Monitoring Battery Cell Temperature with a Keithley 3706A System Switch and Multimeter

APPLICATION NOTE

KEITHLEY
A Tektronix Company

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Introduction

In the next decade, many governments and companies have pledged to transition to fully electric fleets of vehicles. The electric vehicle depends on battery packs, and battery manufacturers must increase volume to meet the demand for new vehicles. All batteries manufactured must meet strict standards for safety, reliability, and efficiency. To ensure these standards are met, a variety of electrical and mechanical tests are performed during manufacturing. One such test is monitoring the temperature on the battery cells. This test has multiple functions, and test solutions that are fast, dense, and automated are highly desirable for manufacturers to keep test time from becoming a bottleneck. Test systems should also remain highly accurate, so that manufacturers can be confident in their test results. The Keithley 3706A System Switch and Multimeter combines the best of both, which makes it a great solution for monitoring battery cell temperature during testing.

Cell Temperature and Thermal Runaway

During normal operation of a battery cell, heat is generated as part of the chemical reaction within the battery and from small amounts of internal resistance. When this excess heat energy is allowed to dissipate from the battery, it does not affect the performance. However, when multiple batteries are connected into a pack, the heat from one battery can contribute to heating up adjacent batteries. Overheating batteries triggers a chain reaction called thermal runaway. Thermal runaway occurs when the internal temperature of the battery is hot enough to cause the chemical reaction inside to occur faster, acting as a short. The increased rate of reaction in turn generates more heat, creating a cycle that often ends in battery failure.

Thermal runaway can result in dangerous failures, such as fires and explosions, in the battery pack. Therefore, many battery testing standards such as IEC 62660-2 and UL 2580 include stressing tests to test battery behavior under potential thermal runaway conditions. Monitoring the temperature of the battery cells during testing can provide early insights into cell and pack behavior and weaknesses in the quality of the pack.

Battery Cell Environmental Testing

Another reason to measure the temperature of battery cells during testing is to help characterize the temperature dependent behavior of the battery. Battery cell charging and discharging is not linear with temperature, and manufacturers may wish to test the cells in varying environmental conditions depending on the application. To provide the most accurate understanding of the pack behavior with respect to temperature, the temperature should be measured at the cell level.

Monitoring Cell Temperature

Battery pack testing can be time consuming due to the time it takes to charge and discharge the batteries. Therefore, a key goal for manufacturers is to reduce the test time necessary to collect the required data. A multi-channel digital multimeter (DMM) is a great solution for this. Battery packs may contain hundreds of cells, and to get an accurate measure of the cell temperature, the transducer should be placed as close to the cell surface as possible. A multi-channel DMM means that you can measure the temperature at more points on the pack with a single box. DMMs are also highly accurate, and most models provide built-in conversions for a wide variety of temperature transducers, eliminating the need to convert measurements after the test.

The accuracy of the measurement directly contributes to the accuracy of the battery behavior model. Temperature measurement accuracy depends on the accuracy of the transducer used. Thermocouples are cheap and simple; however, they have larger tolerances than other transducers, so the measurements will be within 1–2° C of the correct value depending on the type used. They also have higher temperature drift over time, meaning measurement accuracy will decrease over their lifespan. RTDs are highly accurate, with tolerances within as little as 0.01° C but are expensive and slow, making them unideal for manufacturing solutions. Thermistors provide a good middle ground between accuracy and speed. Typical thermistor tolerances are between 0.05° C and 1° C. They are stable over long periods of time; however, they have a more limited temperature range than thermocouples.

The Keithley Solution

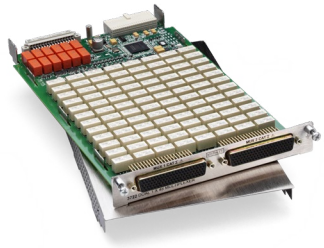
The Keithley 3706A System Switch and Multimeter provides an excellent solution for testing temperature on battery cells. **Figure 1** shows the options for measuring temperature using the 3706A.

Switch and Measure

3706A System Switch/Multimeter

- 7.5 digit digital multimeter
- 6 slots for switch cards
- 0.01 °C resolution
- Supports 2.2k, 5k and 10k thermistors
- 0.08 °C accuracy at 1 year

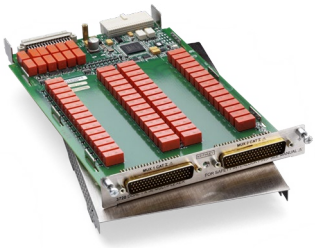
High Density



3722 Dual 1×48 Multiplexer

- 96 2-pole channels
- With 6 cards, total 576 channels in 1 mainframe
- Scan and measure over 110 channels per second

Best for Thermocouples



3720 Dual 1×30 Multiplexer

- 60 2-pole channels
- Optional 3720-ST Screw Terminal accessory for easy connections and on board automatic CJC for thermocouples

Figure 1: Keithley solution for multi-point temperature monitoring.

The 3706A has several options for switch cards. The 3722 is the highest density solution with 96 two-wire channels per card, and a total of 576 channels in one mainframe. For applications requiring less channels, the Keithley DAQ6510 Data Acquisition and Logging, Multimeter System and 7708 card provide up to 80 channels. For applications using thermocouples, the 3720 card paired with the 3720-ST screw terminal module provide on-board cold junction compensation (CJC) to increase the accuracy of the thermocouple measurements. For more information on temperature transducers, refer to Keithley's *Low Level Measurements Handbook*.

The 3706A can be controlled remotely using Keithley's Test Script Processor (TSP®) programming language, via USB, Ethernet, or GPIB. This provides a fully-automated solution to save time and effort collecting data.

Figure 2 shows an example of measuring multiple channels using the 3706A.

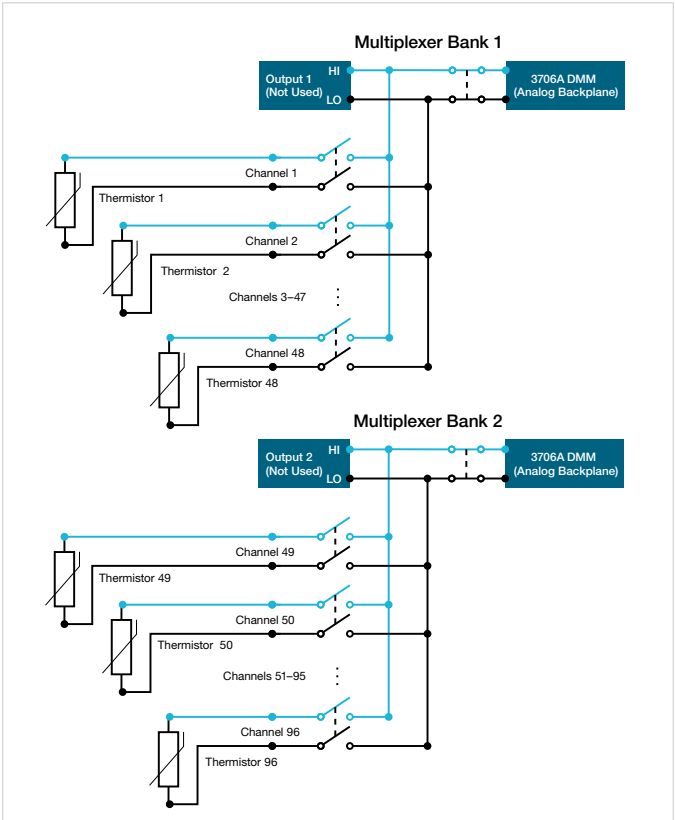


Figure 2: Measuring multi-point temperature with the 3706A and 3722 High Density Multiplexer Card.

Conclusion

Temperature measurements during battery pack testing provide crucial information about battery performance and quality. Keithley's 3706A System Switch and Multimeter provides up to 576 channels using the 3722 card, and the DAQ6510 Data Acquisition and Logging, Multimeter System provides up to 80 channels with the 7708. These high-density solutions are perfect to collect all the data you need — faster.

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