Extreme Temperature and High Current Testing Challenges of Automotive Devices

Praveen kumar Ramamoorthy, Murad Hudda
Infineon Technologies

Dan Maccoux, Muhamad Izzat Roslee
JF Microtechnology

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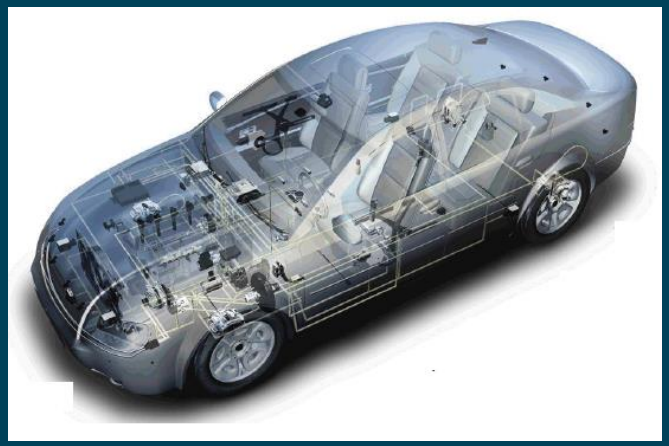
Introduction

- 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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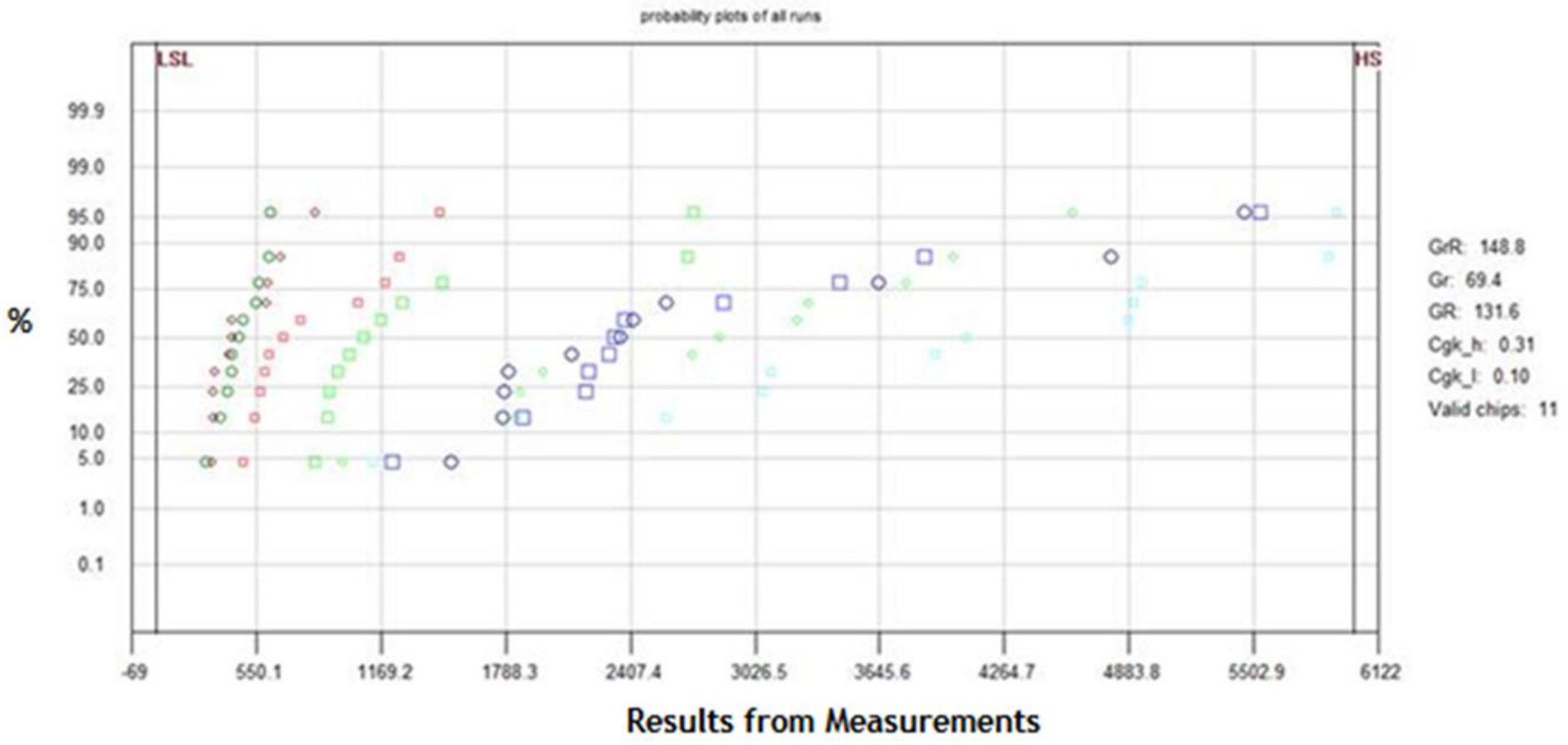
- Final testing of the devices are performed at extreme temperatures to cater the quality requirements
- This work shares the design & development of a new VQFN socket for production operating at a temperature range of -60˚C to 170˚C with performance of ±2˚C deviation from the setpoint temperature

Production performance of VQFN socket

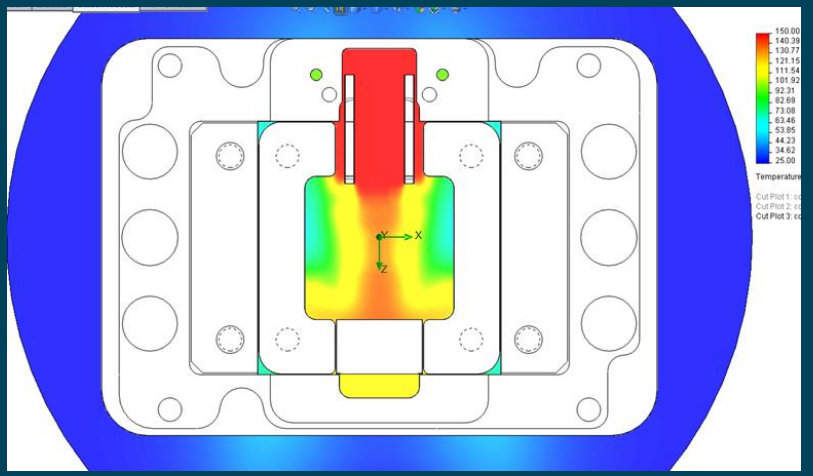
- Measurement capability analysis (MCA) was performed on the new VQFN socket at production and gR&R study was performed on the tester data. gR&R acceptance criteria is <=30%
- Electrical data of the new socket was found to be better than the existing sockets
- For temperature check test gR&R was observed to be >30%
- As per tester data a deviation of up to ±10˚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

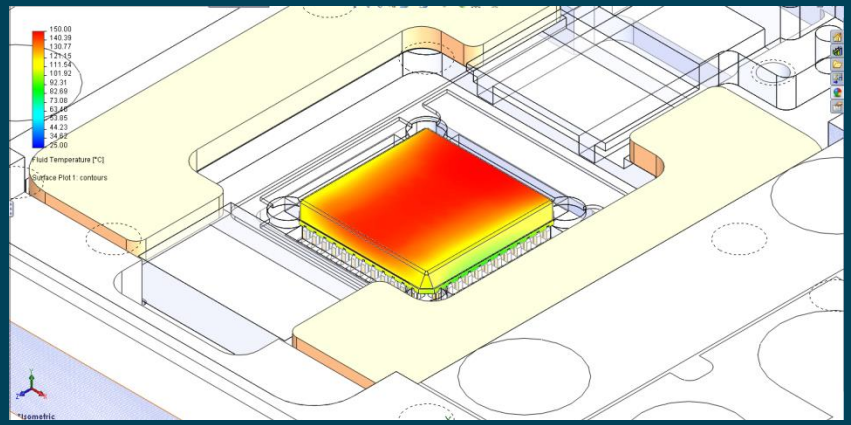
gR&R plot

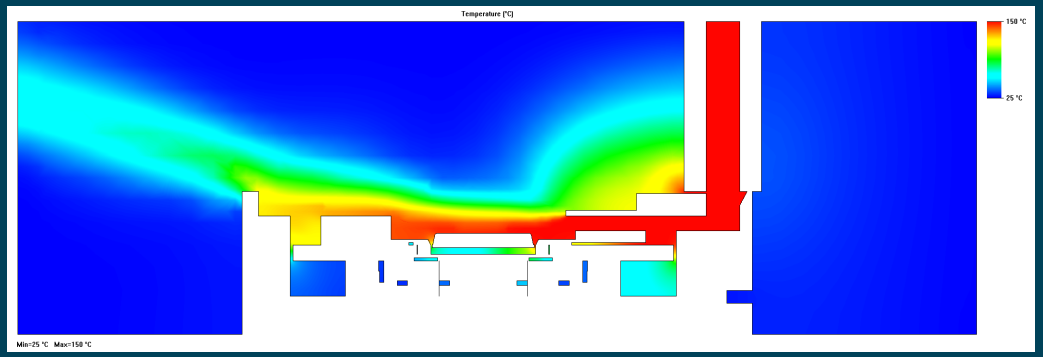

probability plots of all runs
LSL
HS
99.9
99.0
95.0
90.0
75.0
50.0
25.0
10.0
5.0
1.0
0.1
%
-69
550.1
1169.2
1788.3
2407.4
3026.5
3645.6
4264.7
4883.8
5502.9
6122
Results from Measurements
GrR: 148.8
Gr: 69.4
GR: 131.6
Cgk_h: 0.31
Cgk_l: 0.10
Valid chips: 11

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

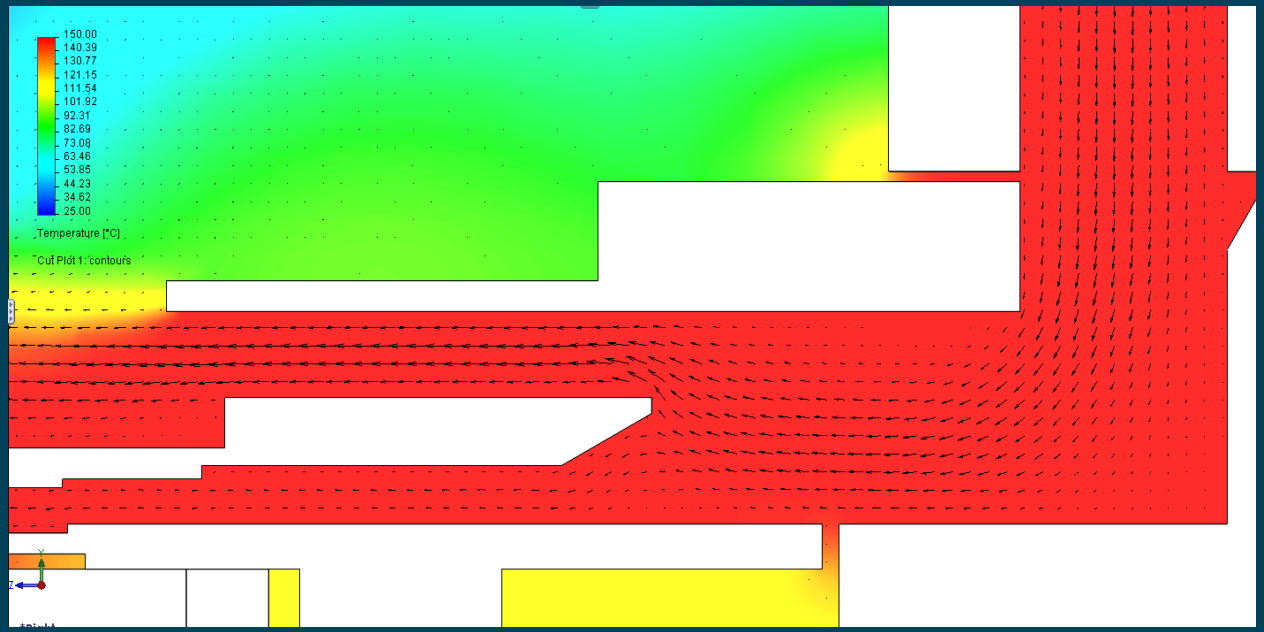






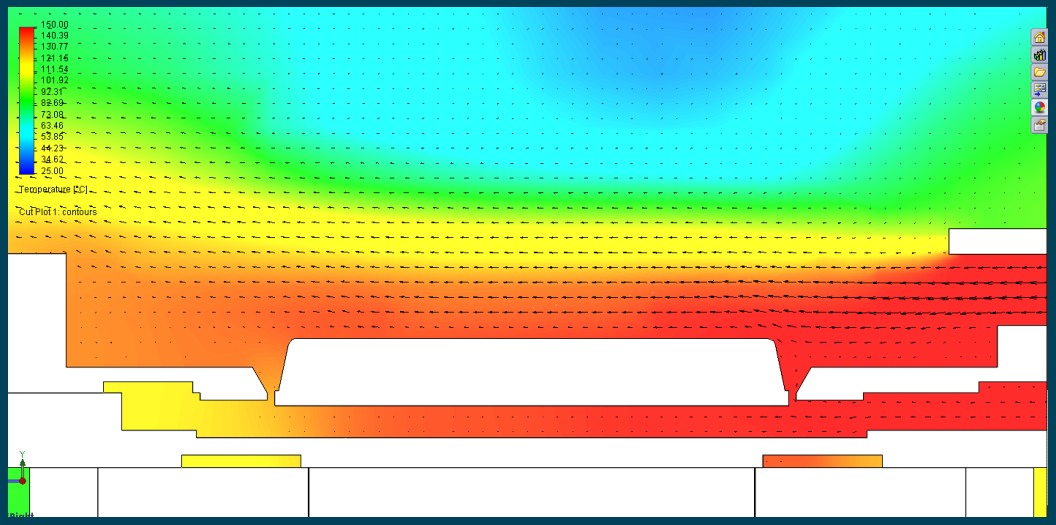
Redesign & Major changes

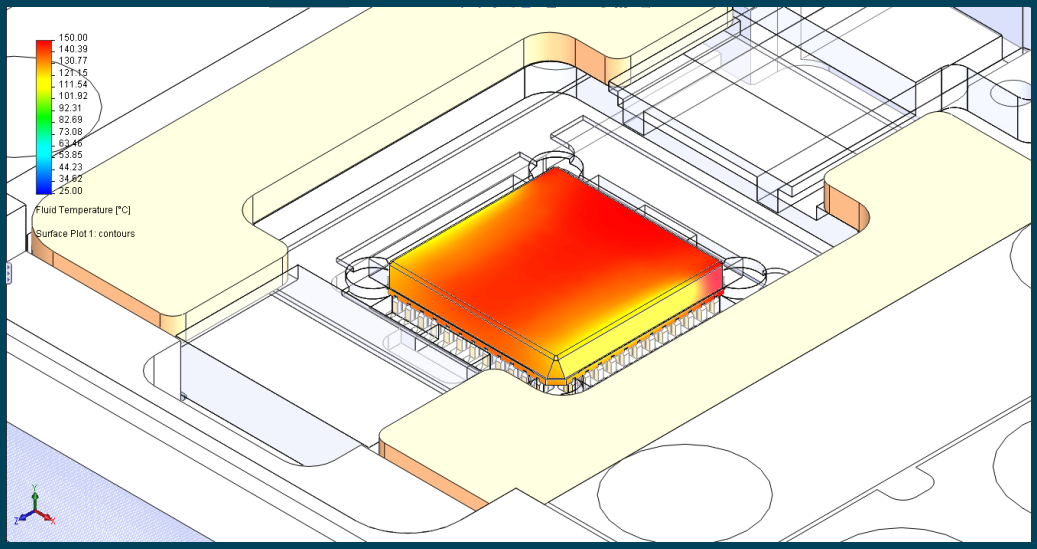
- Air channels were redesigned and went through 3 revisions before concluding on the best design.
- In rev.1, provision was provided for channeling the flow into bottom of the device (inner channel) in addition to the top (outer channel)



Design rev.1

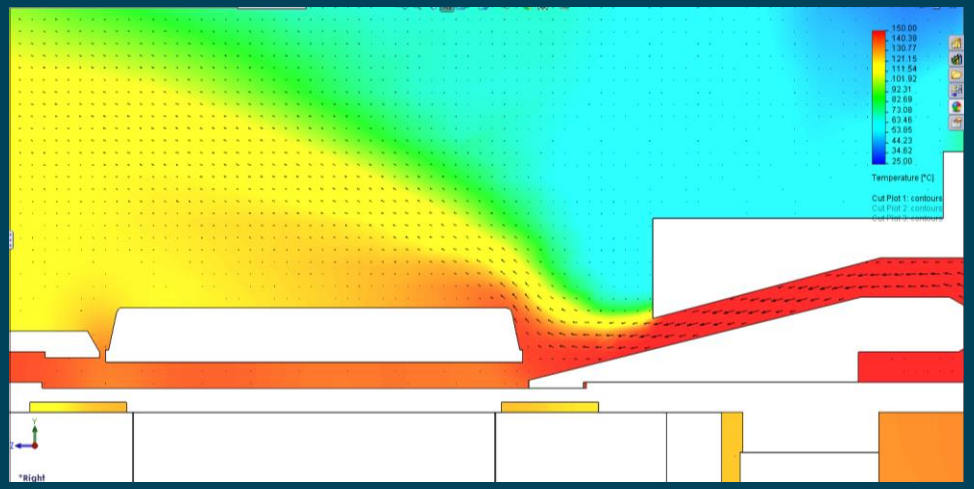
- Results were not promising as this design will have lesser heat transported through air across the package

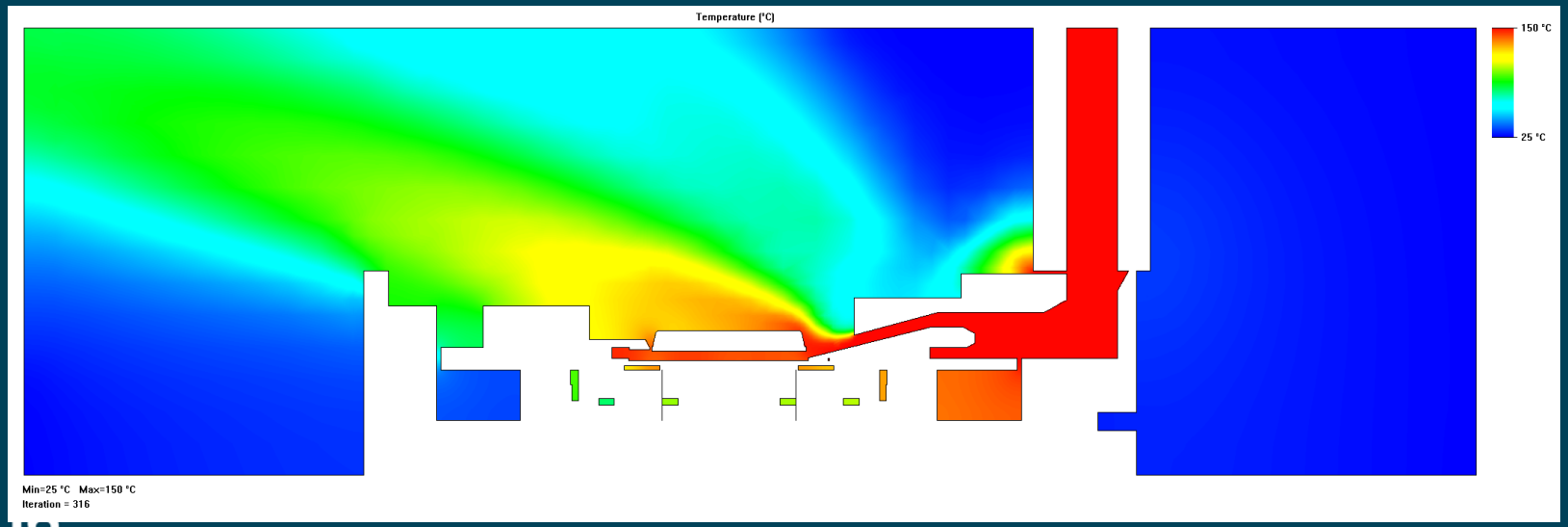




Design rev.2

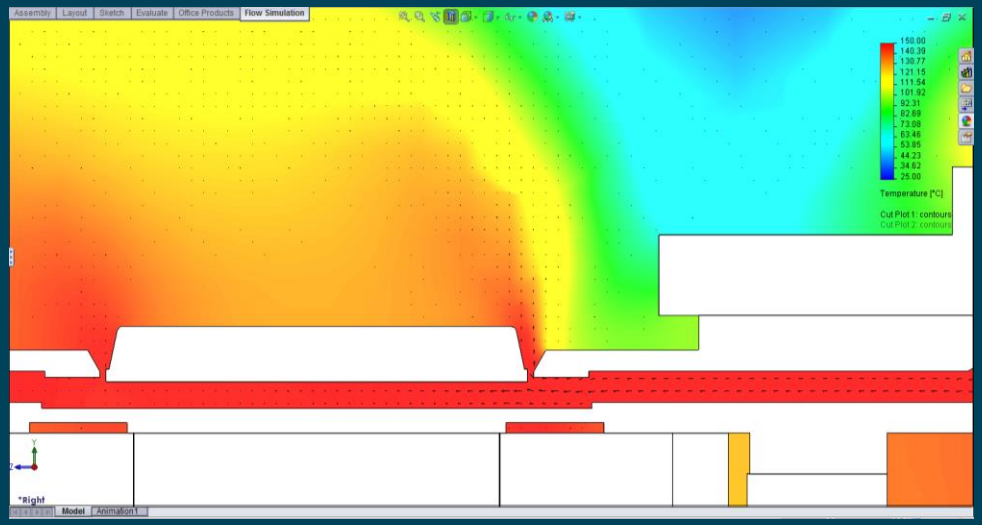
- In rev.2, airflow was focused onto the package
- However, the required setpoint temperature was not achievable with this model due to air on the top venting out to atmosphere

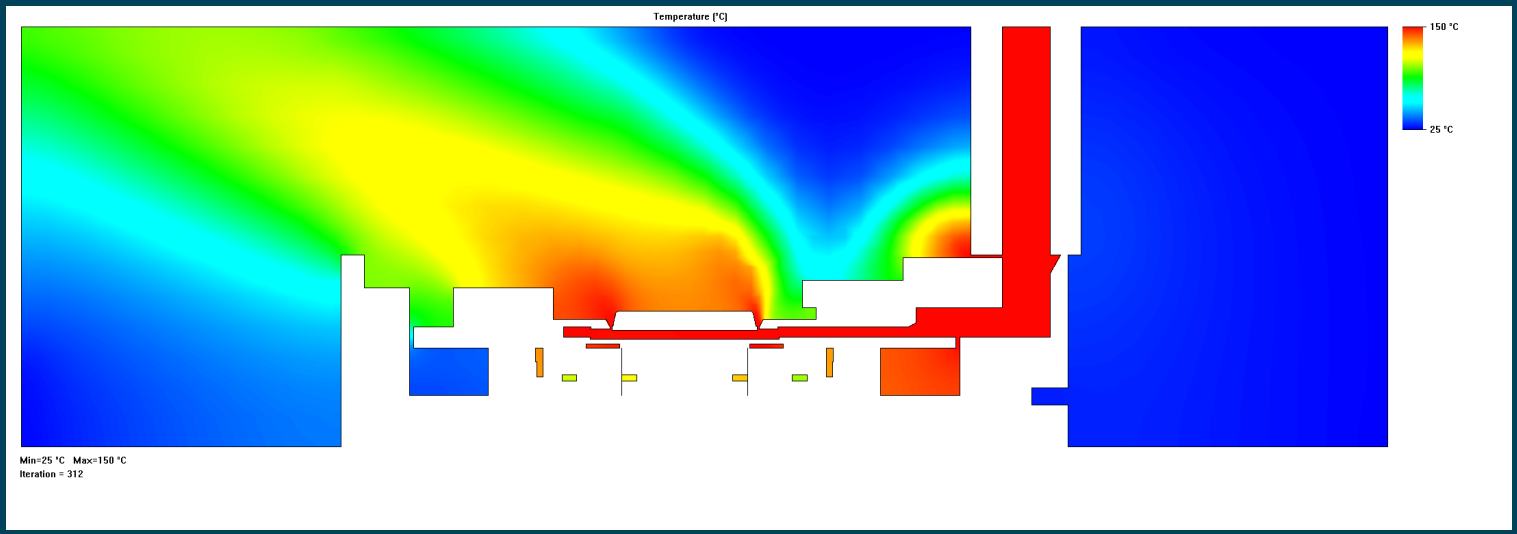




Design rev.3

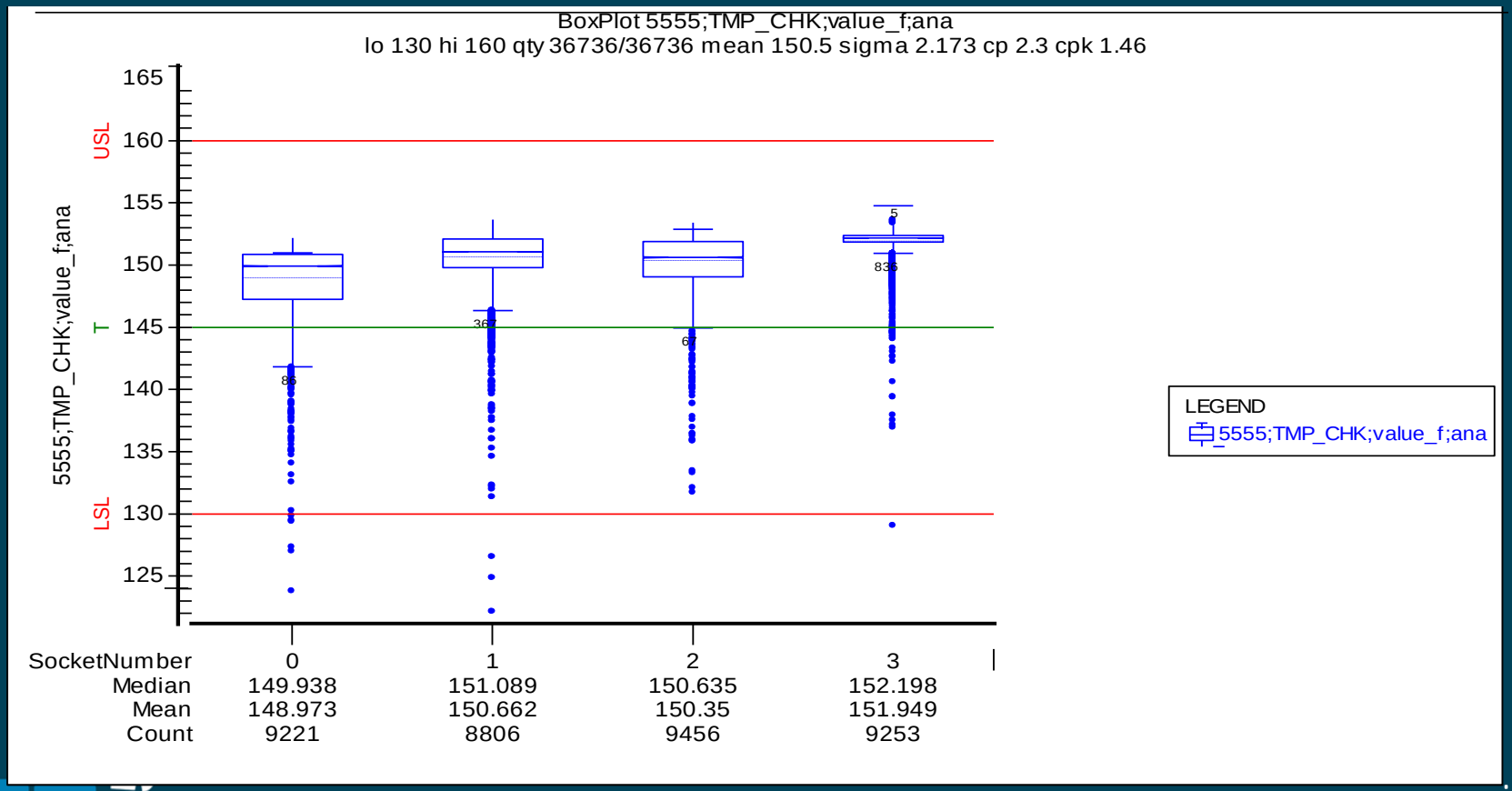
- In rev.3, venting of air was prohibited by concealing the top portion of the channel
- Simulation results seemed to be positive





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 ±2˚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 ±2˚C