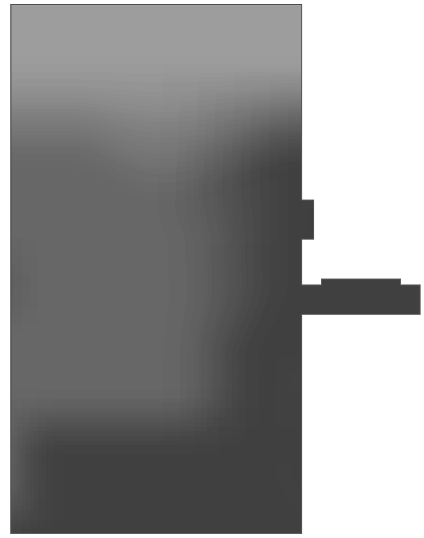

FIG 4 Localized heat zones create a variety of temperatures throughout the test rack.

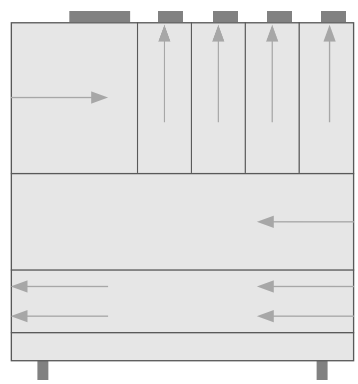

FIG 5 Top view of a modular power supply with airflow direction indicated

The first things noticed are the localized heat zones, which depend on the system's rack layout and device specifications as well as usage. In this example test station, the power supply has the warmest air around it, followed by the PXI chassis. Other parts of the test station appear to be colder than these localized heat zones, so depending on each system, there might be a need to address these localized heat zones differently. Another thing to notice is that the bottom heat zone is nonuniformly distributed in the x-axis.

What Causes Thermal Nonuniformity?

Usually, this nonuniformity is because of the device airflow patterns. For example, the power supply is composed of individual power supply units and a power supply mainframe. As you can see, the mainframe has its airflow from the left to the right. That means most of the warm air is on the right-hand side of the instrument.

The exhausts at the rear end are from individual modules; not all of them might be exercised at the same time, so the rear might not usually be as warm as this side. Moreover, the thermal profile of a rack system changes with usage, so the characterization is more involved than simply looking at the temperatures of a given case.

How Should the Thermal Profile of a System Look?

There are a few aspects of the rack-mounted system that you need to understand to determine how the thermal profile should look.

To begin, you need to understand the unique needs of each system:

- What are the required system-level specifications?
- What environment will the system be operating in?
- What instrumentation will be used and what are the temperature requirements for those instruments?
- Is keeping the temperature within a range enough or does your application require the temperature to be stable as well?

For example, if your DUTs are PXI modules and you need to power the DUT PXI chassis on and off while switching DUTs, the thermal profile of your rack would change repeatedly. These repeated changes require awareness of any instability in the rack's thermal distribution.

Lastly, not all points inside the rack are necessarily required to maintain the same temperature. It is typical to have some areas warmer than others, as long as the inlets of all instruments are drawing air that is in the specified temperature range.

Design Approach

This next section highlights best practices for developing a rack-mount system from design through rollout.

Before starting a rack design, you should understand several key elements about the instruments you are using that will have an overall impact on the design:

- **Evaluate the Air Inlet and Outlet for the Device**
  First, investigate your instruments and understand where the air inlets and outlets are on the module. The ability to provide the temperature requirements for the device is heavily dependent on the temperature at the air inlets and where you exhaust the heat generated from the instruments. Having an understanding of this will help you to successfully map out a rack design.
- **Understand the Specifications and Temperature Requirements**
  Often, devices specify certain storage, operating, and calibration temperatures. Which ones do you care about and how do you interpret each of them? Understand the way in which each instrument specifies temperature and what the impact is on the instrument performance or specifications—specifically, those specifications that impact warranted performance. For example, the 3458A states that you must maintain 23 °C ± 5 °C of ambient temperature to warranty the specifications of the device. Further, it states that you must autocalibrate the device if you have a relative change of ± 1 °C from the last autocalibration. The first specification is absolute to ambient, and the second is relative to the last calibration. Understand the differences and how that might impact your solution.

- **Understand the Definition of Ambient for the Device**
  Most traditional box instruments define ambient temperature as the temperature of air in the environment that surrounds the instrument. Typically, for PXI products and chassis, ambient temperature is defined as the temperature of the air immediately outside the fan inlet vents of the chassis. Because chassis like PXI-1045 require a clearance of about 1.75 inches for correct flow of air, you can safely assume that measuring the temperature within this clearance close to the inlet fans would give you the ambient temperature you care about. A common mistake is to assume that the ambient temperature for your instrument is the same as the temperature in the room where you are using the instrument.

  In general, this may hold true if you are using your instrument on the desktop with no influencing heat sources in close proximity; however, in a rack-mount design, you must consider the localized air temperature inside of the rack as the ambient temperature for your instrument. Instruments inside a rack design are more susceptible to thermal issues.

  Depending on your application and use of the instrument, be sure to accurately understand what your ambient temperature for each device may be.

Before selecting your rack or getting into any other specifics of the rack design, understand the expected thermal load that your rack may experience. This is easily done by performing a power budget of all of the electronics planned for the system. An understanding of power consumption provides insight into the thermal load.

Power Budget for All Electronics

Consider all instruments and peripherals in the design. This can include measurement devices, PCs, monitors, battery backups, or anything that may be a heat-generating source within your rack. For these devices, reference the product specifications to determine the power consumption of each. In general, product specifications list the worst-case power consumption (under full use or full load), which often isn't representative of the general or average performance of the device over time. Often, 60 percent rated max power consumption is used as a general guide for design. Having said that, in the future you may use your rack design for other purposes, which may result in an increase in thermal load, so consider adding some guard-banding to your calculations as you see fit.

Ideally, if you can measure the actual power consumption of your devices ahead of time, this gives the best outlook of the overall power consumption; however, this may not be feasible while planning your system. As a best practice, come back after the system is designed and make these measurements for documentation purposes.

Temperature Requirements and Airflow Profile

Based on instrument temperature requirements and airflow profile, map out the general locations wanted for instruments. Heat rises, so, often, the rack is cooler toward the bottom and warmer toward the top. Plan to place your most sensitive instruments toward the bottom of your rack design. You can use techniques to establish an acceptable thermal environment for your instruments in other rack locations, but often that comes at a cost.

Usability may be a constraint that drives the placement of some of your instruments, but evaluate and understand the impact of that placement. Maybe it requires additional consideration of how to handle airflow or how to provide cooler air to a device intake that is somewhat unconventional. Keep that in mind as you continue with your design. Also, account for any clearance constraints specified by the instruments. Often, instruments specify a certain distance that must be maintained around the device or in proximity to its inlets and outlets. Be sure that these specifications are met.

Rack Size Based on Layout

The layout should give you an idea of the size of the rack required to house the instruments. Remember to factor external constraints, such as floor space and room height, into your rack selection.

The exhaust air from all instruments should have an unobstructed pathway to exit the rack. In this example layout, you can see a whole instrument blocking the exhaust from instruments below it. Another bad practice is to have the hot and cold air short circuited. You can fix these by laying out the rack more cleverly, but start with a good understanding of the instruments' inlets and outlets and expected airflow.

Rearrange the instruments to provide a continuous airflow path from all instrument outlets. In addition, use mechanical separations to ensure that all instruments are getting inlet air from outside air when possible.

For situations where the air inlet of an instrument is located on the inside of the rack, because of how the instrument is installed, the exhaust from one instrument may be recycled into the inlet of another instrument. You could have multiple instrument exhausts feeding into each other's inlets. This could raise the ambient temperature inside the rack significantly, and would increase as you go up the rack.

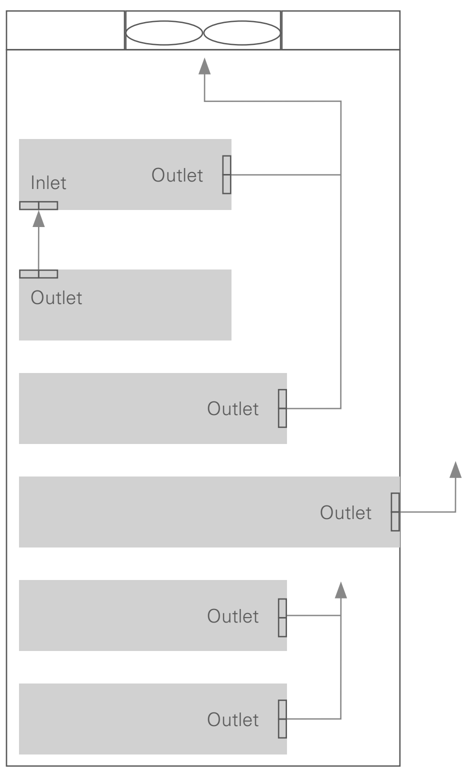

FIG 6 Example of instrumentation blocking exhaust in a rack system

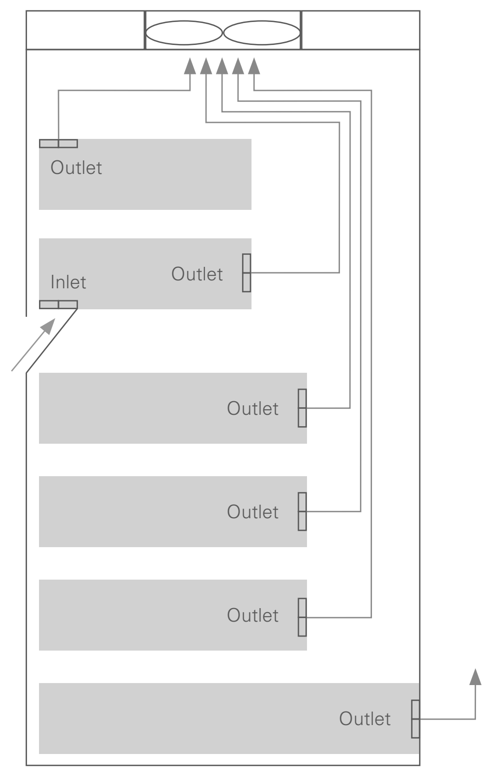

FIG 7 Example of proper exhaust layout in a rack system

In these situations, the ideal approach is to provide an isolated path from outside the rack to the inlet of the instruments. This ensures that the ambient temperature for an instrument is understood and controlled.

Remember, it's not enough to look at only the inlet temperatures. Be sure to provide adequate clearance for every instrument per the instrument's specifications so that it has proper insulation and airflow around it. It may be tempting to ignore these constraints because often it results in quite a bit of unused or wasted space. To get the specified performance from of an instrument, however, these clearance specifications must be followed.

From the image, it may appear that you are creating localized heat pockets between the instruments. Keep in mind that the red heat arrows are shown just to illustrate that this heat would be blocked from entering the air inlet. Design your isolations paths to the inlets of your devices to allow air to flow around and up the rack. Most rack assemblies provide adequate spacing to the sides of all instruments to ensure that the appropriate "chimney effect" can be established. Any heat that your instruments exhaust should also be allowed to flow around your inlet isolation barriers. There are many ways to ensure that the heat is properly extracted from the rack without impacting your instruments. These are just a few examples.

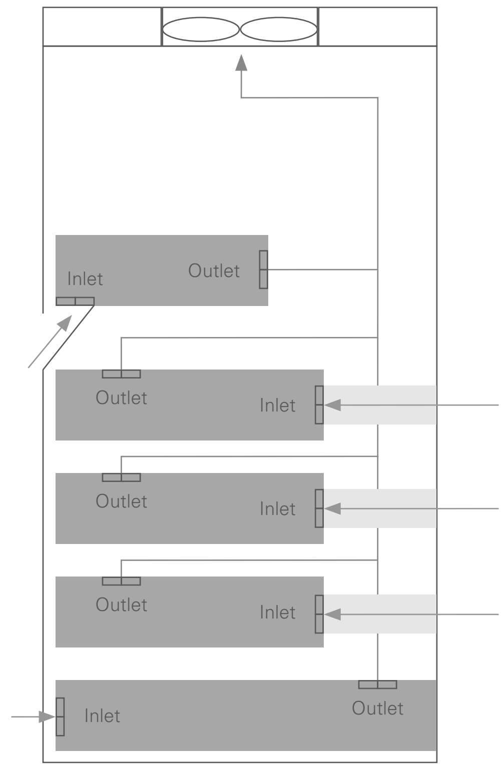

FIG 8 Example of custom inlet venting in rack design

Heat Transfer and Airflow

As you saw earlier, most instruments' outlet temperatures follow the ambient temperature trend.

The difference or offset comes from self-heating and air heating:

- **Self-heating**—Any component on an electronic device will heat up above the ambient temperature because of warm air coming from other components as well as self-heating. Self-heating is not in your control.
- **Air heating**—A cleverly laid out rack system can minimize air heating and a correctly designed rack cooling system or room cooling system can take care of ambient heating. So, control this offset while designing your system.

In this case, the two chassis have slightly different self-heating and air heating because of different PXI cards installed and different locations in the rack.

Passive Cooling

Passive cabinets are designed to maximize the ability of the internally mounted equipment to cool itself through its own fans. In this method, the equipment produces airflows, and the surfaces and ventilation in the rack exchange heat.

Active Cooling

Whereas passive cooling simply relies on the equipment fans and heat transfer, active cabinets use additional, strategically placed fans and/or blowers to supplement airflow, thus increasing heat dissipation.

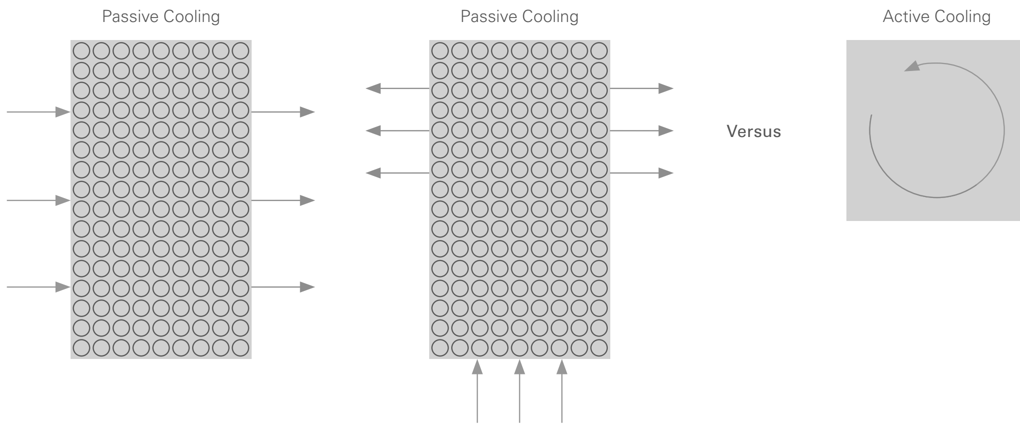

FIG 9 Passive cooling relies on the fans of the internally mounted instrumentation, whereas active cooling uses auxilary fans and blowers mounted in the rack.

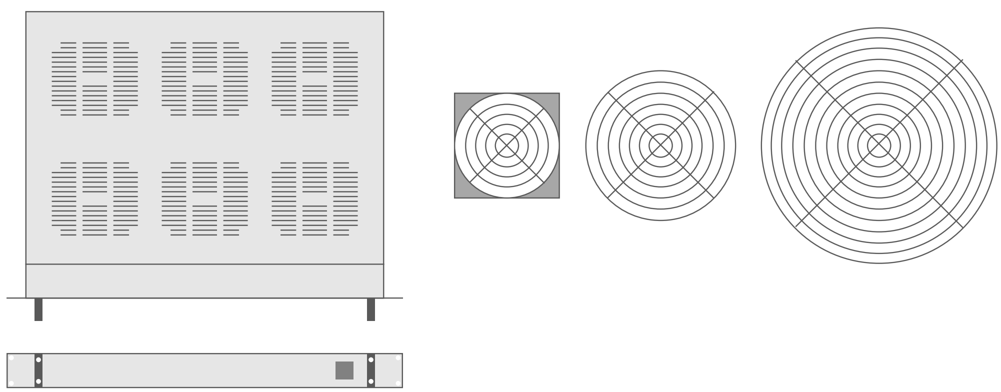

FIG 10 Active cooling options range from internal trays to individual side or top-mounted fans.

More often than not, forced-air cooling is needed for rack-mounted test systems. Having one properly sized exhaust fan at the top of the rack is typical; however, the vents and airflow need to be planned according to the exhaust fan location. Putting a fan tray in the middle of the rack is recommended to help with airflow if your air path has bends, obstructions, or maybe a concentration of high-power instruments in one area. You may also consider localized heat removal if your rack has hotspots that you need cooled. You can use individual fans or fan trays for this purpose.

Fan Capacity

To get a good idea about how large your fan should be, you need to calculate the cubic feet per minute (CFM) of air the fan should be able to move with consideration given to the total power wattage of all devices in the rack and the temperature difference between the air inside and outside the rack.

Higher CFM comes with some trade-offs like cost, vibration, and acoustic noise. Also, however high your fan's CFM is, you can't cool your rack below the room ambient anyway. So the idea of this equation is to arrive at a good balancing power between all these parameters. Air resistance also plays a part in the ability of a fan to cool. Air resistance increases based on the cross-sectional area of objects that are in the path of the airflow, whether it be the area of opening for intake area or area of devices in the path of the airflow. Therefore, margin should be given for the CFM rating of the fan to ensure it can overcome air resistance and still provide the necessary air movement.

When evaluating the total wattage, avoid using the rated power of the devices; this is usually the maximum possible power that a device can dissipate, but rarely does a device use this much power consistently. A good rule is to use something between 50 to 60 percent of the rated power. Or better yet, use the PDU of your rack system to get the actual power being delivered and use that value.

Delta T (ΔT_c) equates to the amount of heat you want carried away from the rack. This comes from looking at the requirements of your devices or by looking at simulation results. It might vary, depending on the location inside the rack—usually higher at instrument outlets or at the top of the rack, so be sure to understand what the appropriate delta T is for your system, and how to confirm you are achieving that delta T in practice.

Modeling and Validation

If a system is costly, includes long lead times for components, is part of a critical or strategic application, or contains many unknowns, modeling should be part of the design process.

Modeling the Rack Design

Apart from theoretical calculations, modeling and simulation of your rack system can greatly speed up your design optimization and provide you with solid feedback on what changes to make.

Enter as many design specifications as possible into the software to get the most accurate modeling. If you cannot locate a necessary specification, evaluate similar components/instrumentation and ask senior members of your team if they have experience with these devices to gather estimates. The fewer unknowns you have, the better your modeling will be.

When you have exhausted research on your design, either through evaluating the instrument temperature requirements, performing calculations to optimize airflow and temperature, or simulating the design, you have done as much as possible short of performing real-world qualification testing. At this point, complete the fabrication of your design and validate the performance.

To characterize the performance, use temperature sensors or thermal imaging cameras. Focus on the critical areas within the rack that are of importance, such as the air intake of the rack and the air intakes of the instruments. Collect temperature data across your rack design while powering the rack and exercising the instruments in a general fashion as they may normally be used for the products to be testing. This gives you the most realistic view of how temperature will behave.

You may also want to exercise certain worst-case loading conditions, such as when the thermal load may be at its highest or lowest, to ensure that your design can still accommodate these conditions. Consider the time of day of testing, the duration of testing, and test conditions (how many operators are present, what normal interactions someone might have with the station, and so on) as factors that can impact your results. Analyze the results carefully to look for any previously unidentified anomalies or issues that you may need to address.

Validation Methods

First, use standard graphs, equations, and simulations early in the design to gain a general comfort level with the approach. Second, perform system characterization using temperature sensors or thermal imaging to validate the design and iterate on it until wanted requirements are met. Last, perform gage R&R studies to validate stability and performance to ensure station-to-station performance and production test to validation to verification agreement.

Maintainability Through System Monitoring

Consider implementing a health and monitoring system that gives you the ability to evaluate the system in real time to ensure that the expected performance is still being met. This ensures you can at least make informed decisions during testing by having feedback on the system performance, but may also lead to better understanding of measurement data and better prediction of system maintenance.

Areas of focus include:

- Stand-alone system to monitor system performance
- System watchdog for reporting maintenance issues
- Feedback for tests to validate test conditions
- Historical logging for evaluation and trend analysis

Spec Validation

Know the assumptions used during your spec derivations. If the ambient conditions while collecting real data differ from your derivations, be sure to account for them. Ensure that you are experiencing the performance you expect under the provided temperature conditions.

Limit Calculations

Similar to spec validation, account for temperature differences and variation in your limit derivations. If the product specifications are stated as a certain range and you are testing in an environment that provides a different temperature range, account for the difference by accounting for the temperature coefficient of your device appropriately. For example, NI switch modules are typically specified at 0 to 55 °C, however, the general temperature environment that they are tested under would be the standard manufacturing test floor, which carries on a maintained 24 °C ± 4 °C. Subtract the equivalent, worst-case temperature coefficient from the specifications and uncertainty of your measurement when establishing your test limits.

Applying Design Criteria to Product

Accounting for Thermals in Specs/Limits

When collecting data using your rack design, do not overlook the effects of thermals when considering specification validation of setting manufacturing test limits. If there are differences between expected results and actual, thermals may be the cause of these differences.

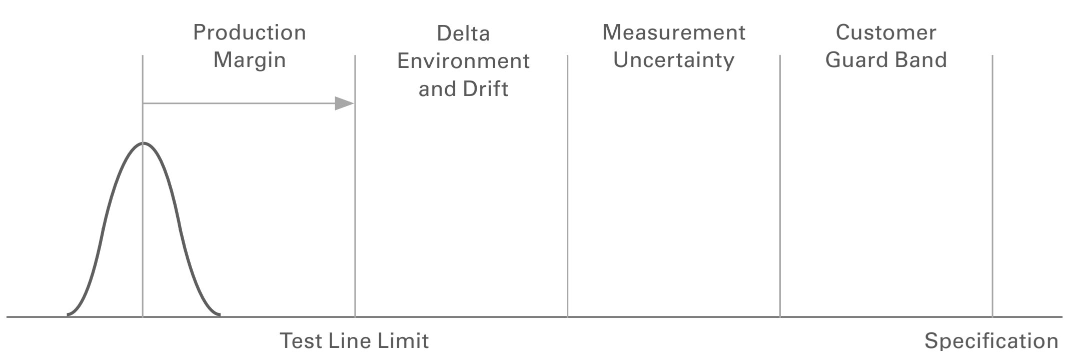

FIG 11 | Example general-purpose specifications model

Independent System Monitoring

Monitoring Temperatures in Real Time

Monitoring temperatures in real time gives you the ability to make dynamic decisions during your testing. You may determine that you are violating a certain operating requirement, thus you may halt your testing; or you may determine that you need to perform a self-calibration or institute a delay before continuing testing to account for stability. Lastly, just having the data and logging it historically may provide insight in the future if questions arise about performance or correlation to measurement results.

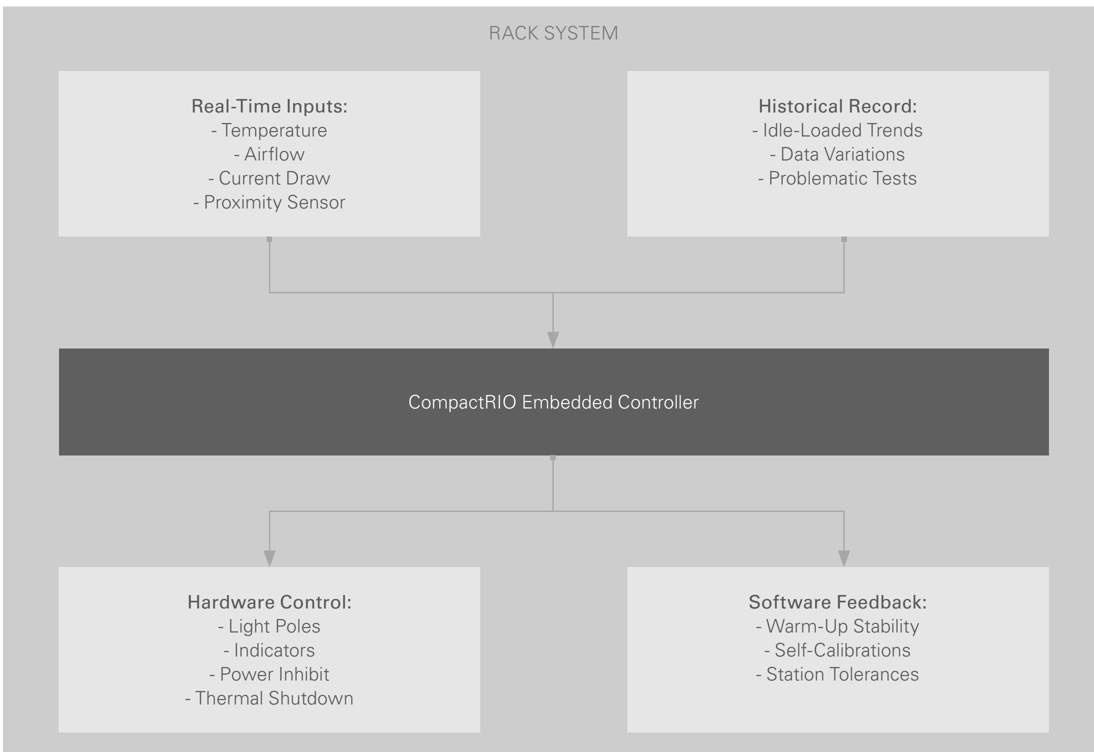

FIG 12 Example independent monitoring system using CompactRIO

For example, you could use an embedded, independent system to monitor and control certain aspects of a test station design. You can monitor temperature and make it available in your test execution to make decisions, as well as monitor and manage resources in the station to support parallel test. In general, you can use an independent monitoring system for several tasks and it can be beneficial during not only the design and validation of your rack system but also the deployment and long-term use.

Although many options exist, you can use an approach like this to:

- Monitor
  - Ambient temperatures throughout the rack
  - Airflow, current draw, and internal temperatures of your instruments
  - Instrument health for maintenance concerns
  - Doors of the racks using proximity sensors to detect if the system has been accessed
  - Temperature conditions to implement thermal shutdown mechanisms to safeguard the system
- Gain data to make real-time decisions in your test application
- Log this historical data for future analysis
- Provide feedback to the user of the station through light poles, indicators, or displays on the status of the station and to report any out-of-tolerance conditions

A health and monitoring system can help you to evaluate the system in real time, make informed decisions during testing, and better understand measurement data and predict system maintenance.

Next Steps

NI Alliance Partner Network

The Alliance Partner Network is a program of more than 950 independent, third-party companies worldwide that provide engineers with complete solutions and high-quality products based on graphical system design. From products and systems to integration, consulting, and training services, NI Alliance Partners are uniquely equipped and skilled to help solve some of the toughest engineering challenges.

Find an Alliance Partner

NI PXI Chassis Cooling

NI chassis are designed and validated to meet or exceed the cooling requirements for the most power-demanding PXI modules. Chassis designed by NI go beyond PXI and PXI Express requirements by providing 30 W and 38.25 W of power and cooling in every peripheral slot for PXI and PXI Express chassis, respectively. This extra power and cooling makes advanced capabilities of high-performance modules, such as digitizers, high-speed digital I/O, and RF modules, possible in applications that may require continuous acquisition or high-speed testing.

Learn more about the NI PXI Chassis Design Advantages

Build Your PXI-Based Test System Today

NI is the creator and leading provider of PXI, the modular instrumentation standard with more than 1,500 products from more than 70 vendors. Select the appropriate chassis, controller, and modules for your application, and let the advisor recommend the necessary components and accessories to complete your system.

Configure your PXI system