

# Fast Thermal Characterization and Testing Your Electronic Devices

## Save Time and Reduce Costs During Product Development

### Why Do You Need Fast Thermal Characterization?

The thermal characterization process is often a rigorous and painstaking task. It involves wiring setups of multiple temperature points and measuring other types of signals such as voltage, current, resistance, and more. To accurately characterize the prototype product, you need to test sample size to support the findings statistically. Very often, you must repeat the process many times until the product development stage is final.

A fast thermal characterization process has its advantages, it provides:

1. Quick initial quantitative insight into your product's thermal characteristics
2. Fast turnaround time to troubleshoot your products
3. Flexibility for many iterations and comprehensive testing

### Importance of Thermal Characterization and Testing

The business impact of incomplete or inaccurate design characterization is higher than many research and development (R&D) managers realize. For example, the cost to fix errors after release is at least several times higher than during the design cycle. A defect discovered during the product development cycle can cause a schedule slip resulting in additional resource and material prototyping costs.



#### Introducing the DAQ970A Data Acquisition System

- Fast time to insight measuring multiple signal types and sensors. Data acquisition that is easy to configure and run, with no programming.
- Comes with new solid-state multiplexer with faster switching speed (up to 450 channels per second).

Learn more by downloading the DAQ970A Data Sheet, **5992-3168EN**.



## What Are the Practical Steps to Expedite the Process?

Fast thermal characterization must align with accurate measurements. Implementation of the proper steps in thermal characterization is essential by using the right tools and test instruments to ensure you get fast thermal characterization and reliable, accurate results.

### 1. Accurately predicting the operating temperatures of your electronic components

When designing complex electronic products, it is advisable to perform CAD software simulations to predict the operating temperatures of your electronic components accurately. There are plenty of interactions on heat flow between components, and you want to confirm there are sufficient heat outlets designed into your product.

Heat outlet solutions are conductive heat tubing, fans, or conductive fins to vent out the heat.

There are computer tools that accurately simulate the dynamics of thermal flow of your electronic product. Figure 1 shows an example of the thermal air flow within the enclosure of a product.

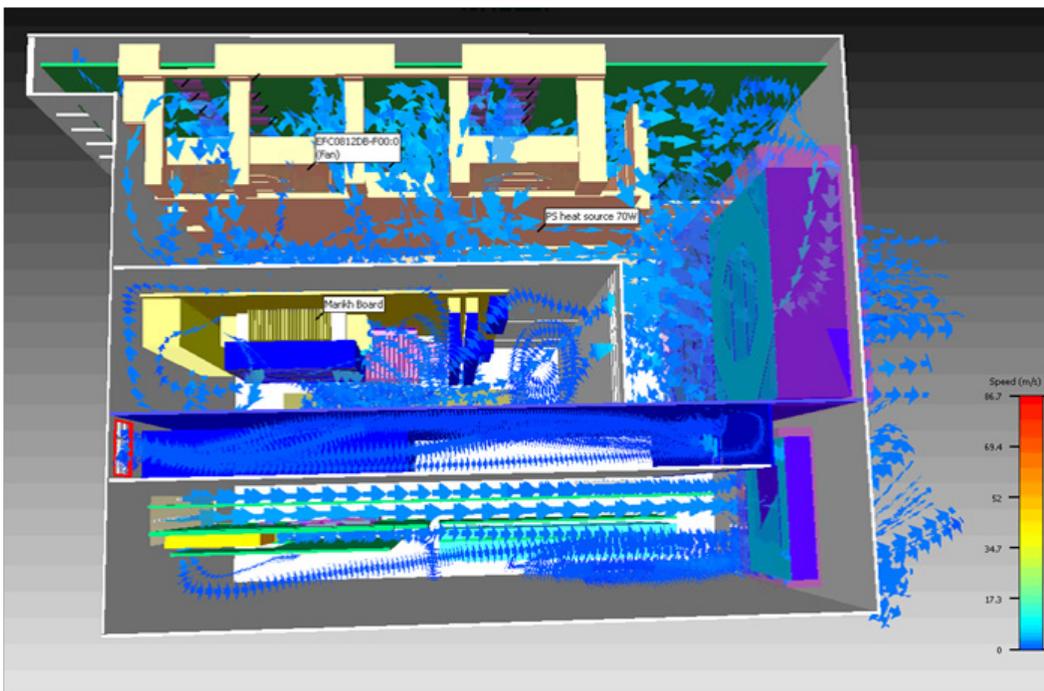


Figure 1: Product enclosure with thermal air flow simulation

Understanding the overall dynamics of the thermal flow helps you design a better product and avoid surprises along your development stage. Troublesome thermal issues can sometimes lead to project delays or even reset your project back to the initial design stage.

## 2. Preview electronic assembly under operation

In most cases, with precise software simulation tools and design knowledge, you know which component to monitor over an extended period. It is useful to also perform a quick thermography preview of the overall electronic assembly under operation. You can quickly confirm the predicted hotspots and see how it thermally affects the surrounding area, and scan to determine how effective the thermal dissipating solutions are functioning.

Figure 2 shows a photo of an electronic assembly (top left), a thermography photo of the same assembly and a zoom out thermograph picture of the main hotspot.

A thermograph preview helps save time before setting up a data acquisition (DAQ) system to monitor many temperature points over an extended period.

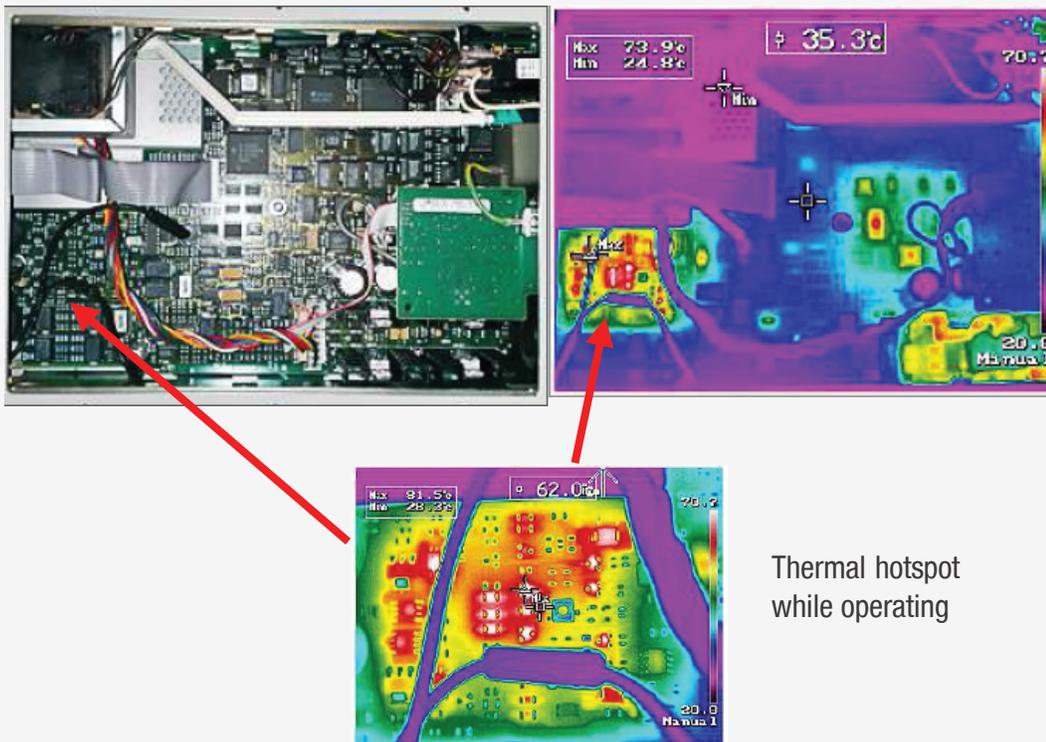


Figure 2: Use thermography to quickly confirm hotspots

Thermography identifies hotspots quickly and even makes absolute temperature measurements. However, in most cases, the accuracy of the thermography may not be good enough for product thermal characterization. Let us now look at thermal data logging using a data acquisition system (DAQ).

### 3. How to make data acquisition temperature measurements

Data acquisition temperature measurements is a crucial step in the thermal characterization process. You must concurrently capture all the temperature points and product performance measurements. You may have to:

- Capture multiple temperature points at various locations of your prototype
- Capture data from multiple prototypes for proper statistical sample size
- Run multiple prototype cycles until the product is fully characterized and the design is finalized
- Besides temperature, measure other types of signals such as voltage, current, resistance or frequency
- Datalog measurements over a specific period, or a required environmental temperature cycle

#### - Choose the right DAQ input modules and sensors

Select the input module multiplexers that provides the scan rate speed that you need. Solid state switch multiplexers are typically 2X faster than reed relay switch multiplexers and about 10X faster than the mechanical armature switch multiplexers. However, there is a trade-off between switching speeds and voltage handling capability.

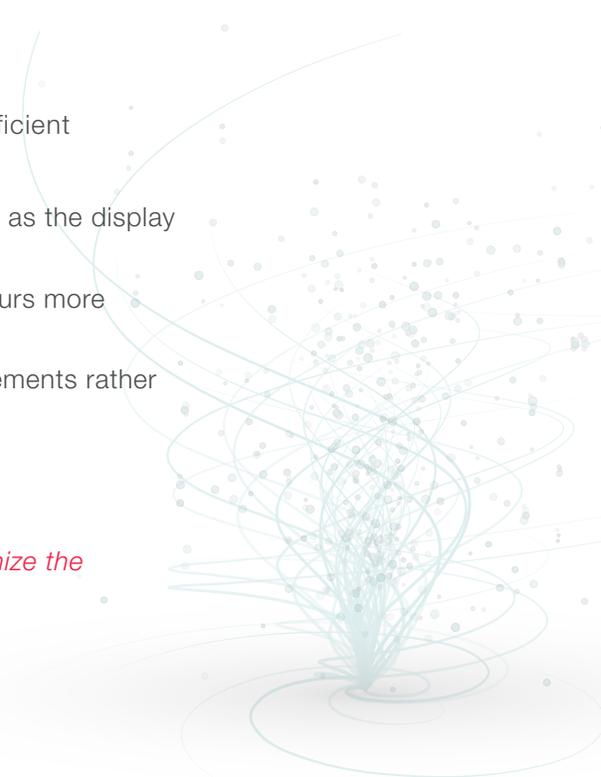
There are three types of temperature sensors to choose from; the thermocouple, thermistor, and resistance temperature detector (RTD). In short, select thermocouple sensors for its ruggedness and a wide selection of temperature ranges; a thermistor sensor for its high-sensitivity and fast response; and an RTD sensor for its stability and high-accuracy.

#### - Optimize DAQ hardware settings

There are many ways to optimize your hardware for fast and efficient measurements. Your DAQ system is configurable to:

- Reduce system overhead; turn-off unnecessary functions such as the display and monitoring services
- Select adequate measurement resolution; higher resolution incurs more processing time which impacts speed
- Select appropriate measurement range that meets your requirements rather than running auto-range
- Select sufficient measurement setting for averaging
- Look for ways to reduce software code transactions

For more details, please refer to the white paper on *How to Optimize the Measurement Speed of your DAQ*.



## - Practical steps to improve test efficiency and speed

When planning the thermal characterization tasks, you need to look at the overall end-to-end process to ensure test efficiency and speed. It is essential to reduce repetitive work to get consistent test results.

- Choose and confirm the correct sensor type, measurement range and resolution, scaling such as gain and offset, and pass/fail limits are in use. This process is made simple with a user-friendly software guide built into modern DAQ or PC applications.
- Automate and record your tests. PC application software is available to help automate the iterative test process.
- Simplify the post-analysis and report generation work with a built-in math computation feature available in modern DAQs and PC application software.
- There are additional practical features available in modern DAQs such as real-time channel computation, digital I/O and alarm capabilities.

For more details, please refer to the white paper on *Practical Steps on Design Verification Using DAQ Data Logger*.

## Application Benefits

Fast thermal characterization helps provide quick initial quantitative analysis and insight, faster turnaround time for troubleshooting, and the ability to perform comprehensive testing. Let us explore the application benefits of fast thermal characterization and testing in specific areas.

### 1. Design verification

Design verification is an integral part of a process in the product development life cycle. It is a rigorous process control to ensure product design is as intended. Design verification checks your design inputs and determines whether they produce the design outputs that reflect specific requirements.



Here is an example of the need for fast characterization during the product development stage.

*You need to meet your prototype characterization schedule. Typically, you must perform iterative testing for multiple prototype cycles: troubleshoot design problems, tweak performance, incremental features, and functionalities added at various prototype cycles.*

The new DAQ system such as the DAQ970A and its BenchVue DAQ application software helps reduce test time with the copy and paste configuration settings, and save and recall configuration settings.

Channel		Measurement			Scaling (Mx + B)			Alarm Limits							
Scan	Number	Name	Function	Range	Res	More	Scale	Gain (M)	Offset (B)	Units	Test	Low	High	HW Alarm	More
	34901A:20-Channel Armature Multiplexer														
<input checked="" type="checkbox"/>	101	Temp (Type J)	None	C	...		1	0	C	Off	0	0	Alarm 1	...	
<input checked="" type="checkbox"/>	102	DC Voltage	+/- 10 V	5.5	...		1	0	Vdc	Off	0	0	Alarm 1	...	
<input type="checkbox"/>	103	DC Voltage	Auto	5.5	...		1	0	Vdc	Off	0	0	Alarm 1	...	
<input type="checkbox"/>	104	DC Voltage	Auto	5.5	...		1	0	Vdc	Off	0	0	Alarm 1	...	
<input type="checkbox"/>	105	DC Voltage	Auto	5.5	...		1	0	Vdc	Off	0	0	Alarm 1	...	
<input type="checkbox"/>	106	DC Voltage	Auto	5.5	...		1	0	Vdc	Off	0	0	Alarm 1	...	

Figure 3: Keysight’s BenchVue DAQ application software configuration panel.

## 2. Developing error correction algorithm

Electronic component characteristics change as its operating environment temperature changes. Some products must function with precision over its allowable operating range. To ensure the product functions with accuracy, product developers must build-in error correction algorithm into their products.

Keysight’s DAQ970A has BenchVue test flow software (see Figure 4) that helps to perform simple test automation, loop and measure multiple signals over time, gather raw data, and exports to Excel or MATLAB for post-processing. The export file can be used formulate and verify the error correction algorithm.

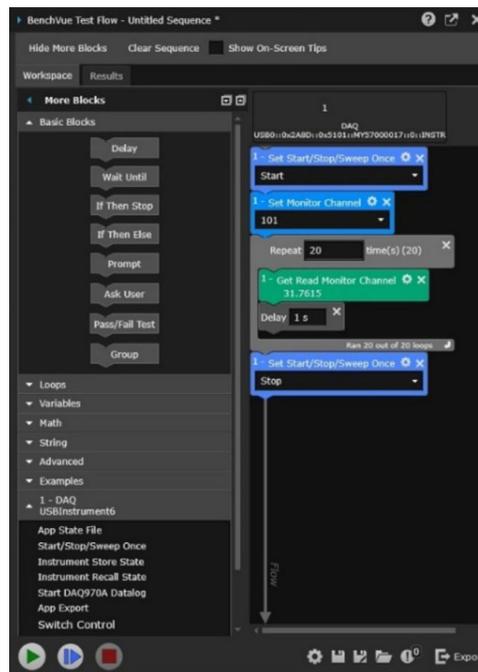


Figure 4: Keysight’s BenchVue Test Flow software; test automation without complex programming

### 3. Design validation

Design validation is a test process to confirm the product under development conforms to user requirements, or its ultimate intended usage requirements. The product must be at a reasonable advance stage during the design validation process. All the design concepts, initial gross design bugs, and obstacles are behind in the product development life cycle. You are ready to test the products in the field or perform trial tests with the actual users, or by simulating its environmental operating situation.

### 4. Quality and reliability

The quality and reliability of a product is now a basic expectation from the users' perspective. High-field failures are costly not only to customers but also to manufacturers of the product. The expense to fix errors after release is at least several times more than during the design cycle. Imagine the cost of recalling products to the factory to replace parts due to quality or reliability problems.

The new DAQ970A has excellent productive features such as trend monitoring and statistical tools for monitoring real-time while data is captured. See Figures 5 and 6.



**DAQ970A Data Acquisition System, is versatile and well-suited for design validation:**

- Built-in 6 ½ digit DMM & signal conditioning circuits
- 3-slots with choice of input multiplexers to measure up to 120 independent channels
- Universal inputs where each input channel can measure multiple types of signals

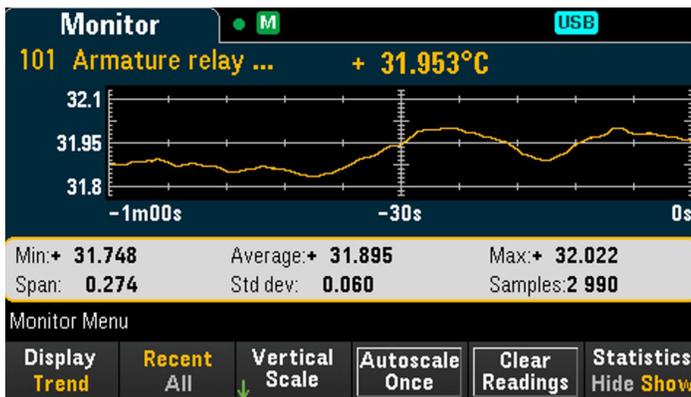


Figure 5: Trend chart displays statistical information while monitoring captured data

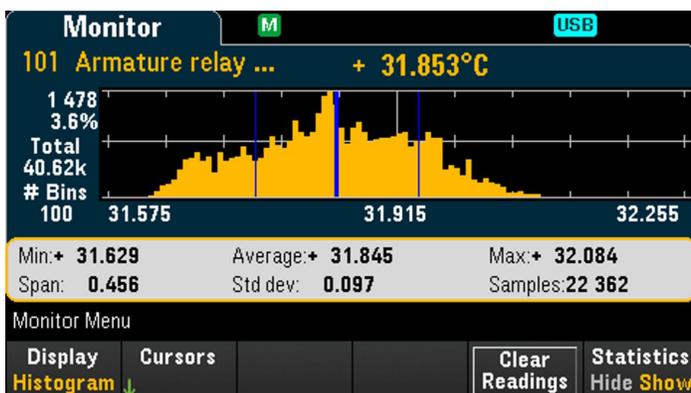
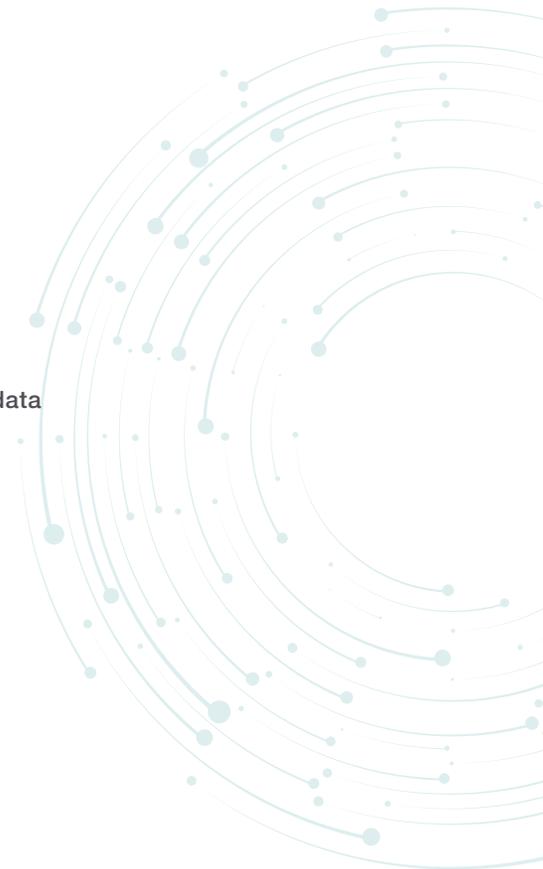


Figure 6: Histogram charting while measurements are in progress with the DAQ970A



## Conclusion

Fast thermal characterization and testing gives you the advantage of quick and qualitative insight into your products' characteristics, the ability to troubleshoot and fine-tune the performance, and the capability to perform additional iterative testing.

Before making qualitative measurements, perform predictive modeling of temperature dynamics in your product. Many product designers use thermal flow software simulations. Performing comprehensive thermal characterization with 20 to 40 temperature points is time-consuming. You can perform thermography to confirm your hotspots before making the actual extensive wired temperature measurements.

When using the DAQ for your extensive wired temperature measurements, it is good to select the correct input multiplexer module and sensors to ensure measurement accuracy and speed requirements. Make sure all your measurement settings are optimal for fast and efficient testing.

Modern DAQ systems are now incredibly versatile to meet all your application needs whether it's for design verification or validation, development of an error correction algorithm, or to improve the quality and reliability of your product.

To learn more about Keysight's new and modern DAQ970A and all its modules and accessories, please visit our website at [www.keysight.com/find/DAQ970A](http://www.keysight.com/find/DAQ970A)



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