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# The power of temperature sensors in EV-charging applications

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**Summary:**
In this work the importance of temperature measurements in the EV-charging infrastructure is explained and requirements for temperature sensors for this specific application are derived. Typical sensors being applied in such environments include platinum-based sensors (Pt-RTDs) and thermistors with a negative temperature coefficient (NTCs). The performance of these two types of sensors is compared focusing on the crucial parameters response time and accuracy over lifetime (stability of the sensor).

**Keywords:** temperature sensors, Platinum RTD, EV-charging, charging infrastructure, power control

## Background, Motivation an Objective

Measuring the correct temperature is crucial for many applications such as exhaust gas treatment, in the medical and lab environment or in other applications enabling a temperature compensation. Also, in the growing field of e-mobility and its charging infrastructure having the right temperature signal is very important.

In charging applications measuring the peak temperature is a necessary safety requirement: The battery needs to be charged as fast as possible without causing overheating in the system, since such an overheating might cause a significant reduction of battery lifetime, a higher wear of components such as connectors and higher maintenance cost. In extreme cases overheating of the battery can cause a system failure leading ultimately to fire, damage of property and in the worst case even injuries of passengers.

It is thus important to closely control the temperature by limiting the power during the charging cycle as it is depicted in figure 1. The temperature at different locations in the charging infrastructure increases steadily with the start of inrushing current. Locations might be the connector pins on the vehicle side or on the station side, power electronics or even the battery. When a certain peak temperature is reached, that is slightly below the critical value the current and with that the power is limited causing the temperature to decrease and thus avoiding an overshoot above a critical value. Obviously charging time shall be limited for the ease of use and at the same time it should happen at a relatively low temperature to ensure safety. Here measuring the temperature as accurately and without any delay is of utmost importance to shorten the charging time as much as possible and at the same time staying away from critical system conditions [1].

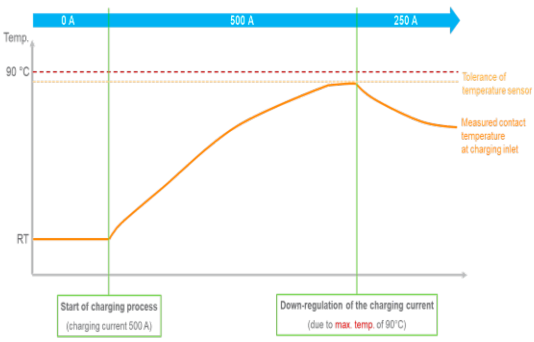


*Fig. 1. Typical charging cycle showing the increase of temperature in the system starting with the inrush of current. Applied power is then limited once a certain threshold in temperature is reached to ensure safety and avoiding any critical conditions [according to a presentation by Phoenix GmbH].*

Widely applied temperature sensors include:

- Platinum based RTDs (resistance temperature detectors)
- NTCs (Negative temperature coefficient)
- Thermocouples
- Semiconductor based sensors

For each if these types of sensors advantages and disadvantages can be found, also depending on the application and the requirements.

In this paper a comparison of the most prominent types, Pt-RTDs and NTCs shall be done, referring to the already mentioned system requirements in charging applications.

## Requirements and Methods

Requirements of sensors detecting the temperature in the charging infrastructure such as the charging pins include:

- Accuracy

  The detected signal must be as close to the real value as possible. This is typically indicated with the potential error of the sensor at 0°C.

- Repeatability

  Due to the high amount of measuring points in the global charging infrastructure a repeatable signal is necessary, meaning that one sensor behaves the same way as other sensors independent of manufacturing batch or even sensor provider.

- Stability

  The signal of the sensor and its accuracy must remain the same over the entire lifetime of the application without showing any drift. Typically, this is proven by validating the sensor with accelerated life-time tests such as temperature endurance tests, temperature cycle tests, temperature shock tests or vibration tests.

- Fast response time

  The sensor signal must follow and detect a presented change in temperature ideally in real-time with the delay being as short as possible. The response time is typically given as a T0.5-value and a T0.9-value, referring to the time elapsed to respond to 50% or 90% of a temperature step. It is measured either by presenting a temperature step in moving air or moving water with clearly defined temperatures and velocities.

- High dielectric strength

  With voltage being as high as during charging cycles, the sensor obviously must be electrically robust for being applied in such conditions.

## Results

In this study a comparison between two prominent temperature sensors, Pt-sensors and NTCs has been done, focusing on response time and lifetime stability.

As depicted in figure 2 it can be shown that Pt sensor elements have a significantly shorter response time when presented to a temperature step. Comparing the median value of 50 measurements each the T0.5-value is up to six times faster for Pt-elements compared to the value of different NTCs.

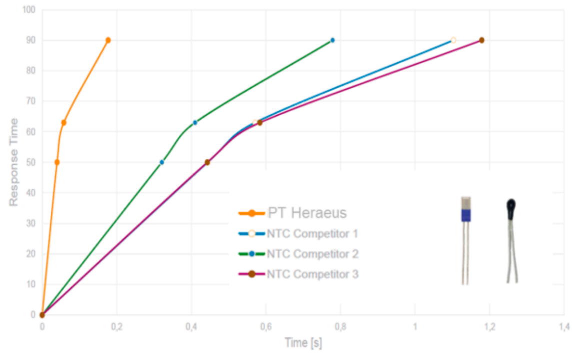


*Fig. 2. Comparison of the response time between a Platinum temperature sensor and three different NTC-sensor elements. The superiority of the Pt-sensor can clearly be seen with the response time being up to six times faster.*

Comparing the performance of the sensor after temperature cycle tests results show a significantly lower deviation in signals for primary housed Pt sensors as depicted in figure 3.

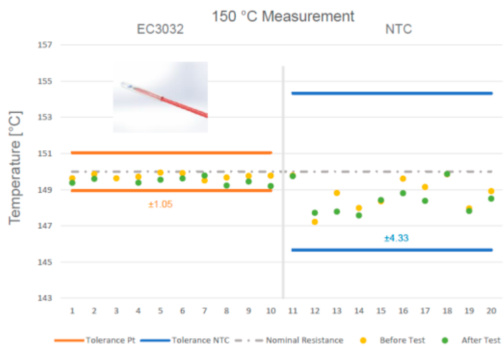


*Fig. 3. Comparison of signal accuracy at 150°C after 1000 temperature cycles (-40°C – 150°C).*

## Conclusion

In this study the performance aiming at the application in the EV-charging infrastructure of Pt-based temperature sensors and NTCs was compared, showing the superior performance of Pt-based sensors in lifetime stability (accuracy) and response time.

## References

[1] T. Stanczyk, L. Hyb, Technological and organizational challenges for e-mobility, *The Archives of Automotive Engineering*, Vol. 84, No. 2, (2019)