MICRO POWER

Safety Circuit Qualification and Testing for Li-Ion Batteries

Battery safety circuits are designed to provide protection for battery packs consisting of 1 or more cells in series. These circuits monitor voltage and current, and can interrupt the circuit in the event of a potentially damaging condition. In the most common safety circuits, this is accomplished by using a pair of MOSFET switches in series, one MOSFET for charging, and one for discharging. Each MOSFET contains an internal diode across the output. This diode is reverse biased to the intended direction of current. The diodes allows charging when the discharge FET is open, and discharging when the charging FET is open. Each cell (or groups of cells) in series is monitored by the protection circuit. The individual cells are checked for over voltage during charge or under voltage during discharge.

The specific test procedures are internal test procedures and highly proprietary to Micro Power Electronics. For that reason, the specific processes, test equipment and fixtures are not published or available for distribution. Micro Power understands that customers need to know that all aspects of the battery pack safety are covered. Therefore, what follows is an outline of the test guidelines that are followed.

The tests for each of the parameters listed below are conducted and repeated at a cell level, and then repeated for each cell in the circuit. Tests for these parameters also are conducted and repeated at a PCA level and, then repeated for the battery pack assembly.

Overcharge Detect

When any cell exceeds a predetermined voltage during charge, the safety circuit will interrupt the flow of current into the pack.

The test procedure will monitor when the charge MOSFET opens. Since test points on the gate of this device are seldom present, the output of the protection circuit must be monitored.

Overcharge Detect Delay Time

When the overcharge voltage is exceeded, a delay of up to 1.5 seconds will occur before the FET opens the circuit. This timing can be captured and monitored. When manually tripping the circuit as is done in the overcharge detect section, viewing the output takes a careful setup as the voltage after the trip is only marginally different than the voltage before the trip.

Overcharge Release

The safety circuit will allow charging to take place after the cell's voltage drop below the overcharge release threshold.

To check the overcharge release voltage, test equipment is used in place of the cell to monitor when the charge MOSFET closes. Because test points on the gate of this device are seldom present, the output of the protection circuit must be monitored.

Over-Discharge Detect

When the voltage on any cell falls below a predetermined threshold, the safety circuit will interrupt the flow of current out of the pack.

Test equipment is used in place of the cell to monitor when the discharge MOSFET opens. Because test points on the gate of this device are seldom present, the output of the protection circuit must be monitored

Over-Discharge Detect Delay Time

When the over-discharge voltage is reached, a delay of up to 1.5 seconds will occur before the FET opens the circuit. This timing can be captured. Appropriate fixtures are required to decrease the transition time of the voltage at the cell.

Over-Discharge Release

The safety circuit will allow discharging to take place after the cell's voltage rises above the over-discharge release threshold. Appropriate test equipment and methods are used to monitor that the circuit complies with this requirement

Over-Discharge Release Notes

The most common protection circuits will simply monitor the cell voltage, and re-enable the discharge MOSFET when a certain level (typically around 2.9 to 3.1 volts) is reached.

With this type of safety circuit, test equipment is placed in the cell location and the voltage is increased until the output of the pack transitions from zero volts to what ever the voltage sum of the cells are.

Another type of circuit tested is an over-discharge release voltage of between 2.9 to 3.1 volts, but this test requires a charging current before the circuit will awaken. The "cell" simulator is set to a voltage just below the over-discharge

release point. The "charger" simulator is set to a level that is above the under-volt cutoff level and below the expected pack output (once the protection circuit wakes up).

Additional types of circuits available are similar to the previous circuits, but state the release voltage as a hysteresis. The hysteresis can range from 0 to 250 millivolts. If the circuit will recover without a charging current, the process of determining the undervoltage release is the same as the first stated above.

If a charging current is required, confirmation is sought that the circuit recovers with a charge.

A word of caution: *Other methods of testing this type of circuit can be used, but experience shows that these methods can sometimes produce mixed results and are not often used.*

Overcurrent

When the pack output current exceeds a predetermined level during discharge, the safety circuit will interrupt the flow of current out of the pack. Verification tests have been established to conduct these parameters and to make sure that the circuit properly functions.

Overcurrent/Short Circuit Delay Time

When the overcurrent level is reached, a delay of 5 to 50 milliseconds will occur before the FET opens the circuit. This timing can be captured on the appropriate test equipment. Allowances are made in the test setup since timing near the threshold current can be indefinite. Measurements and margins are used to make sure that the circuit trip threshold is captured.

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