
SEVENTEENTH ANNUAL
BiTS
TM
Burn-in & Test Strategies Workshop
March 6 - 9, 2016
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive- Session 8
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BiTS 2016 Burn-in & Test Strategies Workshop

Session 8
Jason Mroczkowski
Session Chair

BiTS Workshop 2016 Schedule

Solutions Day

Wednesday March 9 - 10:30 am

Cell-ebrating Test Too

"Modeling Socket Thermal Performance Inside a Burn-In Chamber"
Jason Cullen – Plastronics
Rob Caldwell - Delta V Instruments

"Established the first WLCSP Testing at Tri-temp for RF and Non-RF Products"
Edwin Valderama & Jin Sheng Tan -Intel Technologies

"A Silicon Photonics Wafer Probing Test Cell"
Roberto Aranzulla, Daniele Sala, Roberto Barbon - ST Microelectronics
Giuseppe Astone, Maurizio Rigamonti, Massimo Galli - ST Microelectronics
Jean Luc Jeanneau, Dario Adorni, Paul Mooney - Tokyo Electron
Hubert Werkmann, Fabio Pizza - Advantest Europe GmbH
Jose Moreira, Zhan Zhang - Advantest

BiTS Burn-in & Test Strategies Workshop 2016

Modeling Socket Thermal Performance Inside a Burn-In Chamber

Jason Cullen
Plastronics Sockets & Connectors

2016 BiTS Workshop
March 6 - 9, 2016

Agenda

- Introduction
- Model Definition – Socket Level
- Model Definition – Chamber Level
- Simulation Results & Next Steps
- Conclusions

Introduction

- An increasing number of socket projects require thermal management capability.
- New socket designs typically require a thermal analysis to verify product performance.
  - Inputs/variables that are needed to run an accurate analysis are not finalized or are verified at test (Heat Dissipation, etc.)
- How do we know we are accurately simulating the environment in which the socket will be utilized?

Introduction

- Thermal Management and Control is not limited to the laboratory.
  - We use ovens with digital displays but are they reliable?
  - Do we trust them?

Introduction

The answer is absolutely not!

Why? Because we still need to verify the results

i.e. We still end up doing this:

Or this:

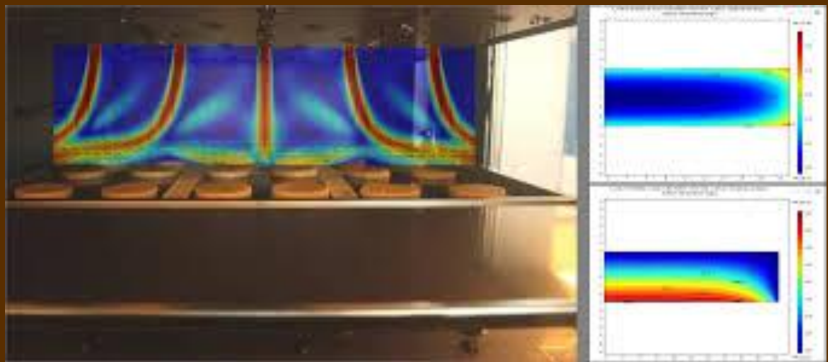
Not Done!

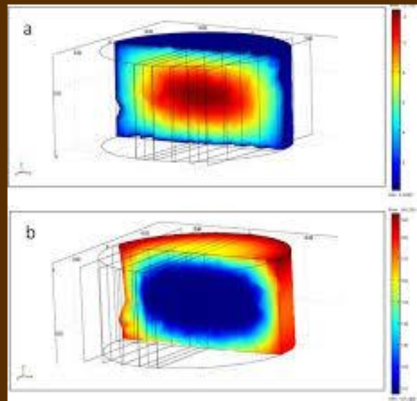
Done!

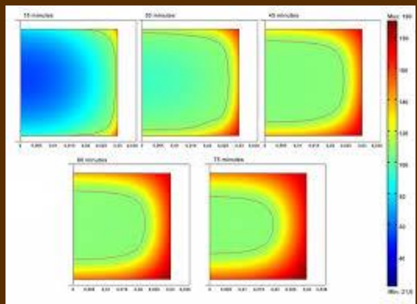
Introduction

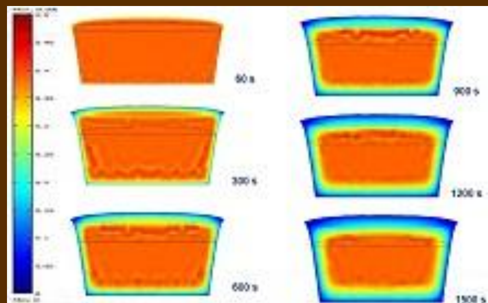
Could we model the baking process?

- Yes we can and do model the baking process – the effects of heat, temperature distribution, etc.





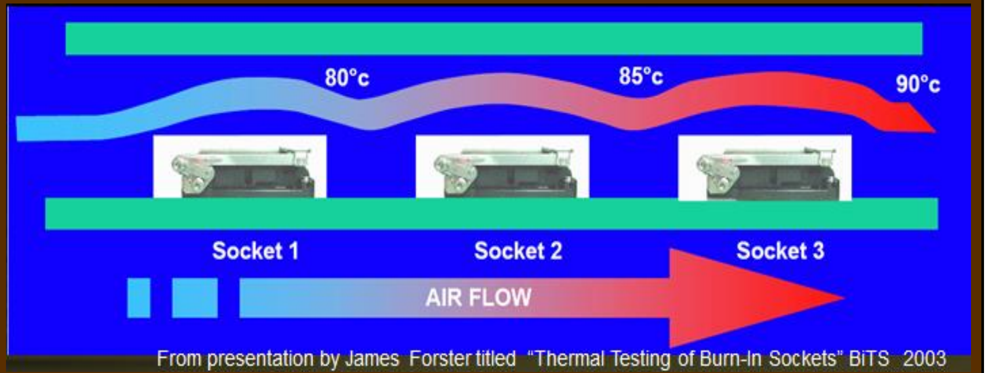




Introduction

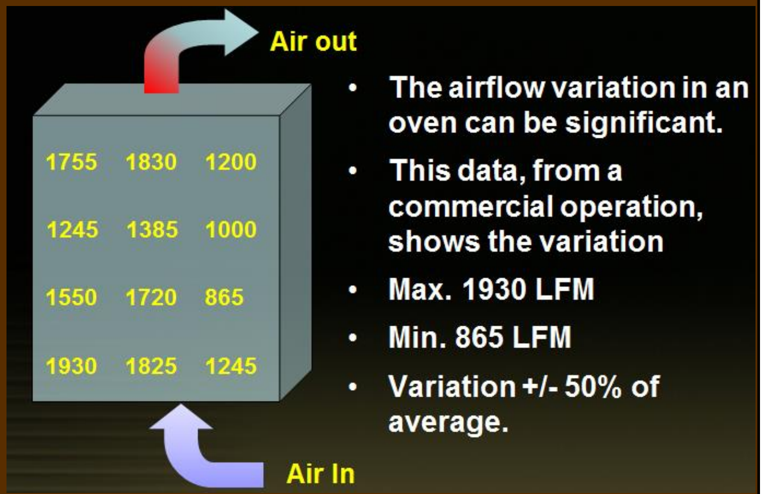
The topic of uniform temperature and airflow in a Burn-In Chamber has been discussed previously at BiTS:

In 2003, James Forster first discussed the topic of Non-uniform air temperature Distribution in a Burn-In Chamber. Paper Title: "Thermal Testing of Burn-In Sockets"



From presentation by James Forster titled "Thermal Testing of Burn-In Sockets" BiTS 2003

In 2011, James Forster and John Moore presented airflow data showing a non-uniform distribution. Paper Title: "Thermal Testing – Some Tidbits from the Lab"



Model Definition – Socket Level

There are 2 basic categories for burn-in sockets when speaking of designs with thermal management:

Actively Cooled

These sockets typically contain:

- Heatsink, RTD, Heater, Fan

Passively Cooled

These sockets typically contain

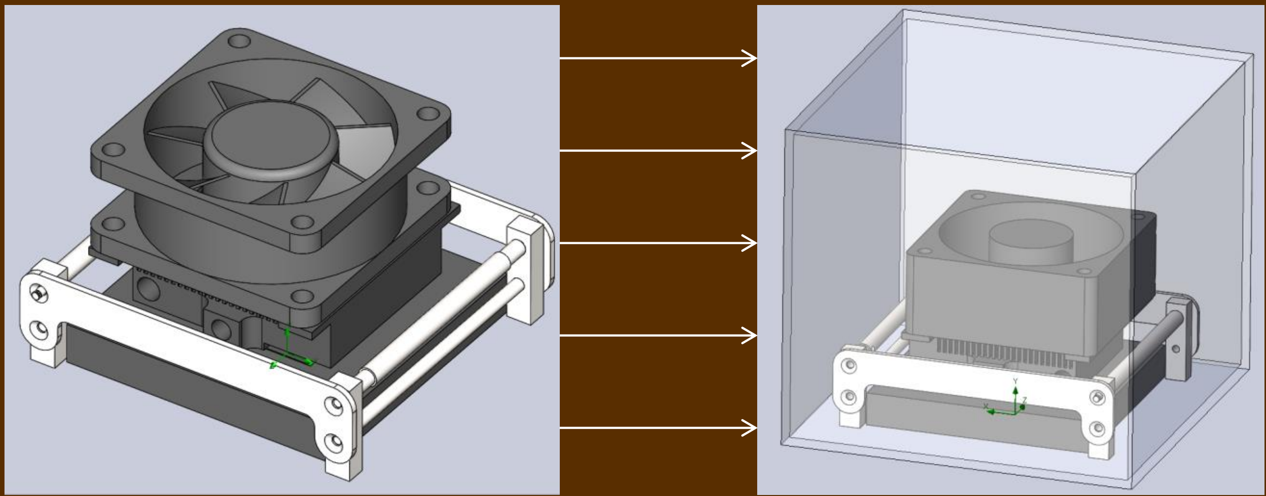
A heatsink only.

Passively Cooled Sockets are impacted more by temperature and airflow variations, they cannot respond to variations in the oven!

Model Definition – Socket Level

First, let's examine the typical method of analyzing a single socket.

Step 1: Simplify the socket model



Eliminate Complex shapes, components and contours.

Model Definition – Socket Level

Step 2: Add Values for Key Parameters

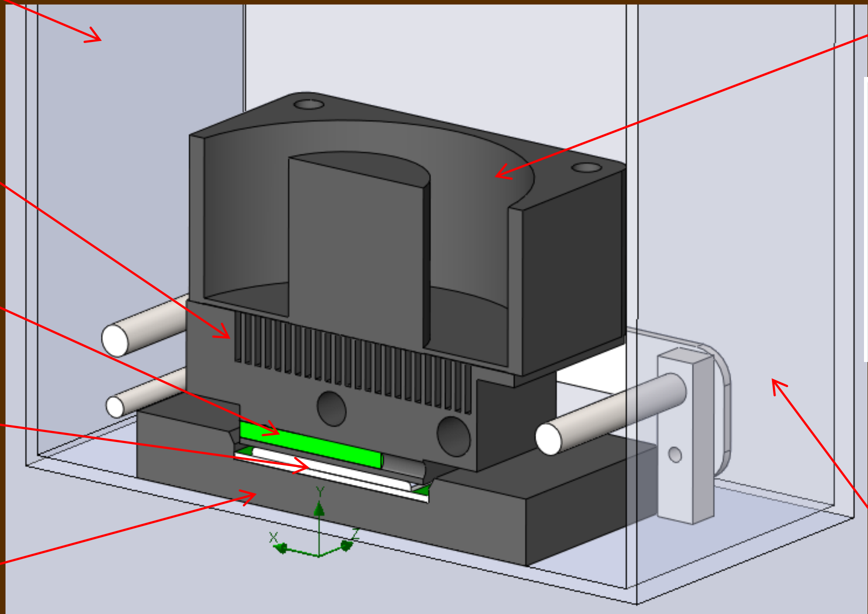
AIR INLET
(airflow rate)

HEATSINK
(apply mat'l)

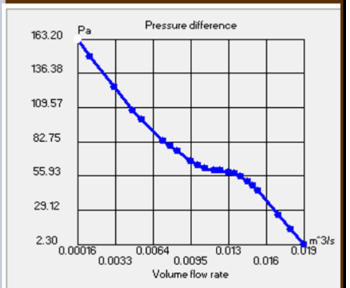
HEATER
(heat capacity)

DEVICE
(power output)

SOCKET BASE
(apply mat'l)



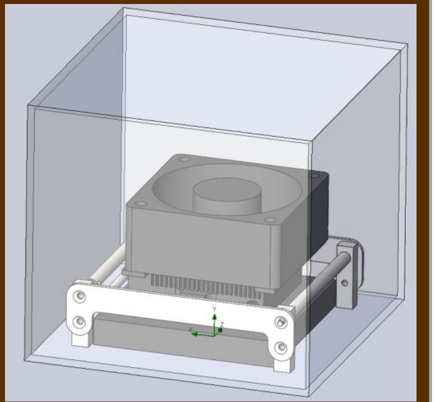
COOLING FAN
(add Fan Curve)

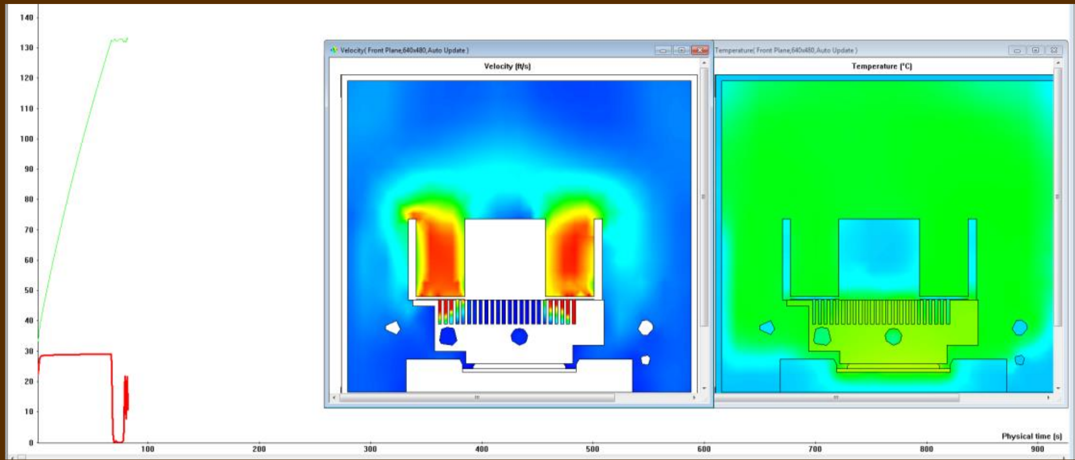


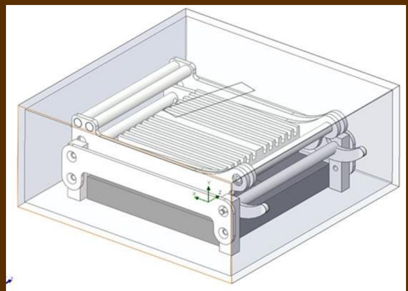
AIR OUTLET
(pressure)

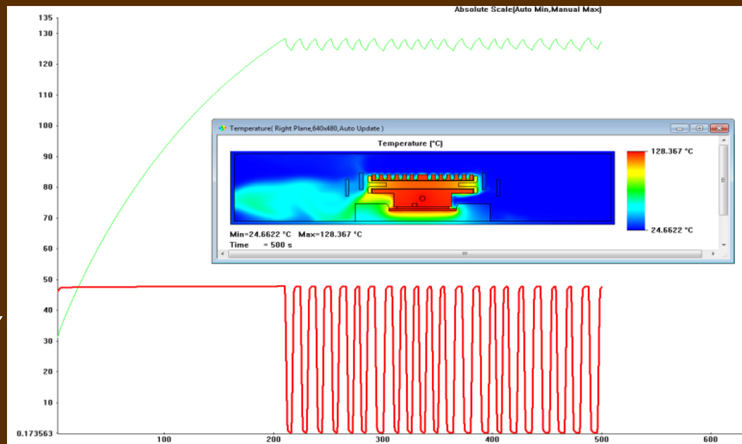
Model Definition – Socket Level

Step 3: Generate Results - Active Cooling





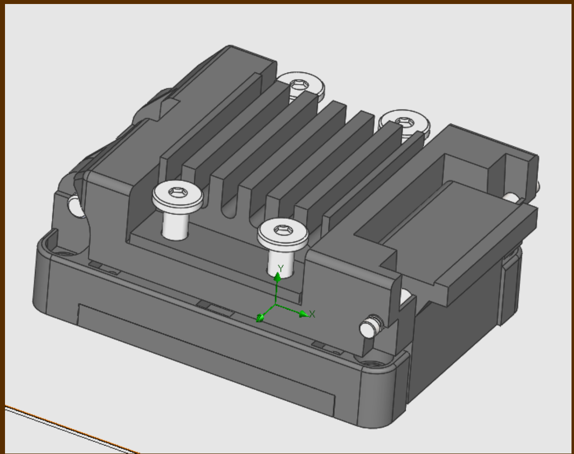


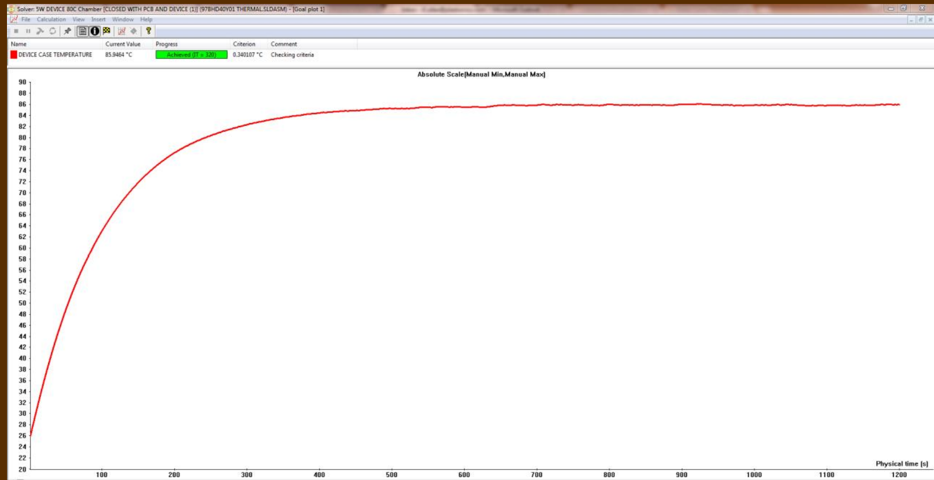


RED LINE = HEATER ACTIVITY
GREEN LINE = DEVICE TEMP

Model Definition – Socket Level

Step 3: Generate Results - Passive Cooling





RED LINE = DEVICE TEMP

- THIS SOCKET IS DEPENDENT UPON CROSSFLOW AIR IN THE CHAMBER TO COOL THE DEVICE.
- WE KNOW THE INLET AIR TEMP, BUT <u>WHAT ABOUT THE TEMPERATURE FURTHER FROM THE INLET?</u>

Model Definition – Chamber Level

The model below represents 2 rows of 4 sockets in a volume similar to a burn-in chamber.

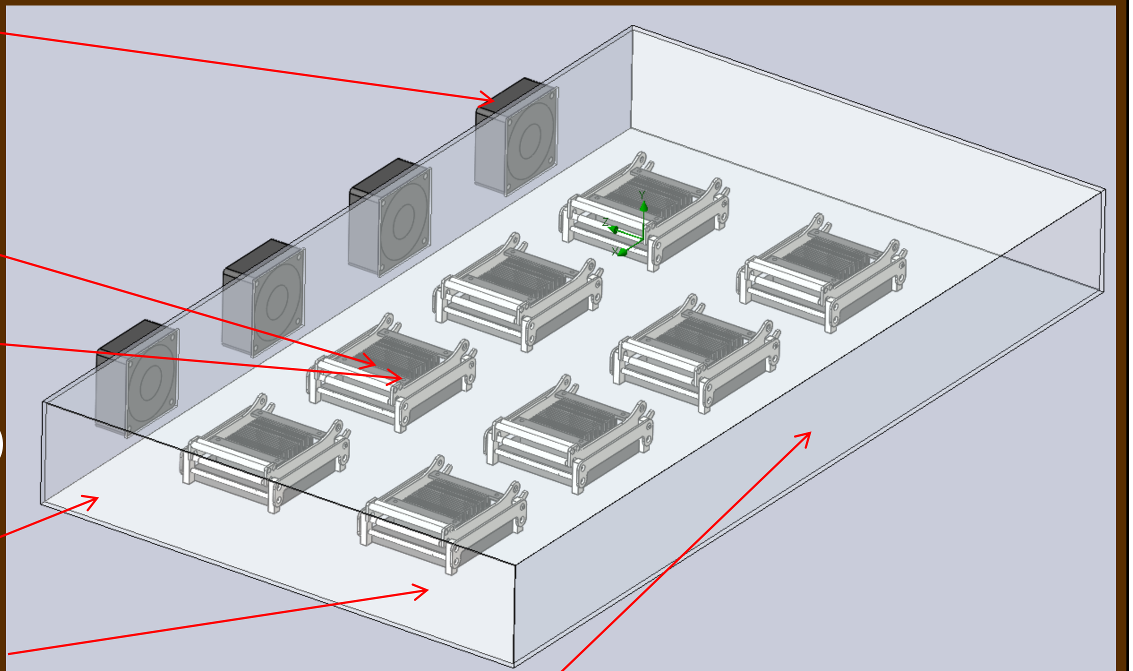
(4)x40 CFM Fans

(8)x35x35mm Devices At 100W

(8)x Passively Cooled Burn-in Sockets w/ Aluminum Heatsinks (23 fins @8mm height)

PCB Material (Floor)

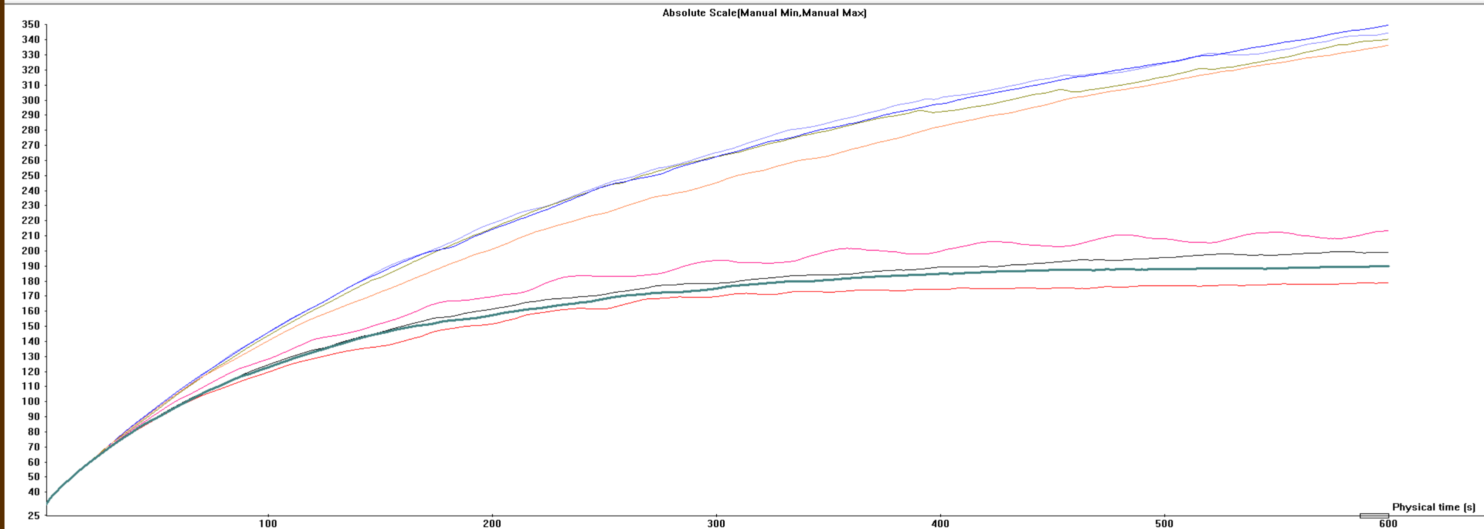
Stainless Steel (Walls)



Air Outlet

Simulation #1 Results

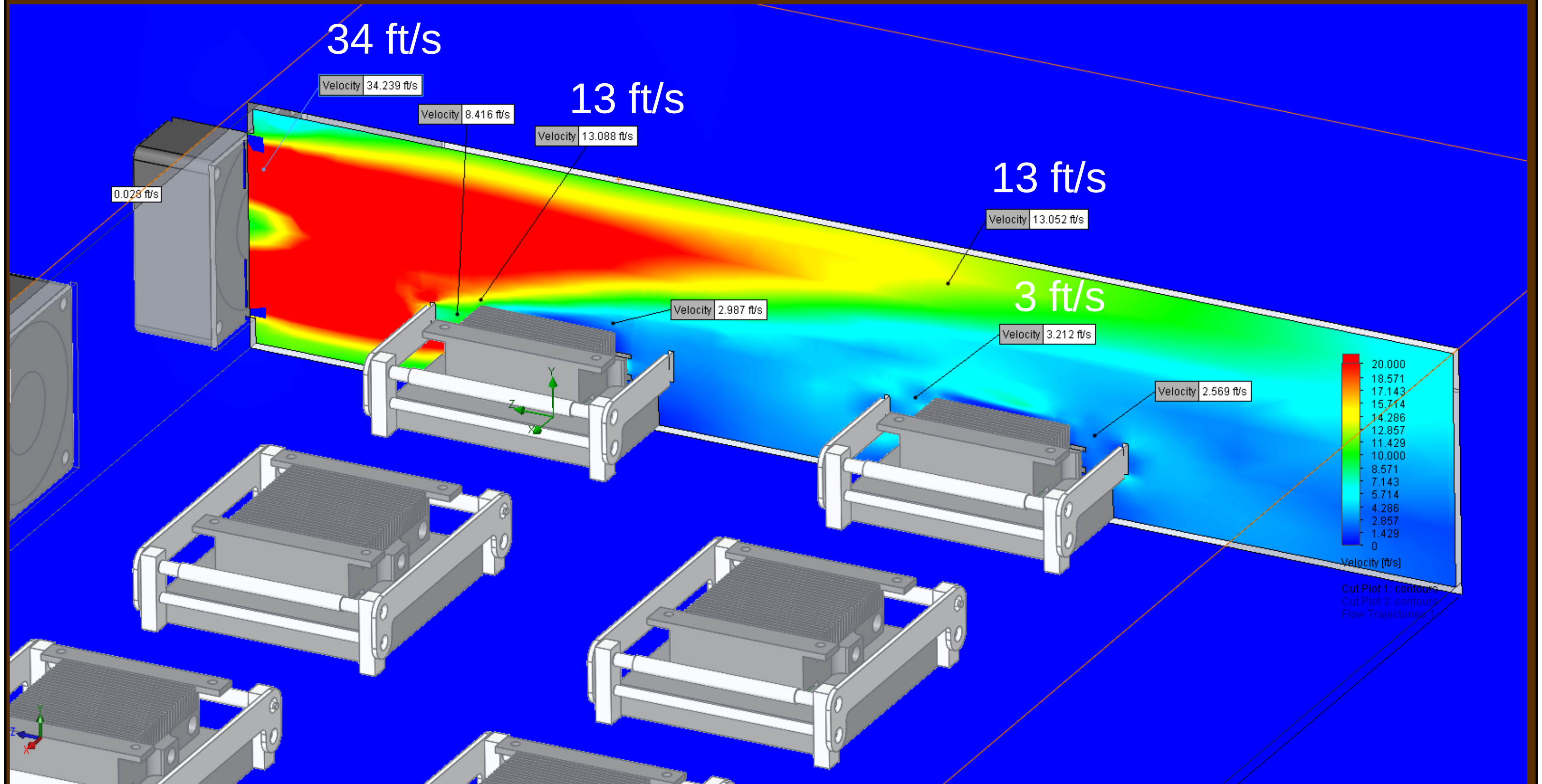
Name	Current Value	Progress	Criterion	Averaged Value
Package Temp	178.949 °C	Achieved (IT = 371)	0.853252 °C	178.721 °C
Package Temp (1)	189.966 °C	Achieved (IT = 386)	0.85237 °C	189.717 °C
Package Temp (2)	336.475 °C	30%	0.900605 °C	334.926 °C
Package Temp (3)	349.792 °C	35%	0.90082 °C	348.243 °C
Package Temp (4)	199.185 °C	Achieved (IT = 583)	0.85338 °C	198.969 °C
Package Temp (5)	213.307 °C	32%	0.873831 °C	212.384 °C
Package Temp (6)	340.55 °C	54%	0.906856 °C	339.608 °C
Package Temp (7)	344.684 °C	66%	0.902447 °C	343.464 °C



- The devices in Row 1 (closest to Fans) average 195ºC after 10 minutes.
- The devices in Row 2 average 342ºC after 10 minutes!

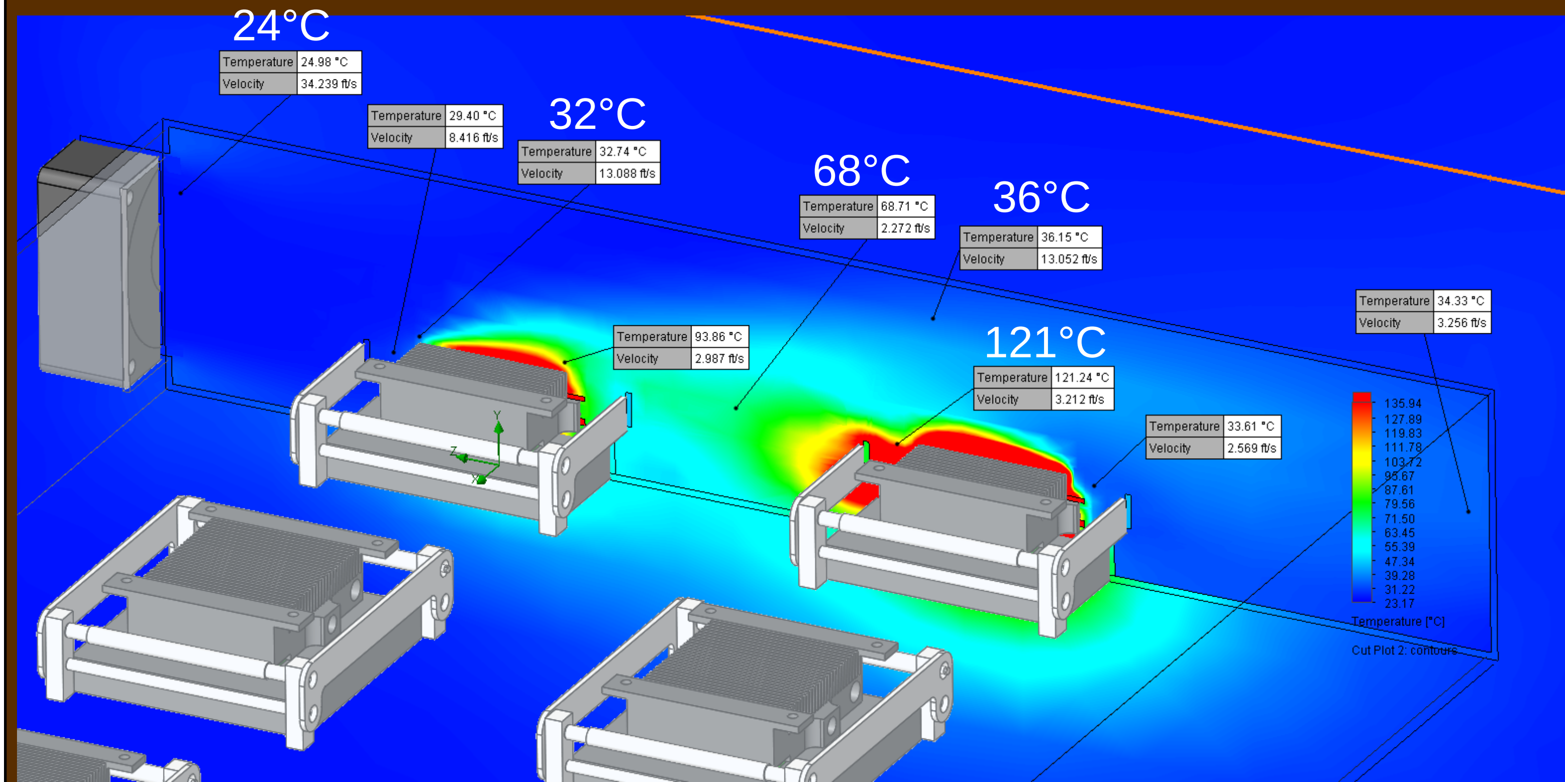
THIS IS AN EXTREME CASE, BUT WE ARE LOOKING FOR TRENDS IN THE DATA. THE SOCKETS IN ROW 2 ARE NOT GETTING ENOUGH AIRFLOW AND/OR THE AVAILABLE AIR IS AT A HIGHER TEMP.

Simulation #1 – Velocity



The airflow velocity drops from a high of 34 ft/sec at the fan to only 3 ft/sec at the heatsink of the socket in row 2.

Simulation #1 - Temperature



The sockets in row 2 are seeing air at the front edge of the heatsink that is At least 12°C warmer than the inlet air at the fan.

Simulation #2 – Chamber Level

The model below adds an air diverter that should provide Row 2 with more available airflow.

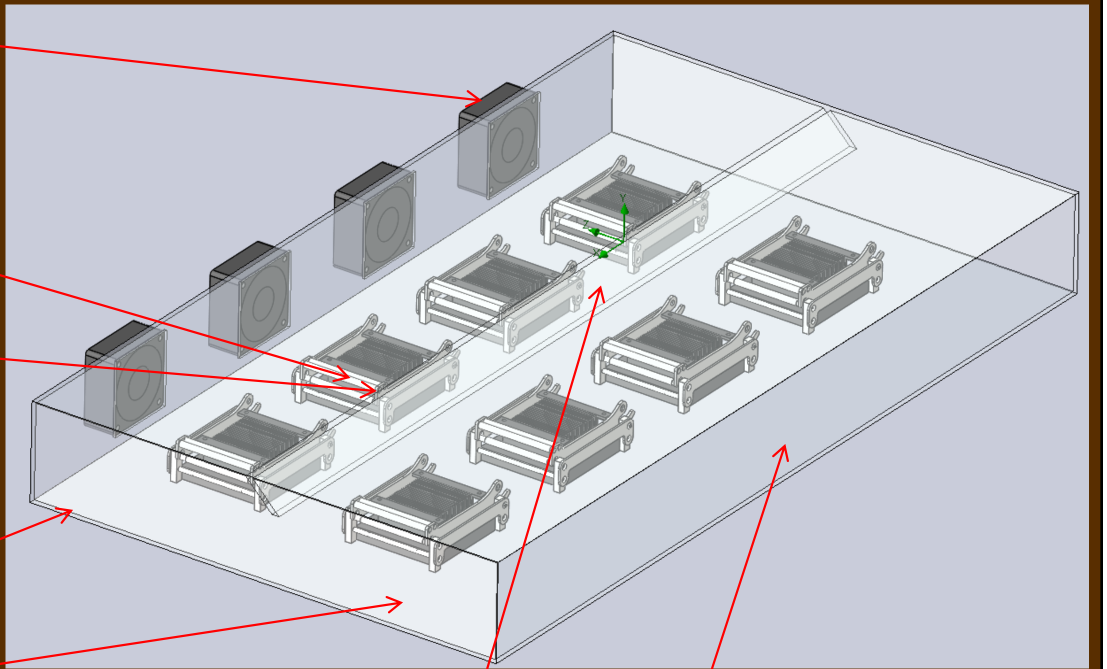
(4)x40 CFM Fans

(8)x35x35mm Devices At 100W

(8)x Passively Cooled Burn-in Sockets w/ Aluminum Heatsinks (23 fins @8mm height)

PCB Material (Floor)

Stainless Steel (Walls)

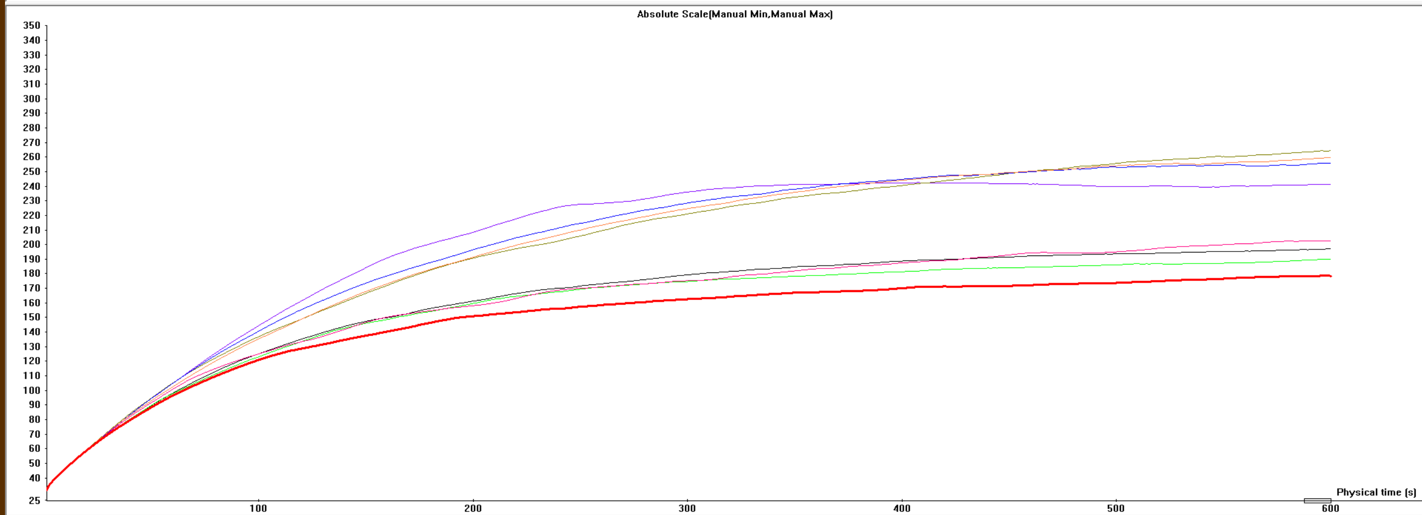


AIR DIVERTER

Air Outlet

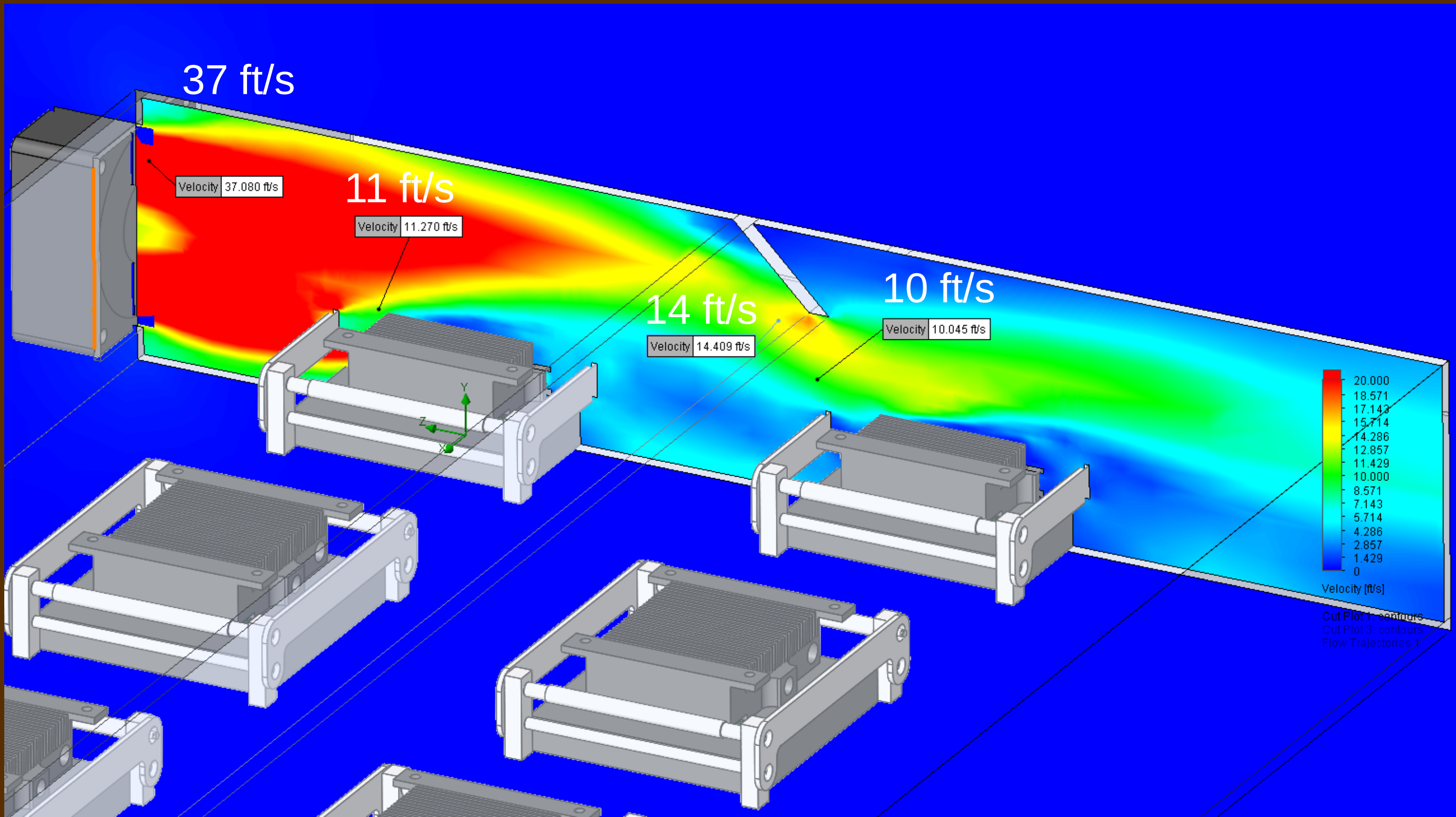
Simulation #2 Results

Name	Current Value	Progress	Criterion	Averaged Value
ROW 1 POS 1	178.512 °C	Achieved (IT = 417)	0.848562 °C	178.526 °C
ROW 1 POS 2	189.973 °C	Achieved (IT = 595)	0.859363 °C	189.68 °C
ROW 1 POS 3	197.106 °C	Achieved (IT = 408)	0.85309 °C	196.74 °C
ROW 1 POS 4	202.569 °C	Achieved (IT = 583)	0.868547 °C	202.585 °C
ROW 2 POS 1	259.71 °C	92%	0.896203 °C	259.2 °C
ROW 2 POS 2	255.853 °C	96%	0.88837 °C	255.5 °C
ROW 2 POS 3	264.293 °C	Achieved (IT = 0)	0.902575 °C	263.972 °C
ROW 2 POS 4	241.181 °C	Achieved (IT = 338)	0.889471 °C	241.151 °C



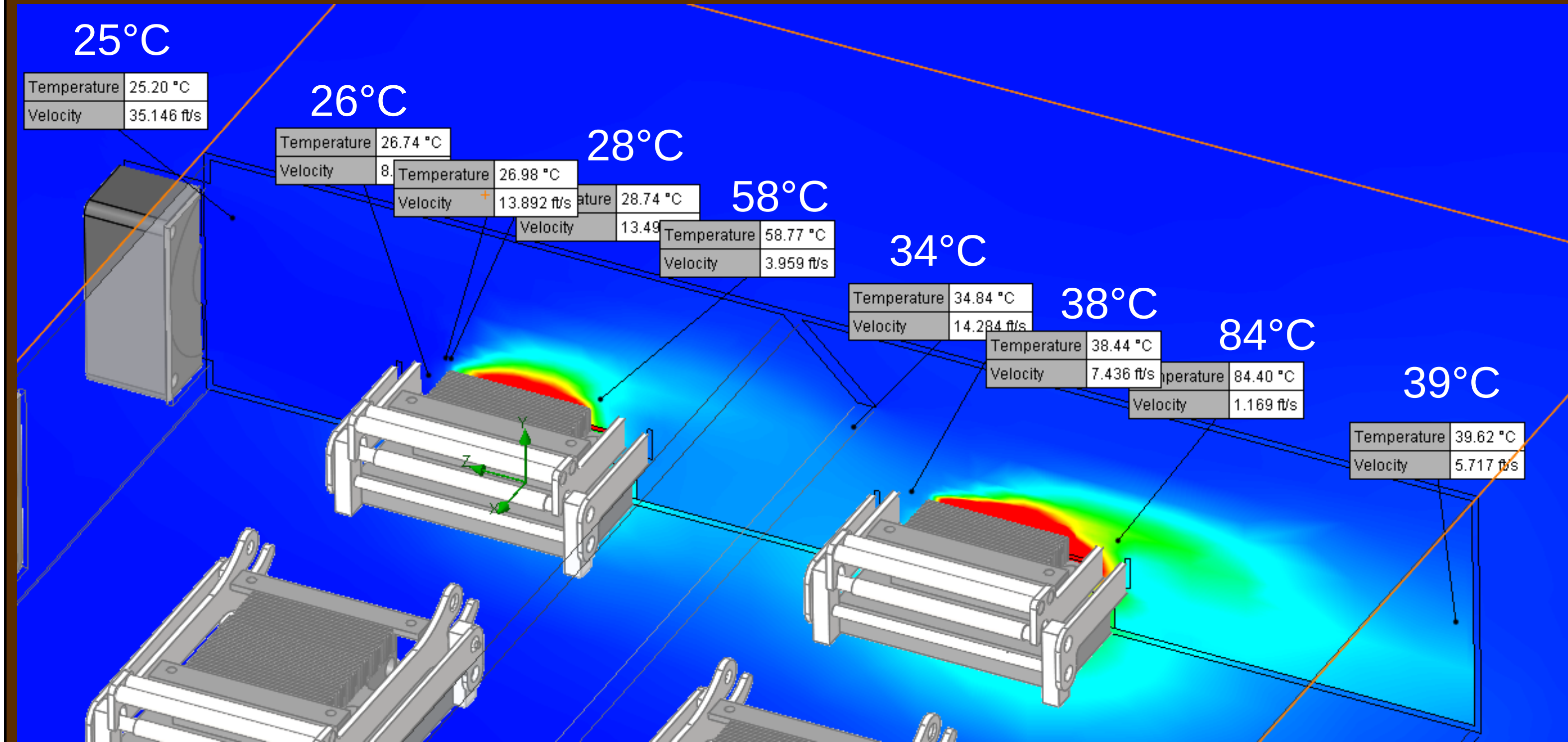
- The devices in Row 1 (closest to Fans) average 191ºC after 10 minutes.
- The devices in Row 2 average 254ºC after 10 minutes. A 25% reduction compared to Case 1.

Simulation #2 - Velocity



Directing the airflow improves (by 3x) airspeed at the heatsink.

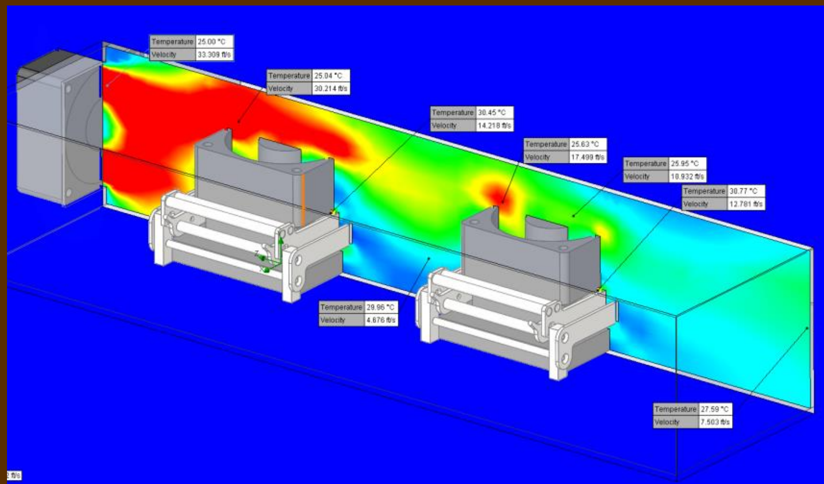
Simulation #2 - Temperature



Directing the airflow improves heat transfer between the heatsink and the air, but the socket in row 2 is still seeing ~13°C warmer air compared to row 1.

Next Steps

- We've been able to produce a working model of the system that needs to be validated with real world measurements.
- Once validated, we can use adjustment factors for available airflow and anticipated temperature to create our thermal models at the socket level.
- Additional models that contain active cooling (fans) can be analyzed.



Conclusion

- We create models because our designs and systems are complex.
- Models help reduce time-to-market and decrease the risk for design-related issues.
- Though we do not expect perfect 1:1 agreement between models and real world performance, we use them to look for trends and areas of improvement in our designs.
- By understanding the environment in which a product will be used, it helps us develop solutions that increase the chances of success for our customers.

Acknowledgement

The author would like to recognize James Forster for his efforts and support with this presentation as well as his contributions to previous BiTS Workshops!

THANK YOU JAMES!