

EPCOS Application Note 2019

# NTC Thermistors

## Monitoring and Thermal Management of Batteries with NTC Temperature Sensors

Rechargeable lithium ion batteries are widely used in consumer electronics due to their light weight and high energy density. Also they are now replacing the lead-acid and nickel-cadmium batteries in high power applications such as energy storage systems or photovoltaic solar energy storage systems.

Constant monitoring, control and management of the cell temperature in the battery pack as well as the ambient temperature are essential in order to maximize battery life expectancy and maintain safety. If battery temperatures

are too low, the charging rate will slow down, while too high battery temperatures will create a critical condition which can result in a battery fire or even an explosion.

Batteries must operate accurately and safely in different environments and at a wide range of temperatures. NTC thermistor temperature sensors are key components in lithium ion batteries or battery systems. They provide temperature readings required to perform the optimum thermal management during the charging process.



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## Temperatures at charging process

Typically, the temperature of lithium ion batteries increases by 5 K during the 2 to 3 hours required for charging. This temperature increase is caused by the chemical reaction occurring during the charging cycle. This heat contributes to the initial temperature of the battery, which is also determined by the ambient temperature in the proximity of the battery. Consequently, the temperature increase during charging and the ambient temperature are the two parameters that must be monitored during the operation of rechargeable batteries.

To ensure safe operation and avoid critical conditions the battery temperature must not increase by more than 10 K during charging. The optimum lithium ion battery temperature range for normal charging is between 10 °C and 30 °C. Fast charging – if necessary – requires that the battery temperature not exceed 45 °C. Charging at above 45 °C will degrade battery performance and should be avoided.

## Quick charging

The ambient temperature must also be monitored, especially for quick charging, as not all batteries allow charging in hot and cold temperature ranges. Battery pack manufacturers usually recommend charging temperatures of between 10 °C up to 45 °C for quick charging, depending on the chemical compounds of the battery.

## Lithium-ion charge controller

Analog-to-digital controllers (ADC) have been developed to precisely control charging current, voltage and to manage the battery temperature. Such ADCs employ NTC temperature sensors that are mounted on the lithium-ion batteries. The controller compensates for high and low battery temperatures, excessive ambient temperature, and will stop charging if the battery reaches critically high temperatures.

## Overtemperature

Overtemperature, whether caused by overcurrent, overvoltage, an ambient temperature that is too high, or any combination of these factors, can lead to a critical condition called thermal runaway. This can result in a battery fire or even an explosion of the battery. To avoid thermal runaway, the upper safe battery temperatures must be monitored and cannot be exceeded.

The battery explosion threshold temperature depends on the specific chemical compounds in the lithium ion battery. Different NTC thermistor designs are being used depending on the temperature limits. For the widely used lithium cobalt oxide batteries in consumer electronics the upper safe temperature limit is 130 °C to 150 °C. The S861 series of EPCOS minisensors offers a wide range of types for these applications.

The upper temperature limit for lithium ion manganese oxide batteries that are popular in battery-powered hand tools is 250 °C. The G1551 series of EPCOS glass-encapsulated sensors features a broad spectrum of types that are suitable for monitoring these batteries.

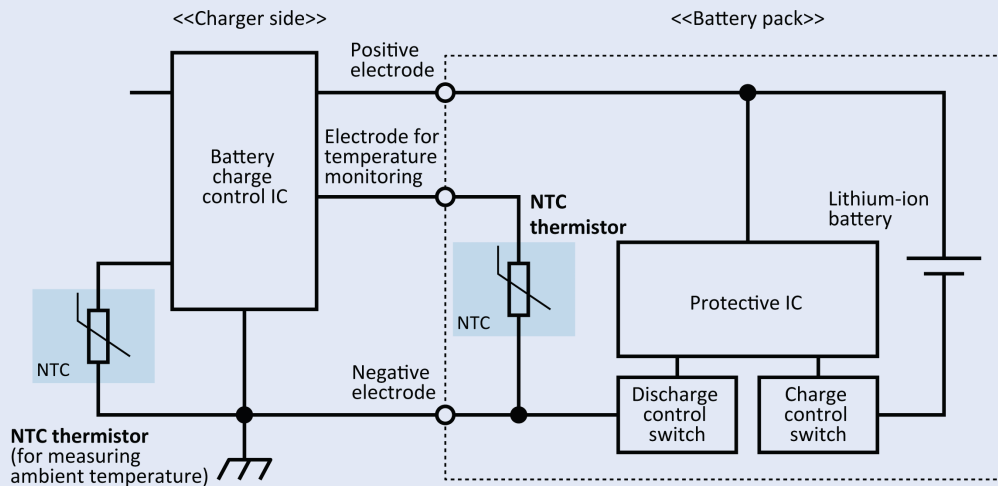
To avoid potential damage to the battery, these upper temperature limits should not be reached. If this does occur, the charging process must be stopped completely. At higher operating temperatures, the self-discharge current of the cells increases and must be considered as an important factor in the total charge calculation.

## Cold temperatures

At cold temperatures, a lithium ion cell becomes more resistive and provides less charge between a full and an empty state. Cold temperature charging can damage the cells, thus reducing the capacity.

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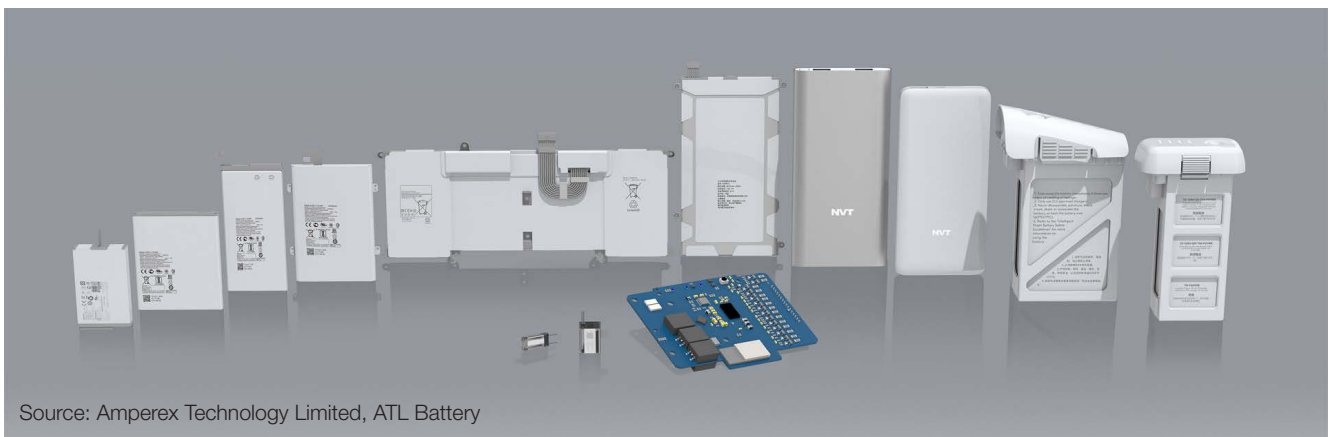
## Battery pack charging control unit with NTC thermistors



## Temperature sensor selection

The selection of the right battery temperature sensor is essential to ensure the safe operation of the battery. The main selection criteria are as follows:

- Temperature accuracy
- Temperature tolerance over entire operating temperature range
- Stability (stable resistance temperature characteristics over lifetime)
- Response time
- Media resistance
- Mounting situation
- Insulation voltage



Source: Amperex Technology Limited, ATL Battery

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## Electrical specifications and ordering codes

Type	$R_{25}$ $\Omega$	$\Delta R_R / R_R$	No. of R/T characteristic	$B_{25/85}$ K	$B_{0/100}$ K	$B_{25/100}$ K	Ordering code
<b>Probe assembly with wire length 115 ±10, AWG 26</b>							
M703	10 k	±2%	8016	3974	3946	3988 ±1	B57703M0103A017
<b>Miniature sensor with bendable wires, component length 350 mm</b>							
S861	10 k	±1%	8016	3974	3946	3988 ±1	B57861S0103A039
<b>Glass-encapsulated sensor with insulation</b>							
G1551	10 k	±2%	8307	3478	3450	3492 ±1	B57551G1103G000

## Dimensional drawings

Type M703	Type S861	Type G1551

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