

Extreme Temperature and High Current Testing Challenges of Automotive Devices

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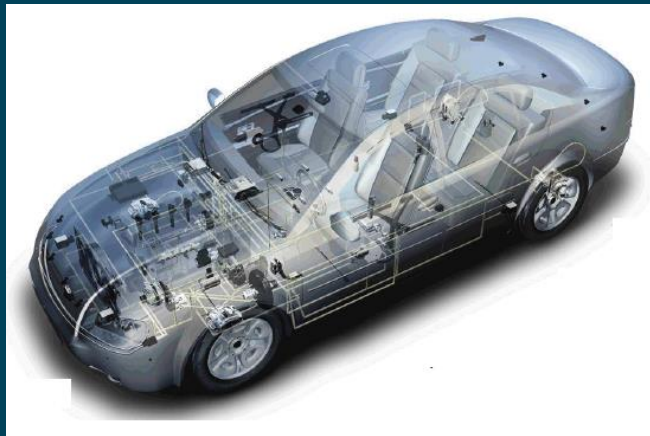


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Introduction

- Modern automobiles are equipped with hundreds of electronic devices to perform various functions such as ignition timing, air/fuel ratio control, air bag control etc
- Stringent quality requirements of these devices must be met before shipping to customers as they are concerned with safety of the passengers



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Extreme Temperature and High Current Testing Challenges of Automotive Devices

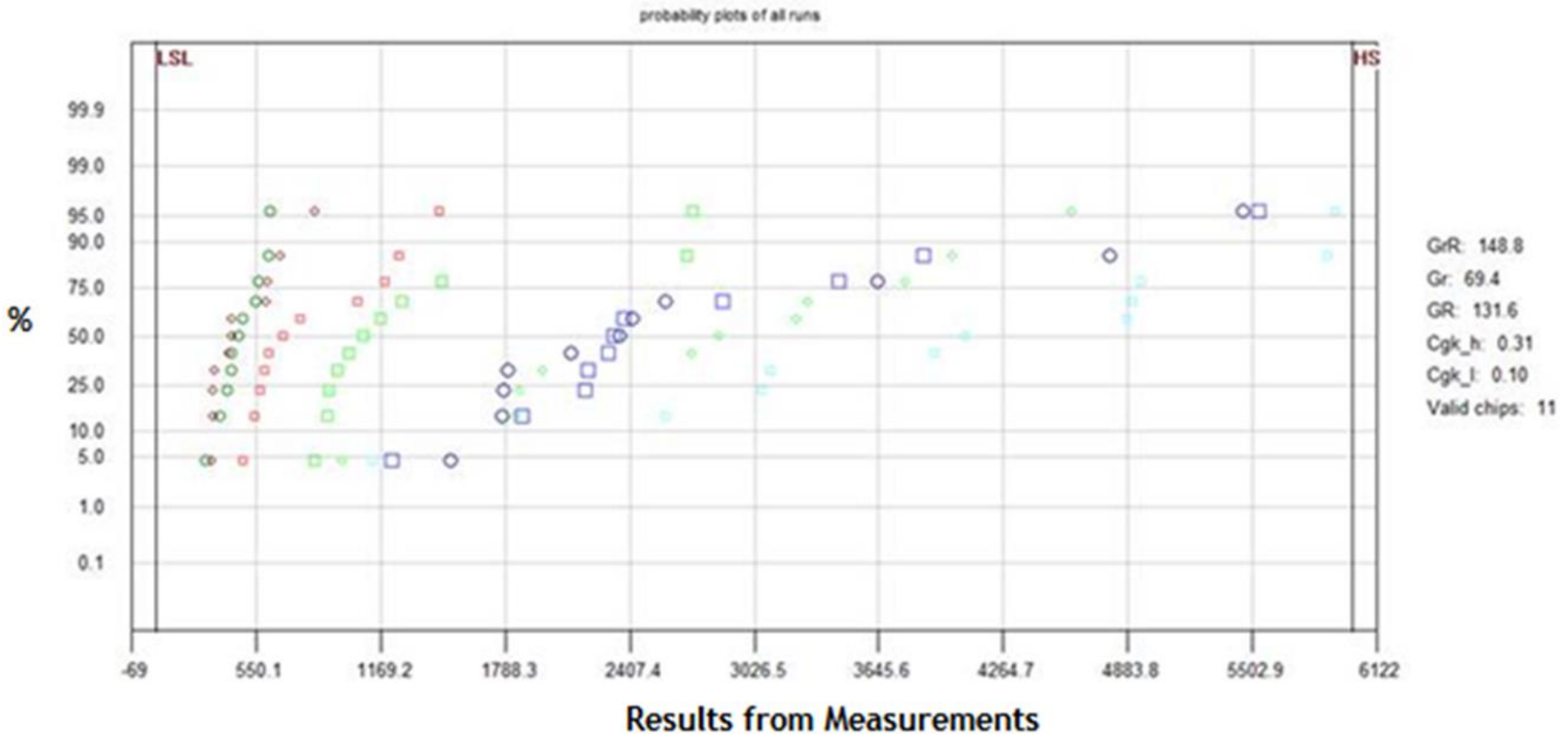
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- Final testing of the devices are performed at extreme temperatures to cater the quality requirements
- This work shares the design & development of a new VQFN socket for production operating at a temperature range of -60°C to 170°C with performance of $\pm 2^{\circ}\text{C}$ deviation from the setpoint temperature

Production performance of VQFN socket

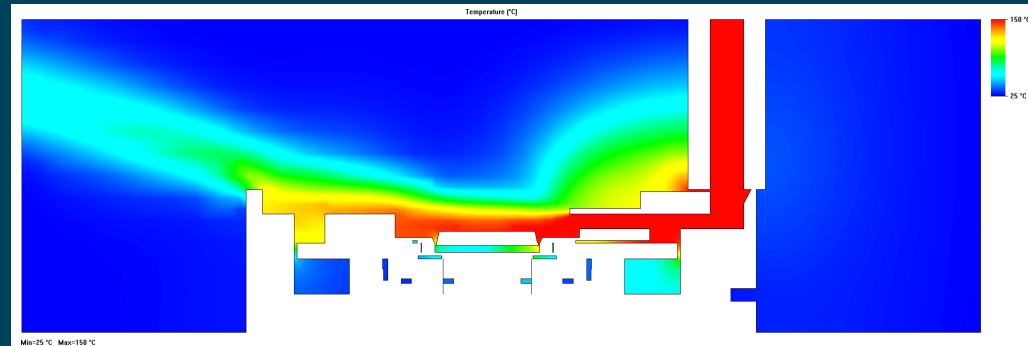
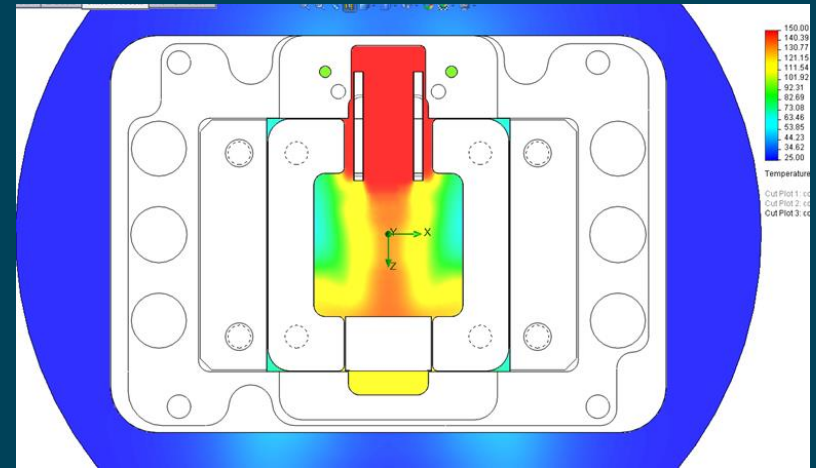
- Measurement capability analysis (MCA) was performed on the new VQFN socket at production and gR&R study was performed on the tester data. gR&R acceptance criteria is $\leq 30\%$
- Electrical data of the new socket was found to be better than the existing sockets
- For temperature check test gR&R was observed to be $> 30\%$
- As per tester data a deviation of up to $\pm 10^{\circ}\text{C}$ from nominal setpoint temperature was noted
- Root cause analysis performed in comparison with the existing sockets pointed out to air channel design of the new socket

gR&R plot



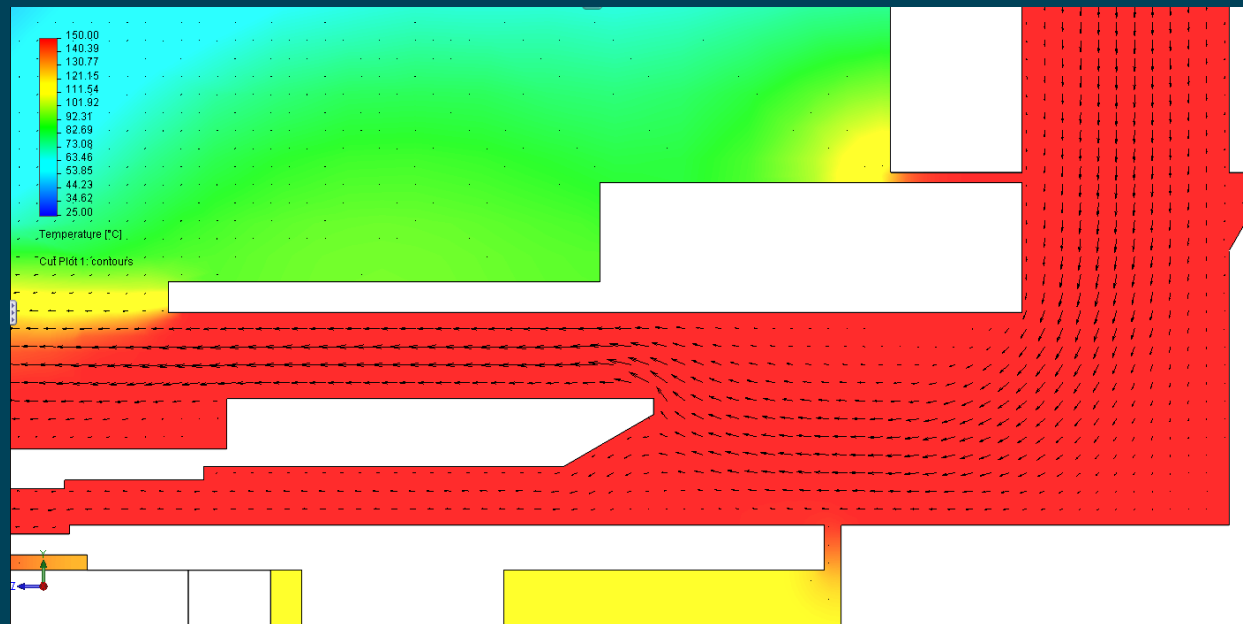
Thermal simulation of the VQFN socket

- Thermal simulation was performed on the VQFN socket tested at production
- Simulation results showed that the heat is not uniformly distributed across the package



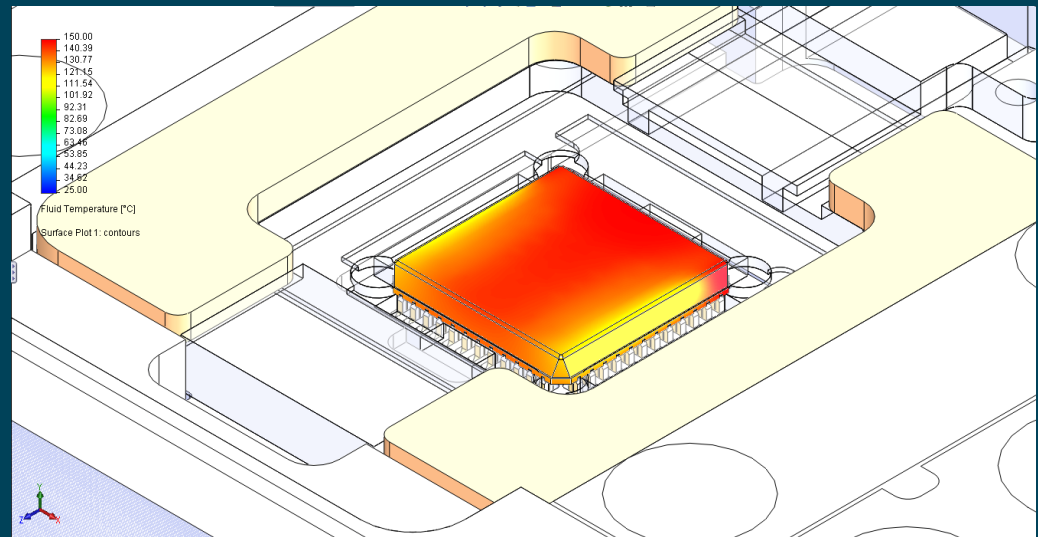
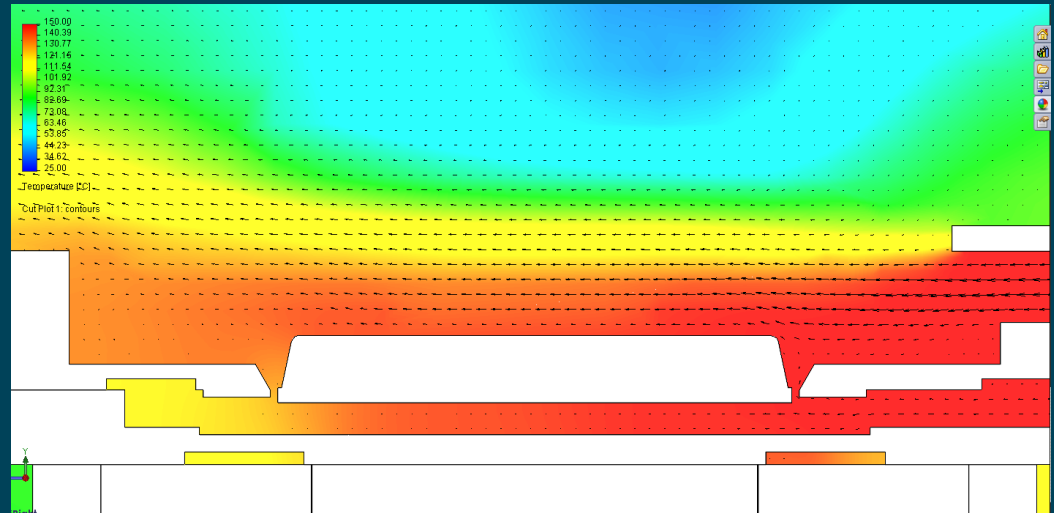
Redesign & Major changes

- Air channels were redesigned and went through 3 revisions before concluding on the best design.
- In rev.1, provision was provided for channeling the flow into bottom of the device (inner channel) in addition to the top (outer channel)



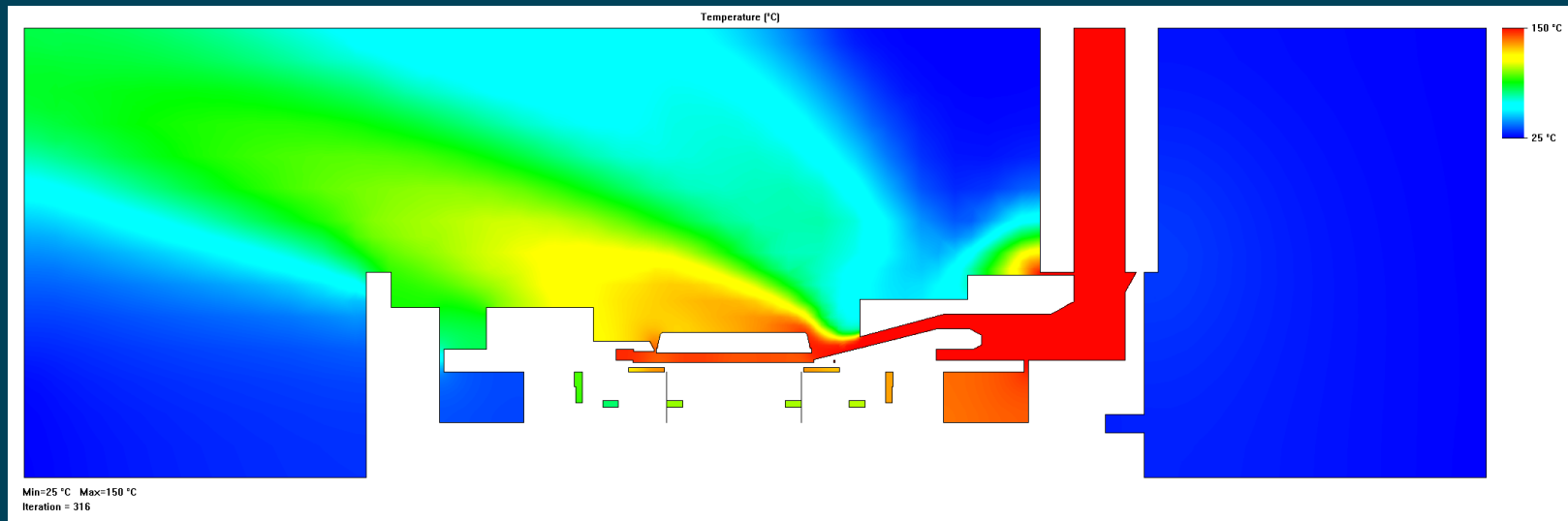
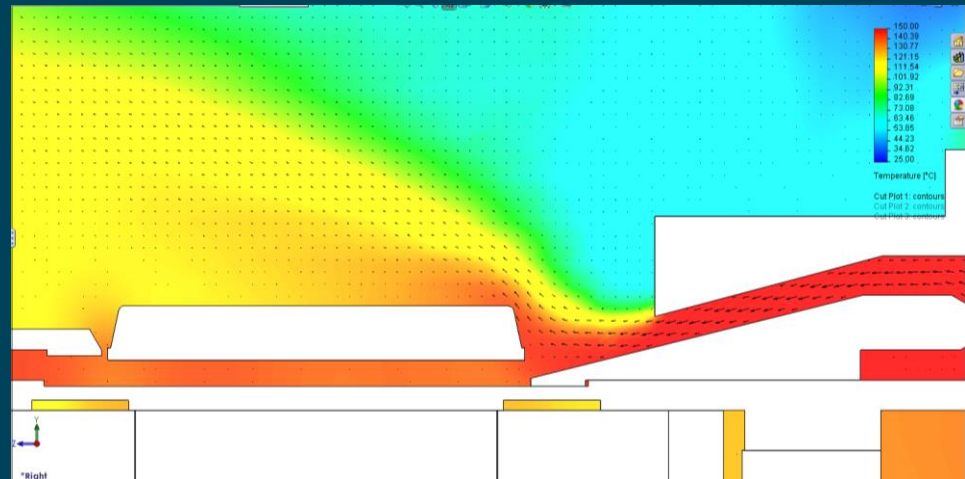
Design rev.1

- Results were not promising as this design will have lesser heat transported through air across the package



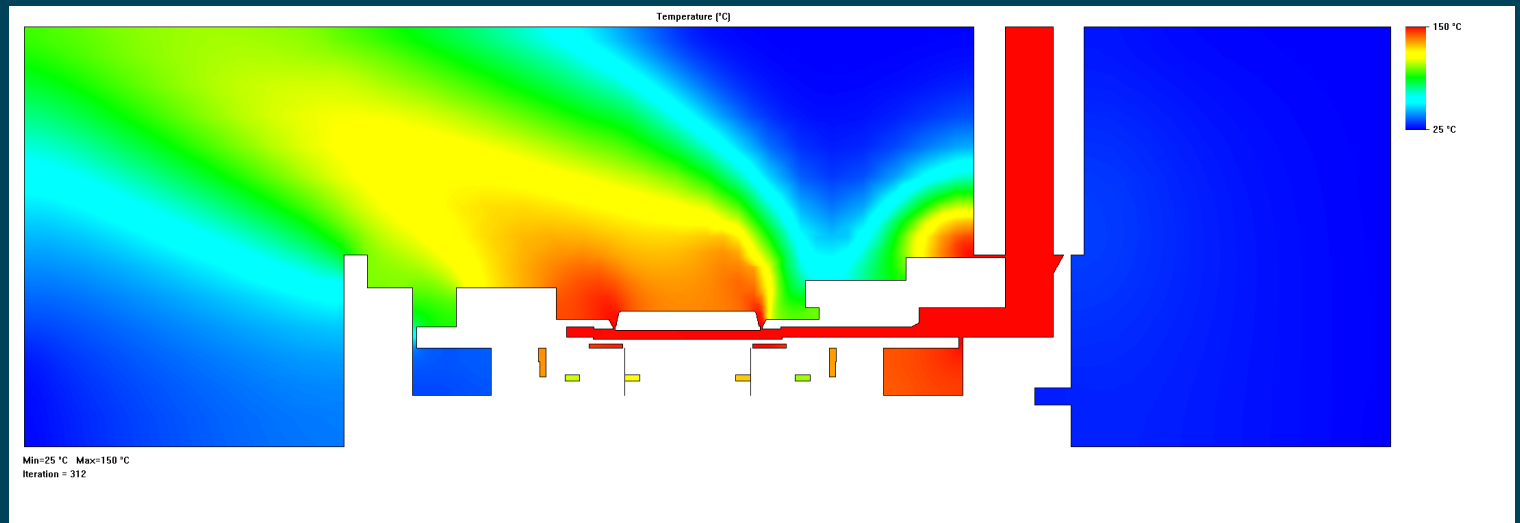
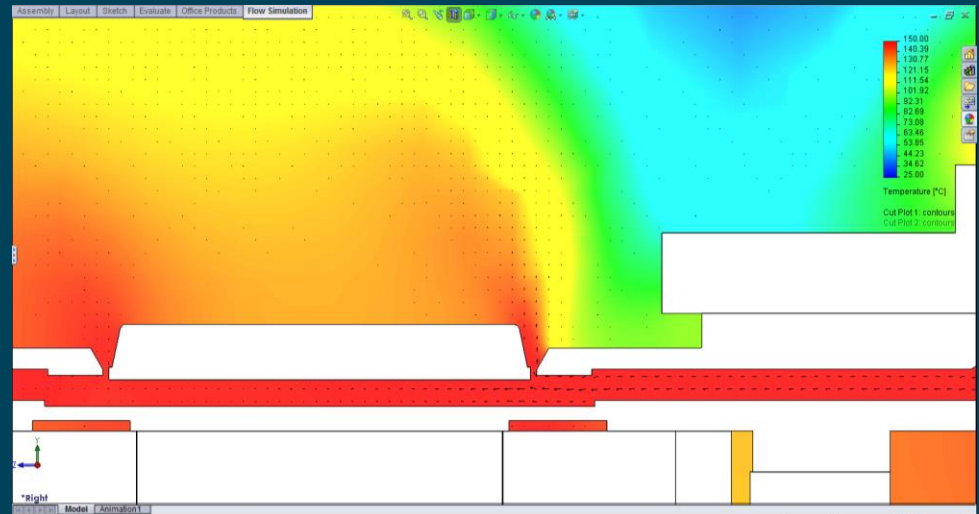
Design rev.2

- In rev.2, airflow was focused onto the package
- However, the required setpoint temperature was not achievable with this model due to air on the top venting out to atmosphere



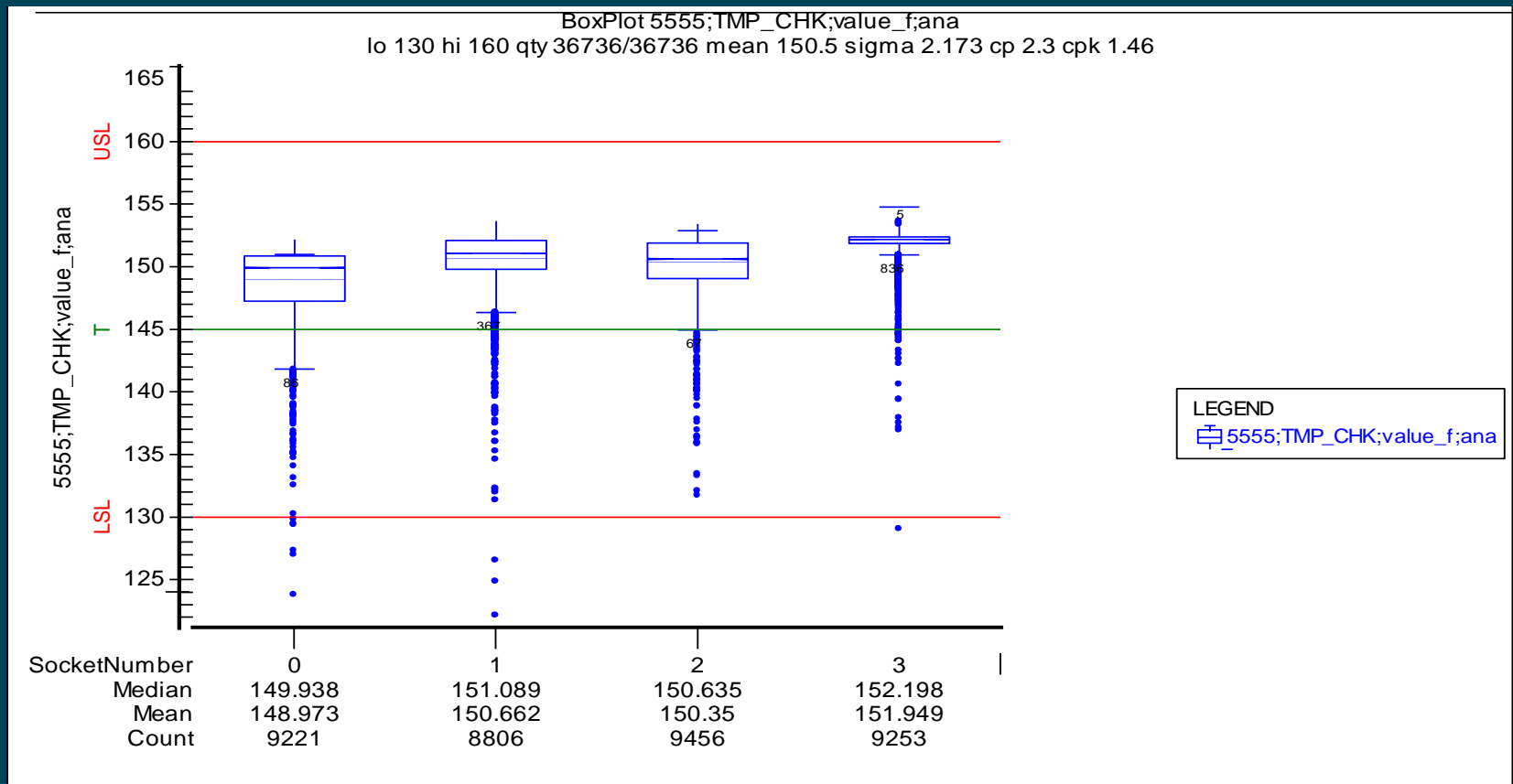
Design rev.3

- In rev.3, venting of air was prohibited by concealing the top portion of the channel
- Simulation results seemed to be positive



Production performance

- The redesigned rev.3 of the socket was fabricated, run through ~9k devices and analysed for gR&R
- Temperature deviation was observed to be within the acceptable range of $\pm 2^{\circ}\text{C}$



Conclusion

- Final testing of automotive devices are challenging due to stringent quality requirements
- VQFN socket developed exhibited improved electrical performance but failed for temperature
- Thermal simulation was used to redesign the air channel which went through 3 revisions before fabrication
- Thermal performance of the socket was within the acceptable range of $\pm 2^{\circ}\text{C}$