Secondary batteries such as nickel-metal-hydride (NiMH) or lithium-ion (Li-ion) that use fast or ultra-fast charging methods are commonly used in devices such as mobile phones, portable battery chargers, and compact cameras. These higher charging rates mean a higher current is being used to charge the batteries. For NiMH and Li-ion batteries the charging rate is 0.5 C* or 1 C*, depending upon the charging circuit design inside the electronics devices. While higher charging rates means the charging time is shorter, which is good for consumers, it can cause the temperature in the batteries and electronic charging circuit components.

There are regulations that state the maximum charging temperature rise by the delta temperature rise from ambient, and by an absolute maximum temperature value. The charging temperature rise limit protects the consumer from safety hazards and potential discomfort caused by heat dissipation during the charging of their personal electronic devices. To ensure the charging temperature rise does not exceed the regulated limits, during product development engineers need to measure the maximum delta temperature rise and the absolute temperature.

*C-rate is a measure that governs at what current a battery is charged and discharged
Limitation of Traditional Measurement Methods

Using contact-type temperature sensors such as thermocouples or thermistors is the best way to measure the electronics’ temperature during charging. However, the questions often asked are, “Where are the temperature hot spots?” and “Where should the thermocouple sensors be mounted onto the device under test (DUT)?” The answers often come from the test operator’s knowledge of the design’s known hot spots, or it may require many test iterations in order to locate the correct hot spots for measuring charging temperature.

Using the Keysight Technologies TrueIR Thermal Imager for Qualitative Thermography, Thermal Image Logging, and Trending

Using a test example, this section explains an alternative method operators can use to find the correct thermal hot spots, and then test and quantitatively measure temperature increases. This method uses an infrared (IR) thermal imager to detect the surface hot spots of the electronics products during charging, illustrated in Figure 2. By logging these thermal images over the charging time, engineers can pinpoint the hot spots required for further evaluation.

Portable battery chargers such as the one shown in Figure 2 can fully charge four NiMH batteries within an hour using super-fast charging. Using this charging method it is critical to ensure that the surface temperature of the battery charger does not rise too high during charging. The charging temperature rise analysis and measurement are typically done during the product design phase and sometimes during random quality assurance (QA) checks.

To evaluate the heat generated during charging, the DUT is scanned for hot spots using an IR thermal imager. As shown in Figure 3, IR thermal image logging can be done using the Keysight Technologies U585x Series IR thermal imager. In this instance, the image logging function in the U8588A is set with an interval of 20 seconds per image. Once the battery charger starts charging, pressing the Trigger key starts image logging. The U5855A allows users to log a maximum of 1,000 images into the secure digital (SD) card, which is equivalent to more than 5 hours of logging. The user can end logging at any time by pressing the Trigger key a second time. In this example, thermal image logging is done on both the front and back covers of the battery charger.
Getting the thermal images trend plot is easy using the TrueIR analysis and reporting software tool. After the image logging is completed, the user connects the U5855A to a PC and exports the related images to the software. The software plots the thermal images trend graph, allowing hot spots on the battery charger to be monitored. Figure 4 shows the basic steps to plot the trend graph using the PC software. Figure 5 shows the charging temperature rise trend graph of a selected hot spot on the rear cover of the battery charger.
Using a Thermocouple Sensor and Handheld DMM to Measure Hot Spot Temperature

After finding the hottest temperature spot using IR thermal imager, a more accurate temperature rise measurement can be performed using a thermocouple sensor and a handheld digital multimeter (DMM), as shown in Figure 6. K-type thermocouples with an accuracy of ±1.1 °C can be connected to a handheld DMM model such as the Keysight Technologies U1273A or the U1242B.
Conclusion

This application note shows how the IR thermal imager and contact-type temperature measurement solutions are used to analyze charging temperature rise. The IR thermal imager, with data logging and trend plot features, is able to scan and identify the temperature hot spots of the device under test. Used with a DMM and temperature sensor, such as thermocouple, it also can be used to measure and trend the actual charging temperature rise in a specific location.

References

Keysight U5855A TrueIR Thermal Imager User’s Guide

Keysight U1273A/U1273AX Handheld Digital Multimeter User’s Guide

Keysight U1241B and U1242B Handheld Digital Multimeters User’s Guide and Service Guide

Figure 7. Analyze charging temperature rise with trending graph using the Handheld Meter Logger Software

The temperature rise trend graph is obtained using the Keysight Handheld Meter Logger Software. The DMM is connected to the PC via a USB cable or wirelessly through Bluetooth®. The logging acquisition starts at the PC when the battery charger begins charging. Using the marker function, the software indicates the maximum temperature measured over the entire logging duration. Figure 7 shows the maximum charging temperature at the rear cabinet of the battery charger is 53.2 °C.