Keysight Technologies

# Quickly Identify and Characterize Thermal Measurement Points

Application Brief

## Test Challenges:

- Temperature characterization of a prototype
- Long-term building inspection

# Overview

Traditionally, the process of identifying temperature sensor locations has been based on knowledge of the design and some intuition. It's not uncommon, for example, for the designer to simply guess at the right location when placing temperature sensors. But what if there were an easier, more accurate alternative? What if you could supplement that knowledge with a test that is fast, non-intrusive and practical?

See our test challenges below to learn how Keysight's 34970A/34972A data acquisition (DAQ) solution and U5855A True*IR* thermal imager can provide you faster, better insight into making temperature measurements.

| Temperature characterization of a prototype | Long-term building inspection |
|---|---|
| You are an R&D electronics engineer having completed your first prototype. Everything works as designed; however, a temperature characterization of your design is necessary to ensure its components don't overheat through normal use. Using your notes, you can theoretically derive where the most power is dissipated and identify the potential problem areas, but a flaw in the design where power is being consumed at an unexpected rate might go undetected. The U5855A TrueIR thermal imager can quickly identify these problem areas. Then, you can characterize your design in different scenarios with up to 60 different thermocouples wired into a 34970A/34972A DAQ system. | Long-term building inspection can be a difficult proposition. As a building's foundation settles, gaps in the structure or insulation may develop. Such issues could cause heating or cooling costs to rise, or worse yet, indicate a structural flaw. To help characterize these changes long term, forward thinking governments and builders now monitor temperature in their buildings. With the U5855A TrueIR thermal imager, problem areas can be easily identified at the initial inspection. Once identified, the 34972A DAQ with LAN capabilities can then be used to setup a temperature sensor network to monitor temperature characteristics from a remote location over a long period of time. |

## Quickly identify thermal measurement points with a thermal imager

You've decided you need to monitor temperature over a period of time. Using a DAQ system makes sense because it is flexible, accurate and can take data at set time intervals. However, you might want help in either choosing the right locations to monitor or have questions about using a DAQ system for monitoring temperature. No matter how much you plan or prepare, surprises often arise when it comes to testing temperature. Here's how you can minimize those surprises.

First, you need to identify areas that you want to monitor. In traditional electronics design, this means finding hot spots or areas where you have poor air flow. In other applications, such as building inspection, hot or cold spots may be areas of concern. In these scenarios, a particularly useful tool in identifying problem areas is Agilent's U5855A True*IR* thermal imager. Using a proprietary algorithm, this cost-effective camera outputs thermal images with 320 x 240 pixels—4X its native sensor resolution. This Fine Resolution capability allows the U5855A's price to be much lower than comparable 320 x 240 thermal imagers.

The U5855A thermal imager has a number of features to help characterize problem temperature points quickly with a fast learning curve. It can visualize temperature with either a static image that you can download to your PC, or a large live-view display on the U5855A itself. With this ability, you can see where the temperature is hotter or colder than you would expect.

Figure 1. Picture of a Printed Circuit Assembly (PCA) under test.

A thermal imaging camera like the U5855A can also highlight minimum and maximum temperatures, or give a spot reading of temperature for a quick readout. You can even use it to characterize your subject in less than 5 minutes; quickly allowing you to determine where to focus your efforts.

To obtain accurate temperature readings using the U5855A, you simply set the emissivity setting of the thermal imager to match your Printed Circuit Board (PCB) or the material you are measuring. Emissivity of a material is its relative ability to emit infrared energy. As an example, the emissivity of normal FR4 PCB is 0.91. One other option is to spray your board with a spray-on high emissivity coating, such as boron nitride lubricant, that has an emissivity value of 1.

In Figure 2, we have two images of the same Printed Circuit Assembly (PCA). The image on the left is an image of the whole PCA, while the image on the right is a close up of the hot spots that were found in the left picture. There are 9 hot spots we are interested in characterizing, in addition to 5 areas on the board that we want to monitor for general temperature stability.

## Measurement tip

If you want to characterize an enclosed Device Under Test (DUT) to better judge the product design with airflow, you can use a polyethylene plastic sheet to simulate part of an enclosure. Polyethylene does not insulate and allows the Infrared (IR) energy to pass through.


Figure 2. Two thermal pictures of a PCA. Right image is a close up the left-hand portion of the PCA.

The U5855A can focus in on objects as close as 10 centimeters from its lens. There is also an optical zoom feature that allows you to zoom in up to 4X closer, in the camera. Blending, picture-in-picture and other tools allow for easy comparison between optical and thermal images of each and every component.

## Measurement tip

The U5855A has one of the best thermal sensitivity specs in its class, which allows you to see component temperatures with a difference of 0.07 °C.

The U5855A is an optimal solution for electronics characterization. Most other thermal cameras with a longer focal length must be placed further away, leading to a coarser thermal image. Coarser images don't allow you to capture finer details. To compensate for the blurred image, upgrading to a higher resolution thermal camera is often necessary.

Many electronic designs are encased within a chassis or enclosure. Temperature characterization within that chassis is therefore, preferable. This allows you to determine if your airflow is adequate. One method to quickly determine hot spots is to create a chassis with a cutout or window into the circuit-of-interest. You can then cover this window with a sheet of polyethylene plastic, commonly used in trash bags. This method allows you to simulate the airflow of a closed chassis, but still view the temperatures on the design.

## Making Data Acquisition Temperature Measurements

Once the points have been determined, a DAQ system can be used to further characterize the heat profile of your design. Using a system such as the 34970A/34972A offers many advantages over a thermal imager. Through the use of low intrusion temperature sensors, you can accurately measure temperatures down to 0.06 °C (transfer accuracy) and fully characterize your temperature either in design's chassis or in the real-world environment.

One of the first steps to characterizing your temperature is to choose the right temperature sensor. Common temperature sensors include thermocouples, Resistance Temperature Detectors (RTDs), thermistors, and IC sensors. Each has its own particular advantages for different applications.

Thermocouples, for example, are well suited for temperature profiling many points because of their form factor, simplicity and low cost. They can also be used in a range of temperatures and are optimized for various conditions. Thermocouples are rugged, often welded to a metal part for long-term stability, and are the most versatile temperature transducers. The 34970A/34972A does most of the work; from reference compensation to software voltage to temperature conversion. Using a thermocouple is as easy as connecting two wires together. The 34970A/34972A DAQ system provides modules that have a temperature reference built-in to make it easier to achieve accurate thermocouple measurements.

In contrast, a RTD is well suited for use in an environmental chamber because of its relatively high linearity, long-term stability and measurement repeatability. A four-wire ohms measurement, which compensates for lead resistance, is well suited for accurately measuring RTDs. This measurement is a standard measurement function in the 34970A/34972A DAQ system. RTDs are the most accurate and stable temperature sensors; however, they are also the slowest and most expensive. They are a good fit for precision applications where accuracy is critical, but speed and cost are secondary concerns.

Like RTDs, thermistors are also a temperature changing resistor. They offer sensitivity as their main selling point and have a larger behavior change with temperature than the other sensors previously mentioned. This wide behavior allows small differences in temperature to be measured in larger resistive changes.

Of these sensors, only the IC sensor requires power and incorporates signal conditioning in order to output an easily measured electrical signal. Another benefit is that IC sensors can supply an output that is linearly proportional to absolute temperature.

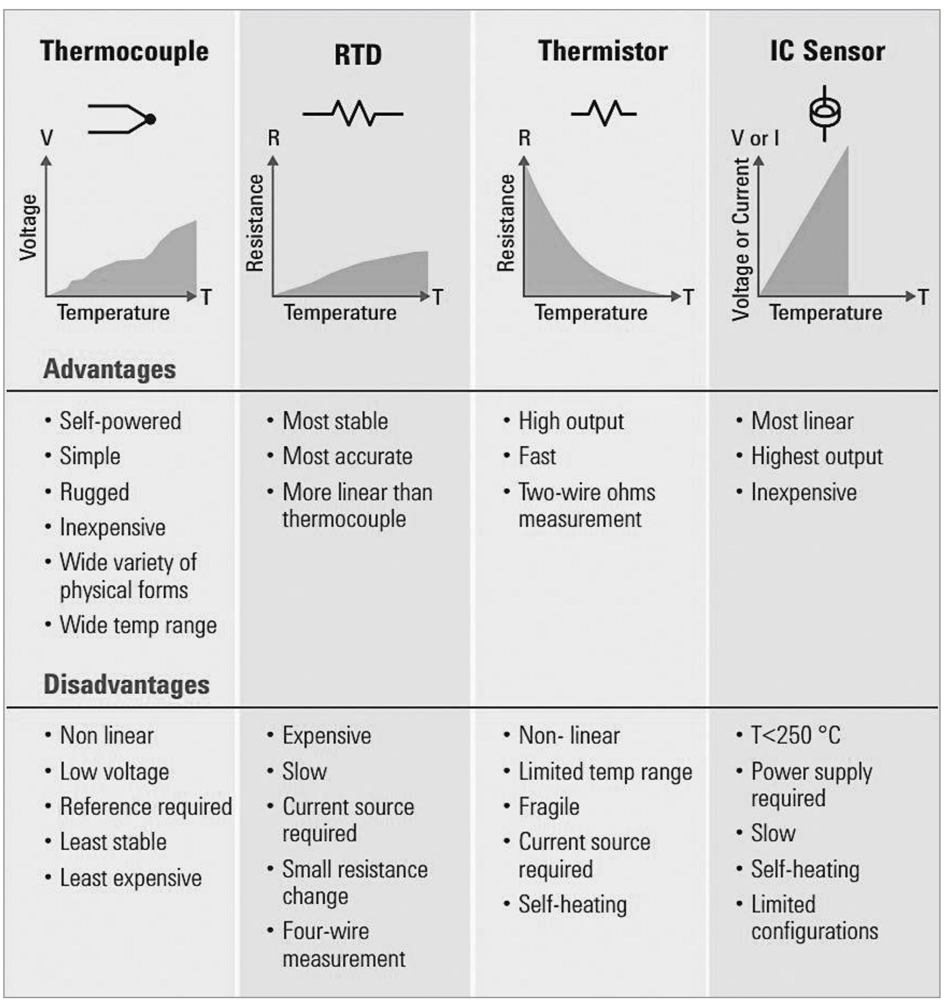


Figure 3. Temperature sensor advantages and disadvantages.

Conversion routines built into the Agilent 34970A and 34972A firmware accept B-, E-, J-, K-, N-, R-, S-, and T-type thermocouples; 2.2-, 5- and 10-kΩ thermistors; and a wide range of RTD’s. Results are displayed directly in degrees C, F or K.

Once you have decided on the type of device to use for temperature monitoring, you will need to mount the devices onto your board or structure. As an example, if thermocouples are used, they must make direct contact with the surface you are monitoring. The mass holding the thermocouple to the surface must be minimal to ensure you are monitoring your surface as it changes.

With structures, a longer term data recording system with monitoring up to a year or more might be desired. In this case, you will want to ensure that your thermocouples are mounted using a rugged and sturdy connection, such as by welding or screwing them to a metal part.

With electronics, you will want to mount the parts for reliable connections; however, you want a connection that does not damage the PCA. You can solder the thermocouples with a high temperature solder, hold the thermocouple down with Kapton tape, or use an adhesive to stick it to your PCA.

Once your system has been wired and mounted, you can monitor it in various environmental conditions, under real-world conditions or in an environmental chamber. Using the 34970A/34972A DAQ, you can easily and accurately monitor your system long term with software automation.

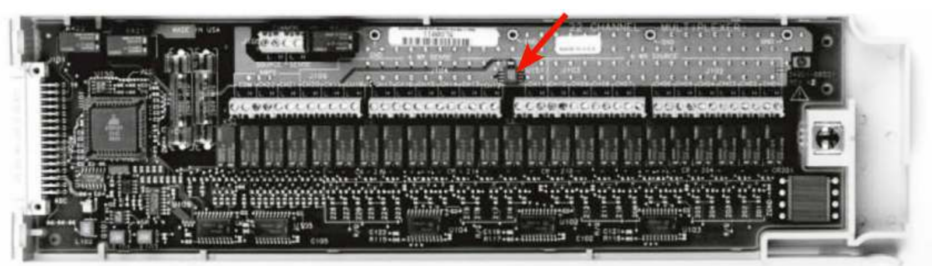

Figure 4. DAQ module for 34970A/34972A with arrow pointing to temperature reference.

## Measurement tip

Don’t feel like programming? Try Agilent’s BenchLink Data Logger Pro, which automates many common DAQ measurements, presents your data in a visual graph.

Figure 5 shows a graph and data points from a PCA board captured using the BenchLink Data Logger Pro software. This scan included 14 temperature measurement points using a K-type thermocouple. The points were identified in the thermal camera characterization. In addition to the temperature measurement points, you can monitor other signals such as voltage, current or other common Digital Multimeter (DMM) measurements. Data Logger Pro's Quick Graph normalizes all of the points on the graph so that you can see details from reading to reading. This provides you a quick graphical view of how your measurements are performing over time.

The DAQ scan characterizes 14 points (identified earlier with the U5855A True*IR* thermal imager) of the DUT as the unit is warming up. The scan be used to gather data at precise intervals over the course of minutes, hours or even days. DAQ scans using the 34970A/34972A system are useful for gathering accurate temperature measurements for long periods of time. The data can then be post processed for further understanding. This is especially useful for characterizing electronics as they are being qualified, or long-term monitoring of building structures.


Figure 5. The results from the 14 points of characterization.

## Summary

Using a thermal imager like the U5855A, you can quickly identify thermal points that you want to monitor. With a DAQ system like the 34970A/34972A and temperature sensors, you can make reliable, accurate and long-term temperature measurements to fully characterize your designs. Thanks to these solutions, identifying temperature sensor locations and performing temperature measurements on designs has never been easier.

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