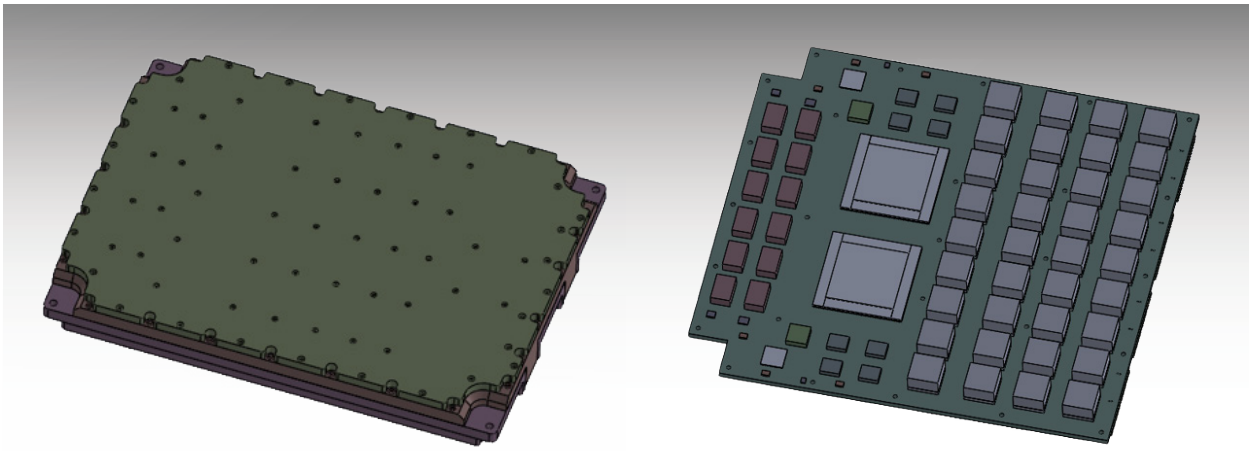
CF-020400-054 Thermal Analysis

June 30, 2022



Objectives

To determine that the critical components on the CF-020400-054 board are within their thermal limits for the following cases:

a) **85°C at sea level, 86 F Coolant**

b) **-40°C at sea level, 59 F Coolant**

c) **23°C at sea level, 70 F Coolant**

d) **85°C at sea level, 140 F Coolant**

e) **-40°C at sea level, 0 F Coolant**

At 2 different power levels:

a) **Predicted** - Total Power of 648.2

b) **Worst Case** - Total Power of 1395.2

Approach

1. This analysis was done using FloTHERM XT V2021.2 CFD software.
2. The thermal model was created from the CF-020400-054m_asm_052722 file provided for thermal analysis.
3. The Falcon & Armada components were obtained from the PDML files provided.
4. It was assumed that no neighboring devices were producing or sinking heat.
5. The model was evaluated with a certain cold plate channel design which is optimized further to increase heat transfer as per the component temperature results obtained from every iteration.
6. Three different thickness thermal gap pads have been used for the components: 0.080”, 0.060”, 0.040” all of which have a thermal conductivity of 17.8 W/m-K.
7. The critical components were modeled as 2-resistor networks with thermal resistance values found on the “Parts Thermal Characteristics.doc”.

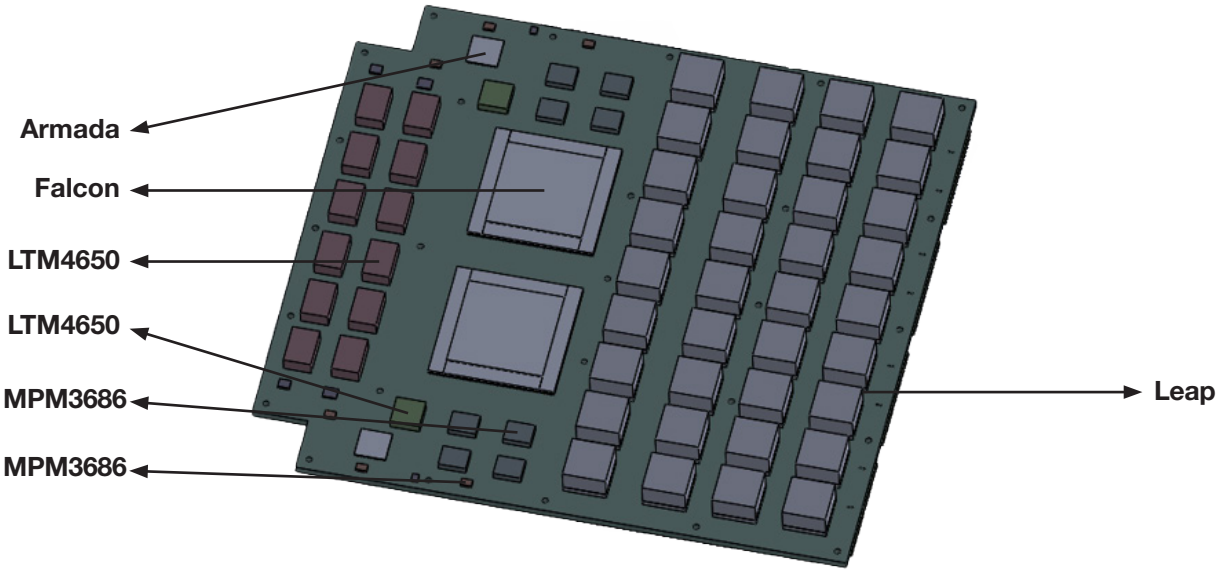
Ray Baruah
Electronic Cooling Solutions Inc.

CF-020400-054 Thermal Analysis

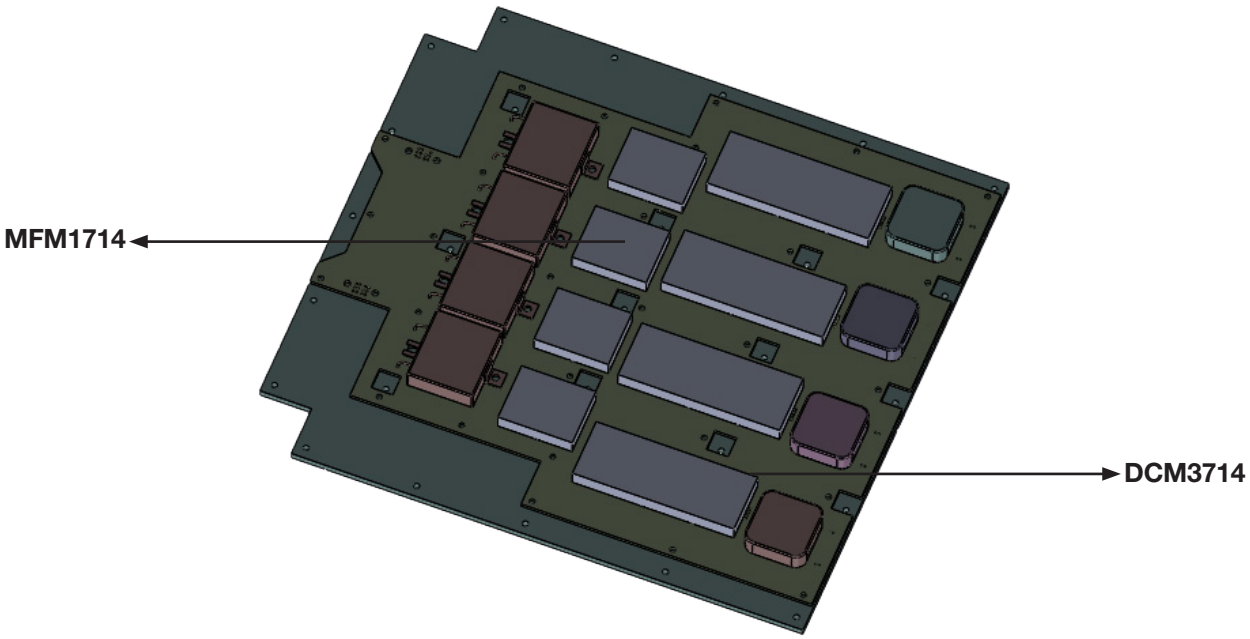
Contents

Thermal Model Setup

Overview: Board Components



Overview: Bottom Components

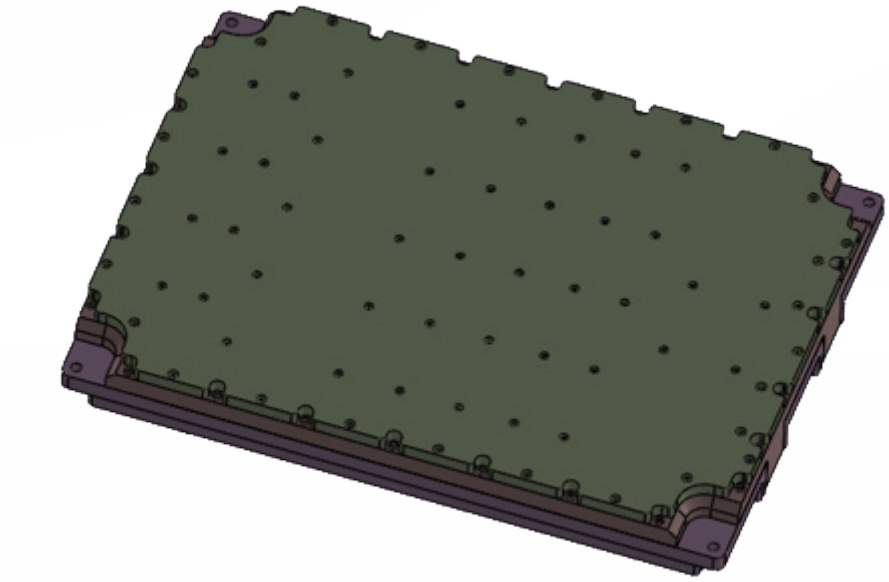


Thermal Model Setup

Overview: Housing

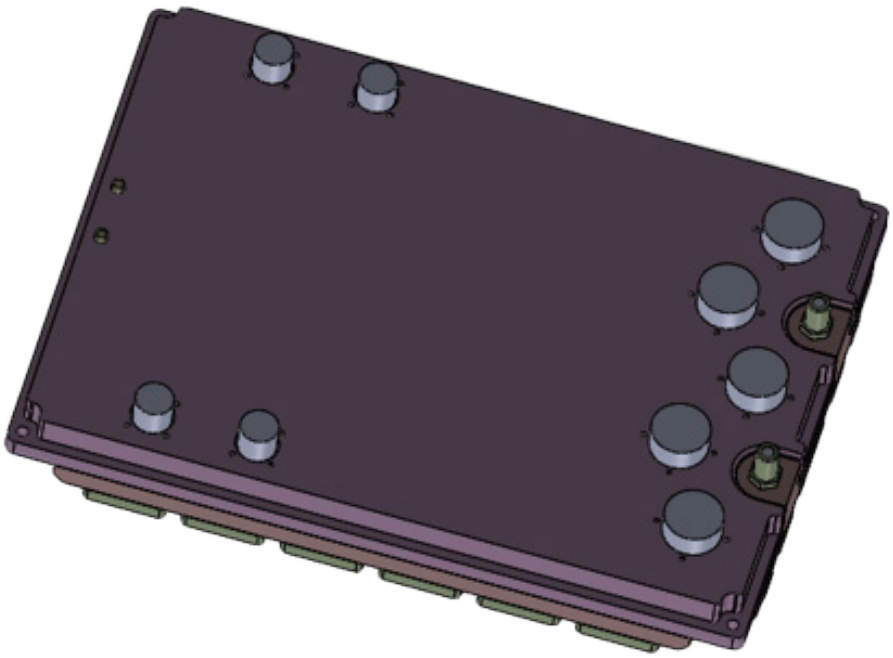
Top Side

Enclosure Material – Al6061 T6



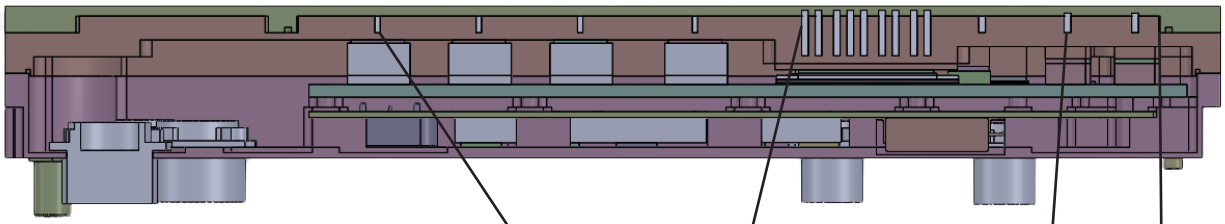
Bottom Side

Enclosure Material – Al6061 T6



Thermal Model Setup

Cold Plate Channel Design 1 New Model



4 Channels - 2 mm wide, 6.22 mm deep, ~36 mm Distance b/w channels Previous model – 5 channels

9 Channels - 2.5 mm wide, 17 mm deep, ~2.58 mm Distance b/w channels Previous model – 9 channels

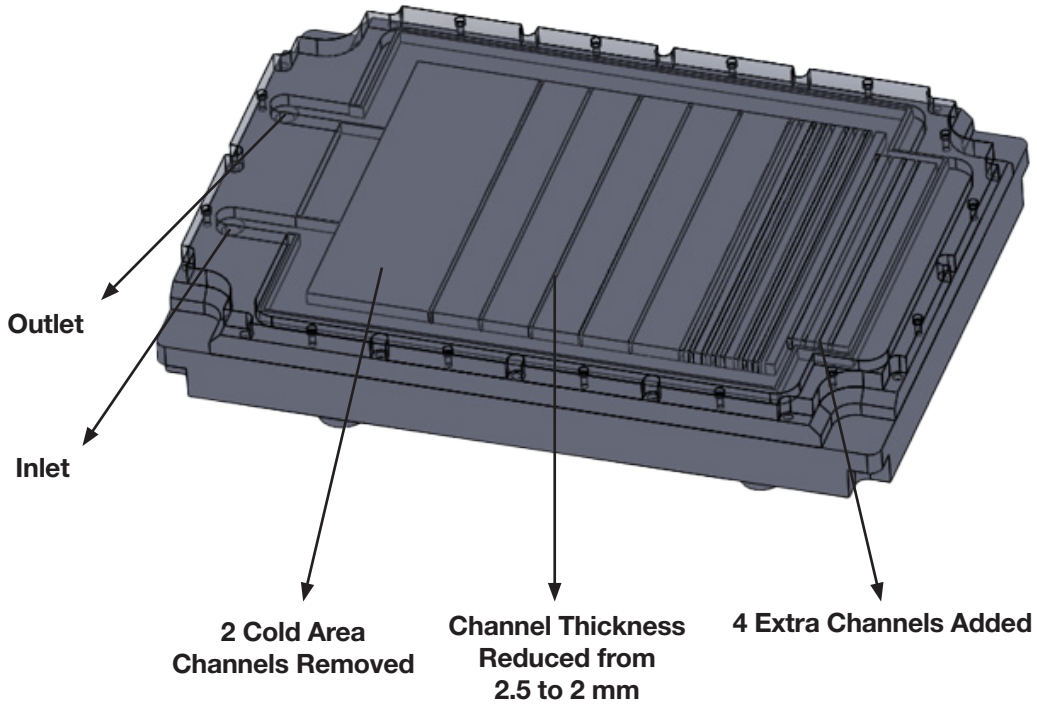
3 extra channels, 2.5 mm thickness, 7.37 mm deep, Previous Model – 4 channels

Thinner last channel compared to previous model

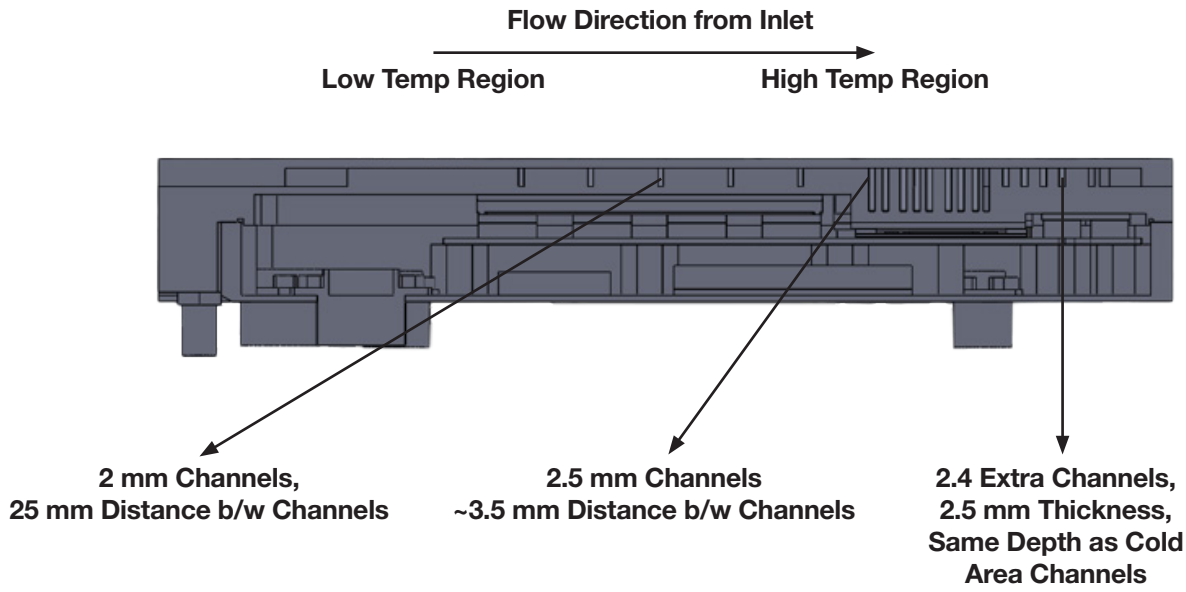
Thermal Model Setup

Cold Plate Channel Design 3 Old Model

Cold Plate Channels Top View



Cold Plate Channels Side View



Thermal Model Setup

Thermal Data

CF-020400-54	Predicted			Worst Case			Thermal Resistance (°C/W) / Model	
Component	Qty	Per Component	Total	Qty	Per Component	Total	R_{JB}	R_{JC}
Falcon	2	189.3	378.6	2	420.8	841.6	0.95	0.022
LTM4700	4	4.8	19.2	4	10.7	21.4	1.75	3.1
LTM4700	4	2.3	9.2	4	5.2	20.8	1.75	3.1
LTM4700	4	1.9	7.6	4	4.3	17.2	1.75	3.1
LTM4650	2	1.7	3.4	2	3.9	7.8	1.75	3.1
LEAP	36	4	144	36	7.9	284.4		
Armada	2	3.9	7.8	2	7.8	15.6	6.89	2.57
MFM1714	2	1.0	2	2	2.1	4.2	1.5	6.5
MFM1714	2	1.0	2	2	2.1	4.2	1.5	6.5
MPM3686	6	1.9	11.4	6	3.8	22.8	2.5	4
MPM3686	2	0.5	1	2	0.9	1.8	2.5	4
MPM3650	2	0.4	0.8	2	0.8	1.4	1.5	6
MPM3650	2	0.2	0.4	2	0.3	0.4	1.5	6
MPM3650	2	0.1	0.2	2	0.2	0.2	1.5	6
DCM3714	2	15.2	30.4	2	32.5	65	1.75	1.97
DCM3714	2	14.6	29.2	2	31.6	53.2	1.75	1.97
LT1963	2	0.1	0.2	2	0.3	0.6		
NCP512000	2	0.2	0.4	2	0.3	0.6		
		Total	648.2		Total	1395.7		

Note: Thermal resistances from junction to case (R_{JC}) and from junction to board (R_{JB}) and thermal limits were taken from “Parts Thermal Characteristics”.

Note: For this set of simulations, the predicted power values were used

Thermal Analysis

Results Summary - Predicted

Cold Plate Design				Design 1			Design 1			Design 1			Design 1			Design 1		
Parameters				Sim 4 - Latest Total Power 648.2 W			Sim 3 - Latest Total Power 648.2 W			Sim 1 - Latest Total Power 648.2 W			Sim 2 - Latest Total Power 648.2 W			Sim 5 - Latest Total Power 648.2 W		
Power Scenerio				Predicted			Predicted			Predicted			Predicted			Predicted		
Ambient Temp., °C				85			23			85			-40			-40		
Fluid Temp., °C				69			21.1			30			15			-17.77		
Elevation, ft				0			0			0			0			0		
				Results						Results								
Component	Min. Limit, °C	Max. Limit, °C	Limit Type	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C
Falcon 1	-40	110	Junction	189.3	106.2	6.6	189.3	66.8	43.2	189.3	73.5	36.5	189.3	56.1	53.9	189.3	27.9	67.9
Falcon 2	-40	110	Junction	189.3	103.4	3.8	189.3	64.4	45.6	189.3	75.9	34.1	189.3	57.9	52.1	189.3	25.3	65.3
Leap (Max)	0	70	Case	4.0	80.4	-10.4	4.0	42.8	27.2	4.0	52.3	17.7	4.0	33.5	36.5	4.0	4.2	4.2
LTM4700 (Max)	-40	125	Junction	4.8	94.9	30.1	4.8	56.3	68.7	4.8	65.9	59.1	4.8	46.0	79.0	4.8	17.8	57.8
Armada 1	-40	115	Junction	3.9	84.6	30.4	3.9	46.2	68.8	3.9	55.8	59.2	3.9	35.2	79.8	3.9	7.6	47.6
Armada 2	-40	115	Junction	3.9	79.2	35.8	3.9	41.9	73.1	3.9	51.4	63.6	3.9	32.5	82.5	3.9	3.2	43.2
MPM3686 (Max)	-40	125	Junction	1.9	93.1	31.9	1.9	55.3	69.7	1.9	64.7	60.3	1.9	45.1	79.9	1.9	16.8	56.8
MPM3650 (Max)	-40	125	Junction	0.4	83.3	41.7	0.4	45.5	79.5	0.4	55.0	70	0.4	34.8	90.2	0.4	7.0	47
MFM1714 (Max)	-55	125	Junction	1.0	93.8	31.2	1.0	59.4	65.6	1.0	71.0	54	1.0	43.1	81.9	1.0	21.0	76
LTM4650 (Max)	-40	125	Junction	1.7	84.7	40.3	1.7	46.2	78.8	1.7	55.6	69.4	1.7	35.6	89.4	1.7	7.5	47.5
DCM 3714 (Max)	-20	100	Case	15.2	92.2	7.8	15.2	57.9	42.1	15.2	69.9	30.1	15.2	40.7	59.3	15.2	19.3	39.3
DCM 3714 (Max)	-20	125	Junction	15.2	111.2	13.8	15.2	77.6	47.4	15.2	89.3	35.7	15.2	61.3	63.7	15.2	39.4	59.4

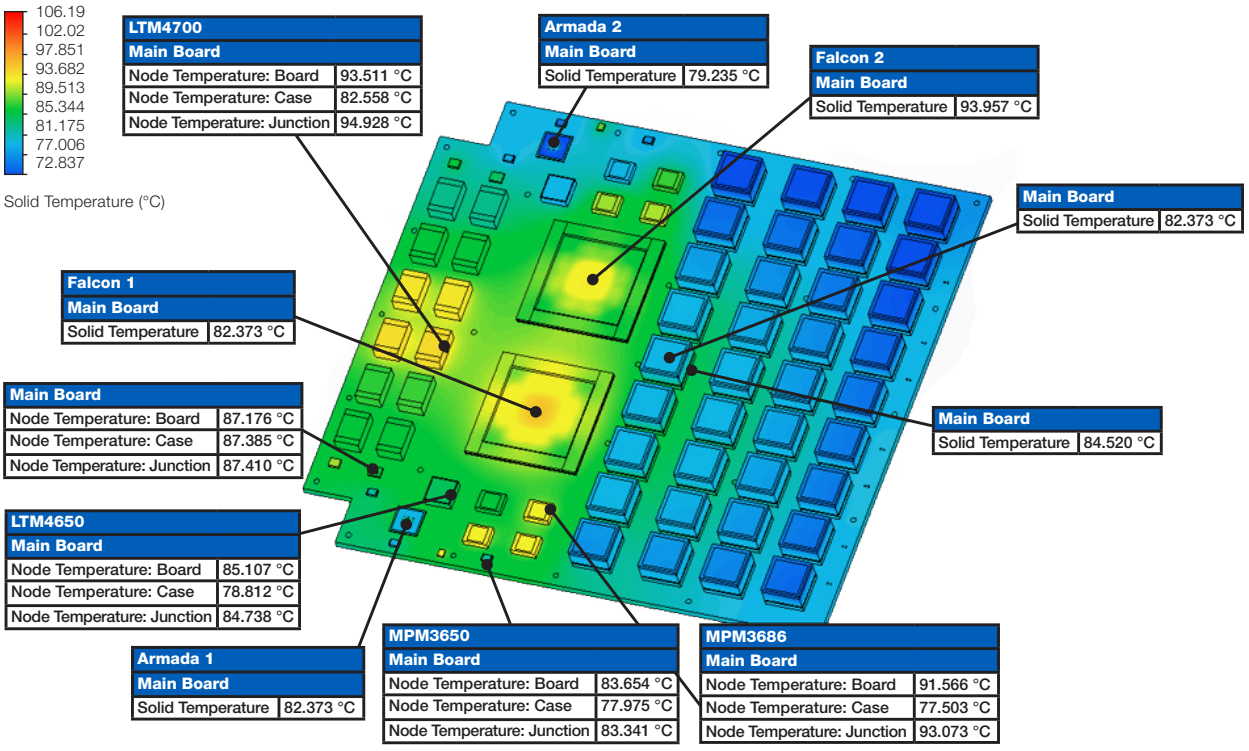
Results Summary - WC

Cold Plate Design				Design 1			Design 1			Design 1			Design 1			Design 1		
Parameters				Sim 4 - Latest Total Power 1395.7 W			Sim 3 - Latest Total Power 1395.7 W			Sim 1 - Latest Total Power 1395.7 W			Sim 2 - Latest Total Power 1395.7 W			Sim 5 - Latest Total Power 1395.7 W		
Power Scenerio				WC			WC			WC			WC			WC		
Ambient Temp., °C				85			85			23			-40			-40		
Fluid Temp., °C				60			30			21.1			15			-17.77		
Elevation, ft				0			0			0			0			0		
				Results						Results								
Component	Min. Limit, °C	Max. Limit, °C	Limit Type	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C	Power, W	Result,°C	Margin,°C
Falcon 1	-40	110	Junction	420.8	158.8	-48.8	420.8	128.0	-18	420.8	116.3	-6.3	420.8	108.7	1.3	420.8	80.6	29.4
Falcon 2	-40	110	Junction	420.8	153.5	-43.5	420.8	122.0	-12	420.8	111.9	-1.9	420.8	104.5	5.5	420.8	74.9	35.1
Leap (Max)	0	70	Case	7.9	100.0	-30.1	7.9	71.3	-1.3	7.9	60.9	9.1	7.9	52.8	17.2	7.9	25.0	45
LTM4700 (Max)	-40	125	Junction	10.7	132.2	-7.2	10.7	102.3	22.7	10.7	90.5	34.5	10.7	81.7	43.3	10.7	55.6	69.4
Armada 1	-40	115	Junction	7.8	107.3	7.7	7.8	78.6	36.4	7.8	66.2	48.8	7.8	57.3	57.7	7.8	31.5	83.5
Armada 2	-40	115	Junction	7.8	9.2	17.8	7.8	68.1	46.9	7.8	58.6	56.4	7.8	50.1	64.9	7.8	22.2	92.8
MPM3686 (Max)	-40	125	Junction	3.8	125.0	0	3.8	97.3	27.7	3.8	85.3	39.7	3.8	77.0	48	3.8	50.6	74.4
MPM3650 (Max)	-40	125	Junction	0.8	104.8	20.2	0.8	77.4	47.6	0.8	65.1	59.9	0.8	56.6	68.4	0.8	30.5	94.5
MFM1714 (Max)	-55	125	Junction	2.1	123.4	1.6	2.1	101.1	23.9	2.1	87.8	37.2	2.1	72.7	52.3	2.1	51.9	73.1
LTM4650 (Max)	-40	125	Junction	3.9	109.4	15.6	3.9	80.5	44.5	3.9	68.1	56.9	3.9	59.6	65.4	3.9	33.4	91.6
DCM 3714 (Max)	-20	100	Case	32.5	119.5	-19.5	32.5	98.2	1.8	32.5	84.7	15.3	32.5	68.5	31.5	32.5	48.4	51.6
DCM 3714 (Max)	-20	125	Junction	32.5	161.9	-36.9	32.5	140.3	-15.3	32.5	127.3	-2.3	32.5	112.0	13	32.5	91.6	33.4

85°C Ambient, 60°C Coolant Predicted Power

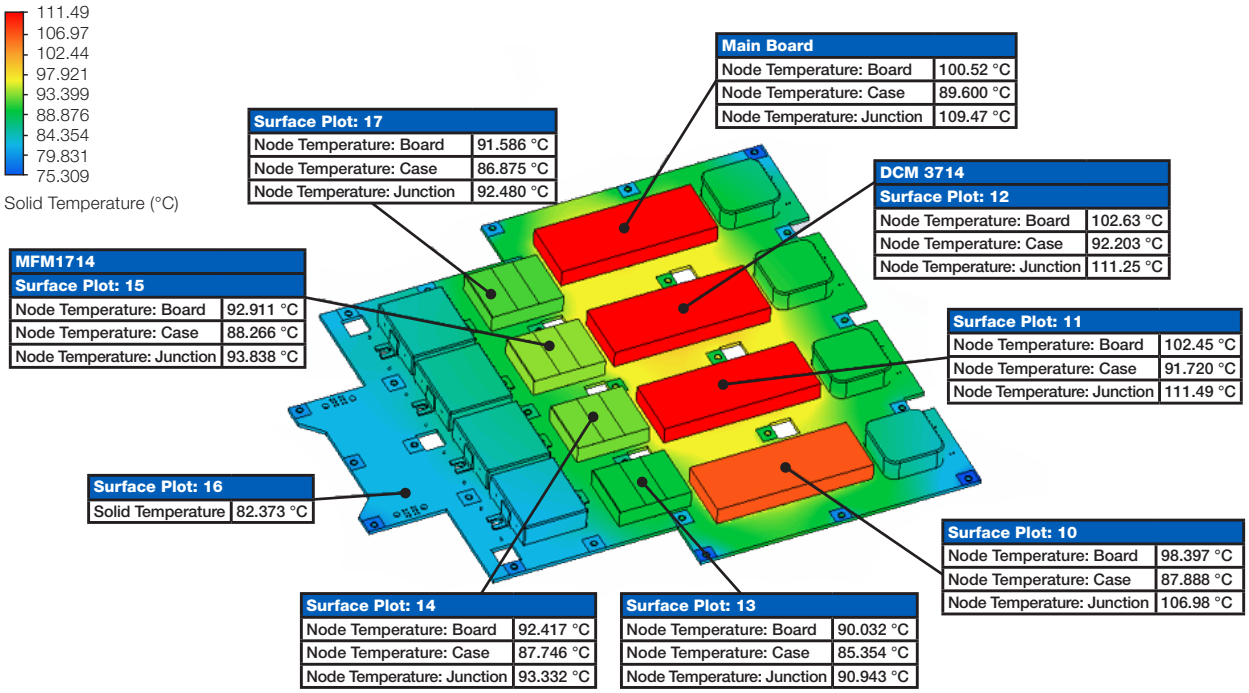
Board Surface Temperature Plot

85°C, Sea Level



Bottom Side Components Temperature Plot

85°C, Sea Level

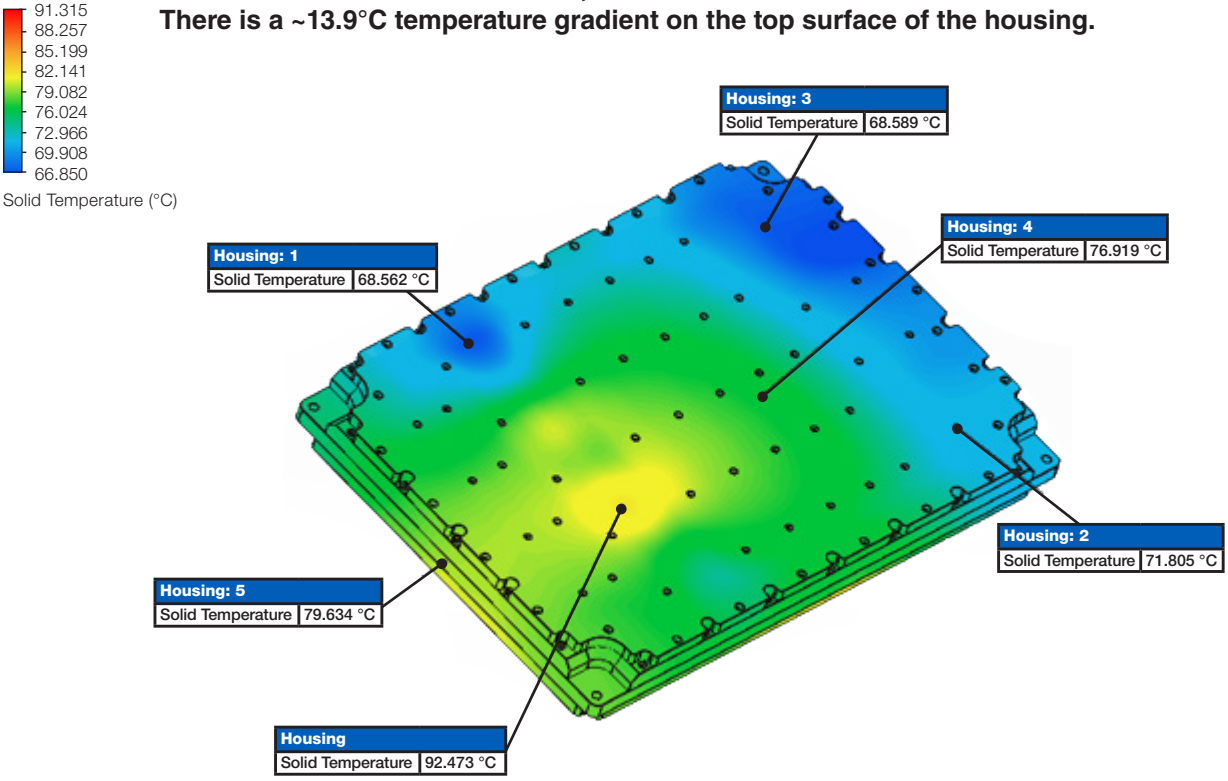


85°C Ambient, 60°C Coolant Predicted Power

Housing Top Surface Temperature Plot

85°C, Sea Level

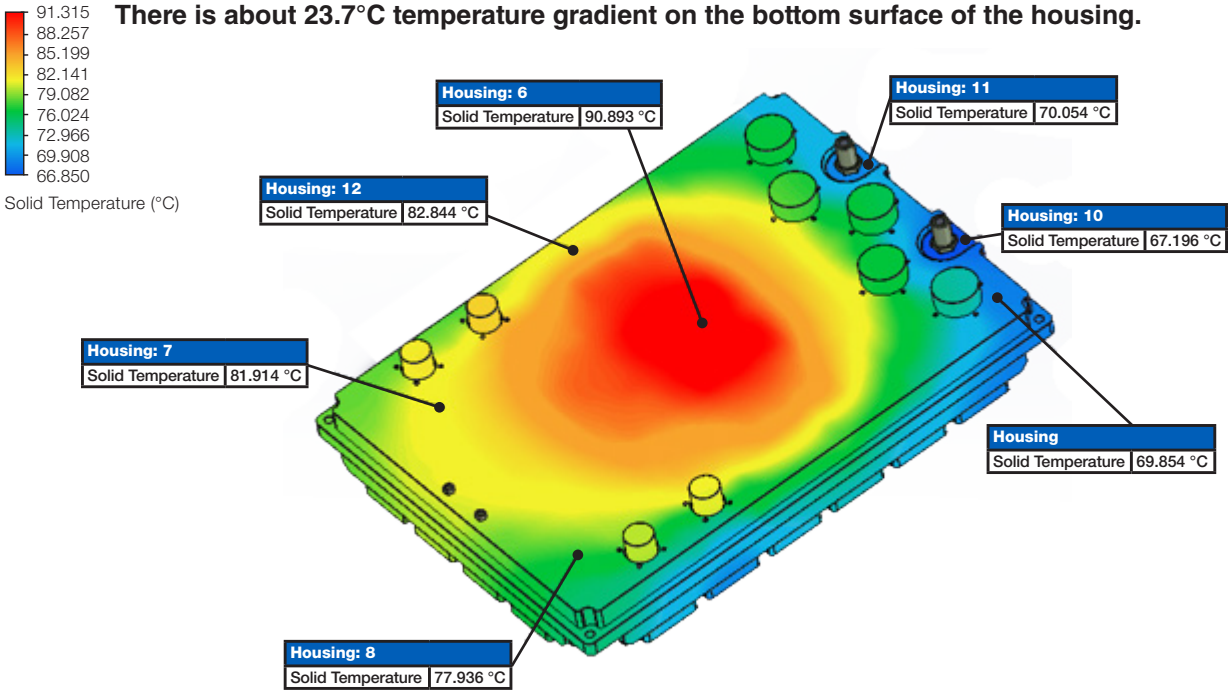
There is a ~13.9°C temperature gradient on the top surface of the housing.



Hosuing Bottom Surface Temperature Plot

85°C, Sea Level

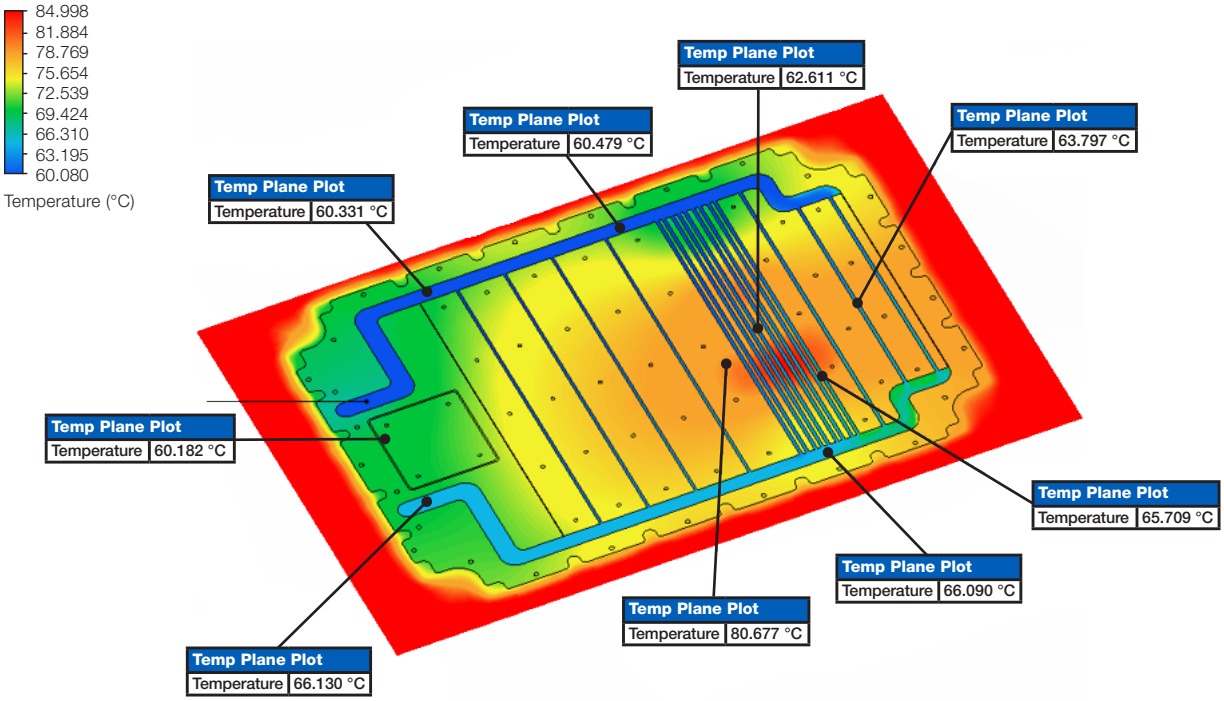
There is about 23.7°C temperature gradient on the bottom surface of the housing.



85°C Ambient, 60°C Coolant Predicted Power

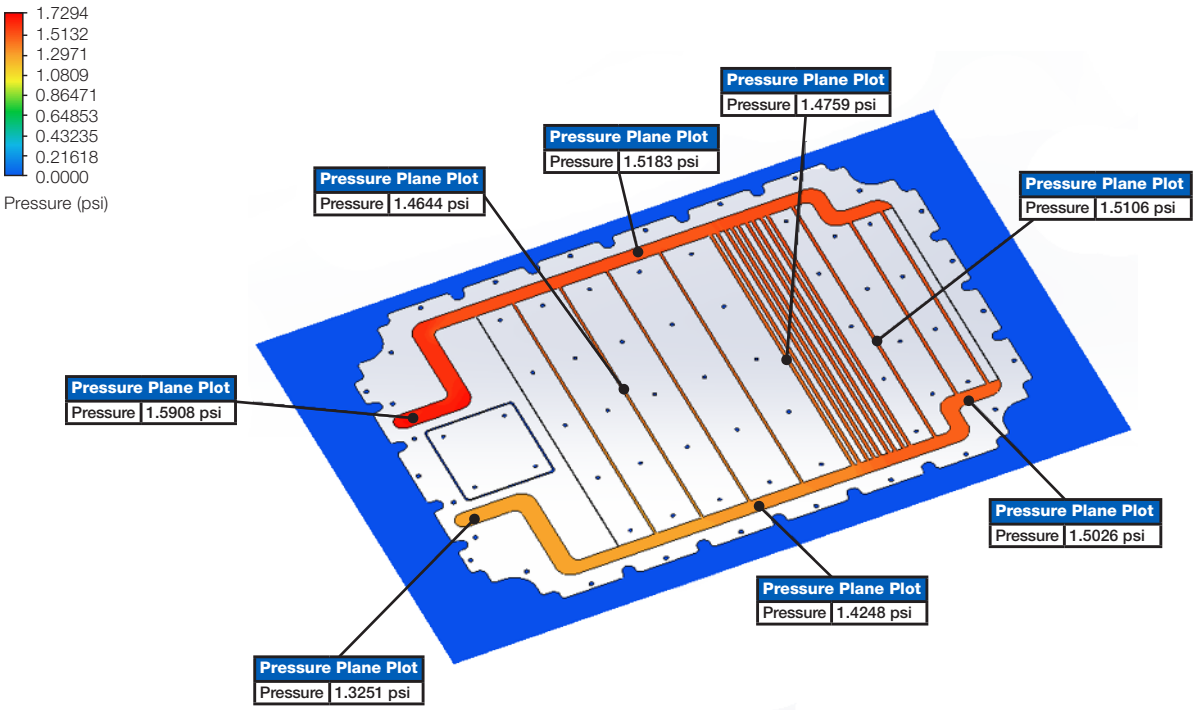
Cold Plate Channel Temperature Cutplane

85°C, Sea Level



Cold Plate Channel Pressure Plot

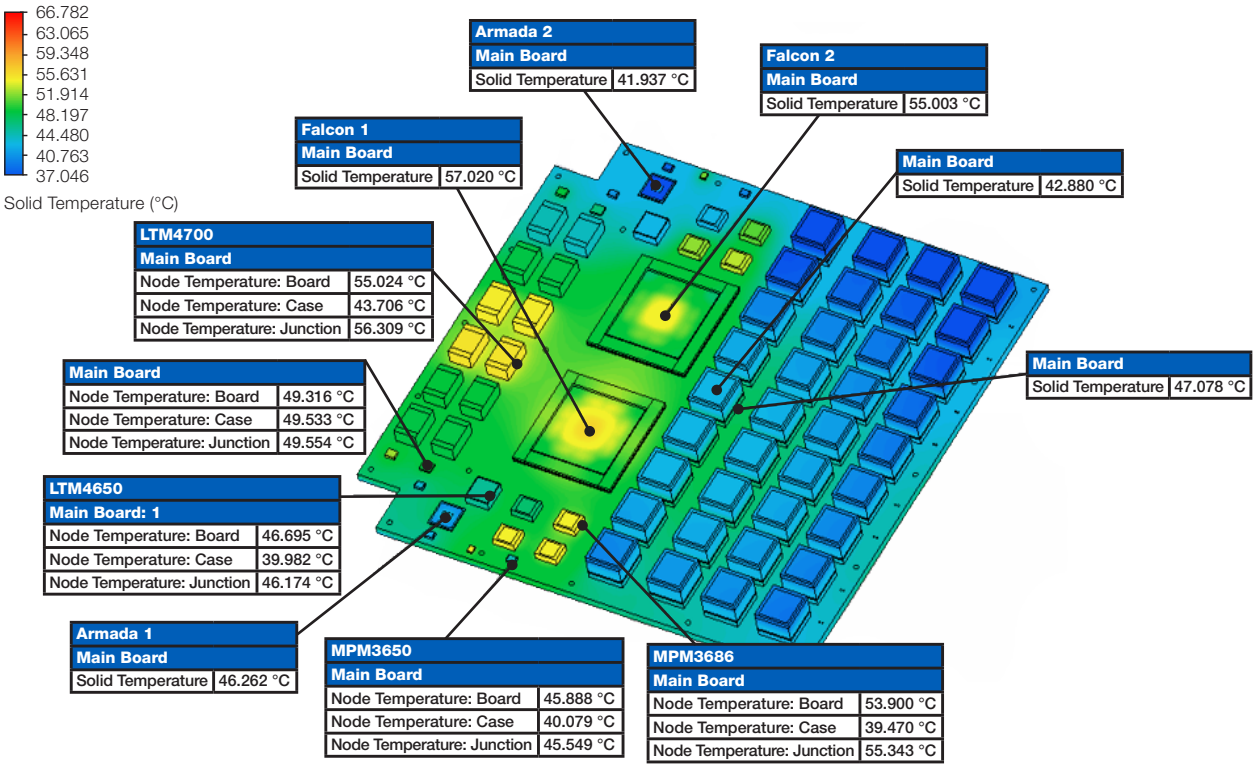
85°C, Sea Level



23°C Ambient, 21.1°C Coolant Predicted Power

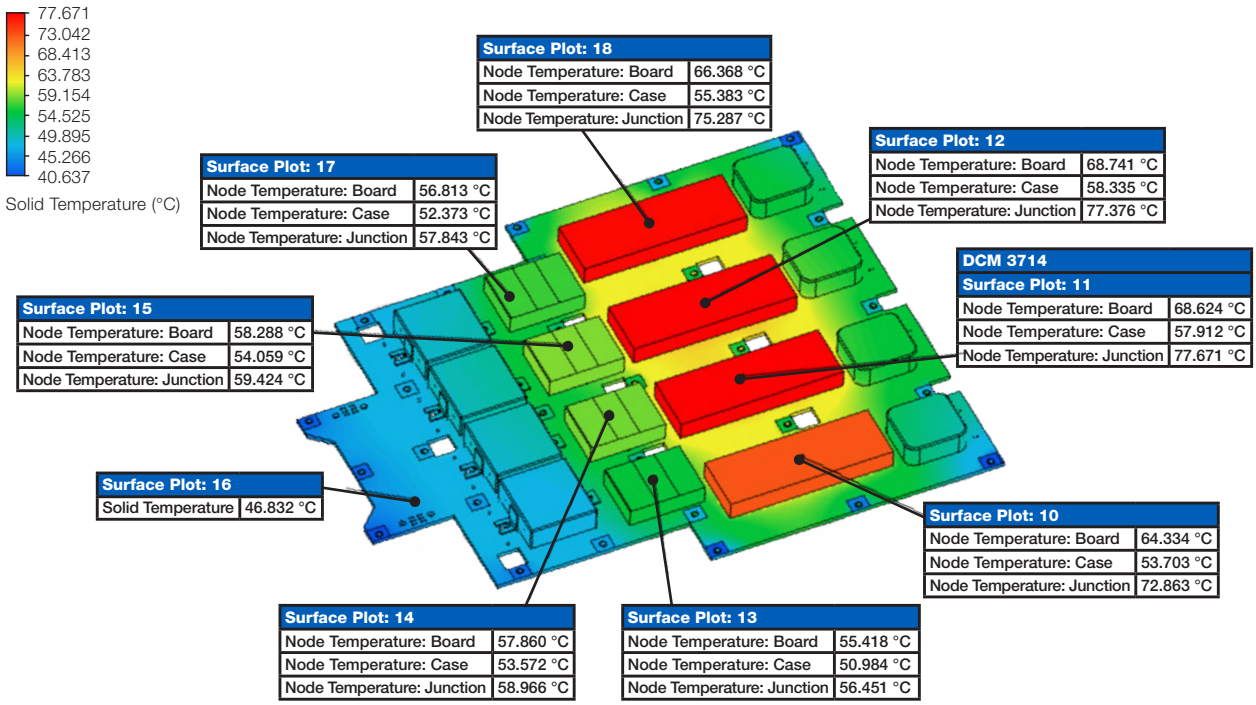
Board Surface Temperature Plot

23°C, Sea Level



Bottom Side Components Temperature Plot

23°C, Sea Level

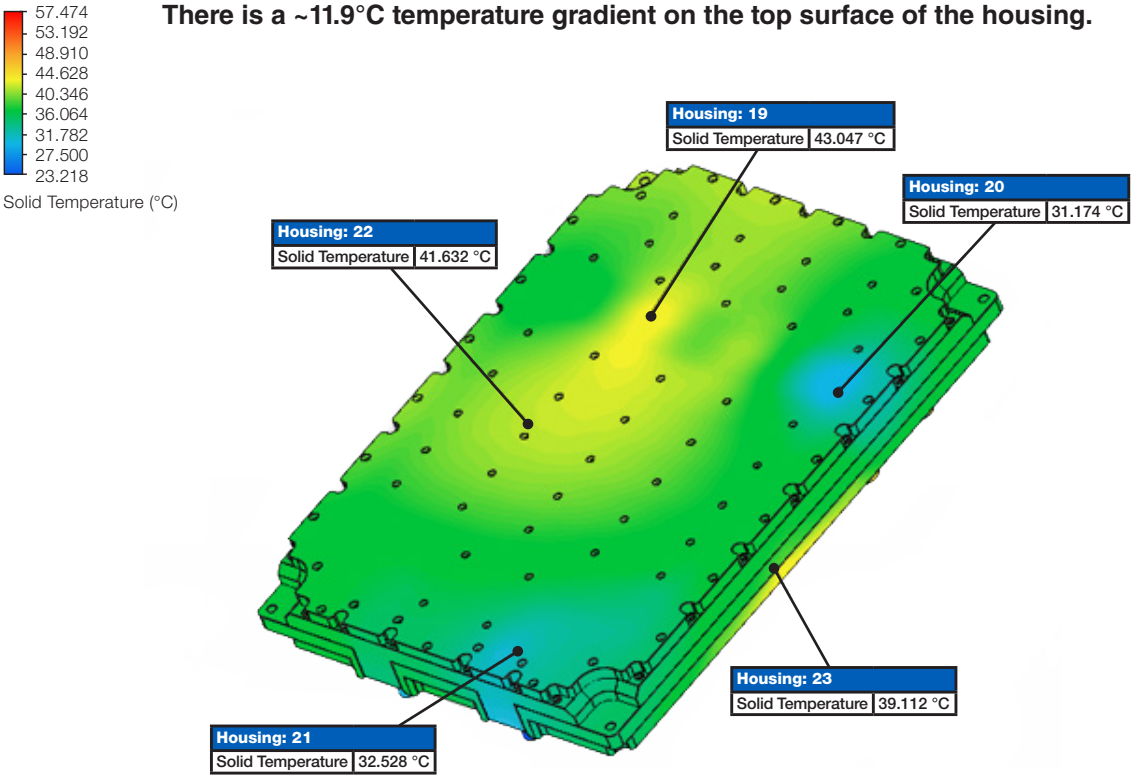


23°C Ambient, 21.1°C Coolant Predicted Power

Housing Top Surface Temperature Plot

23°C, Sea Level

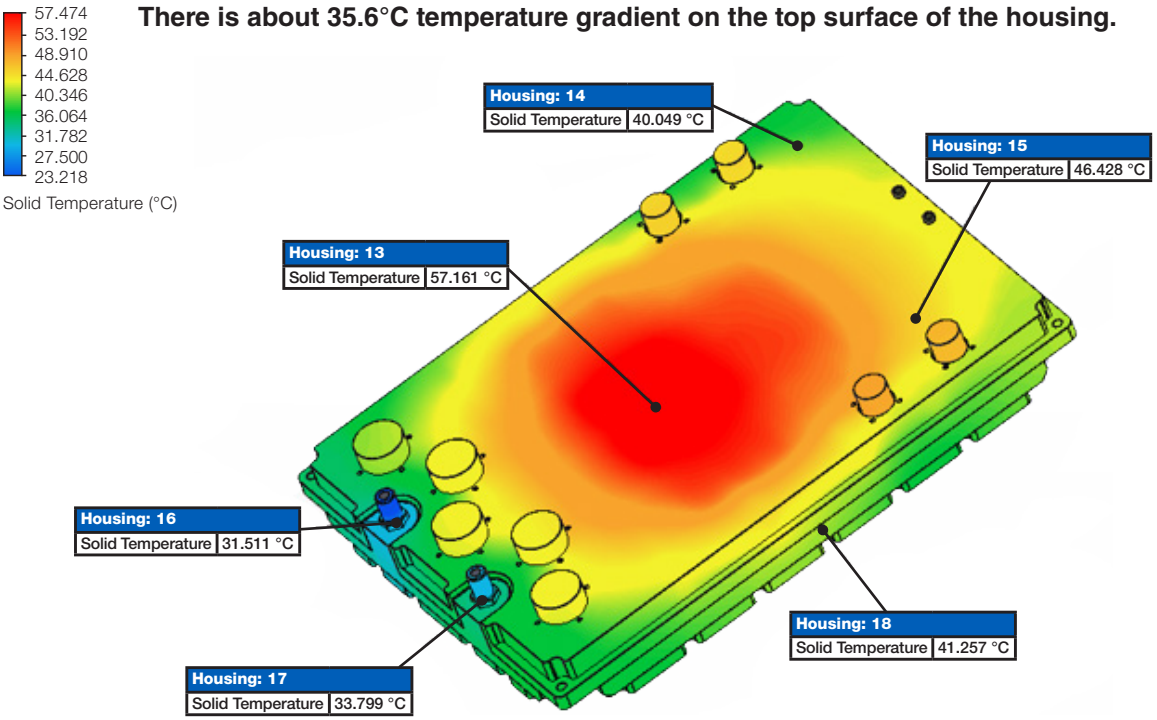
There is a ~11.9°C temperature gradient on the top surface of the housing.



Housing Bottom Surface Temperature Plot

23°C, Sea Level

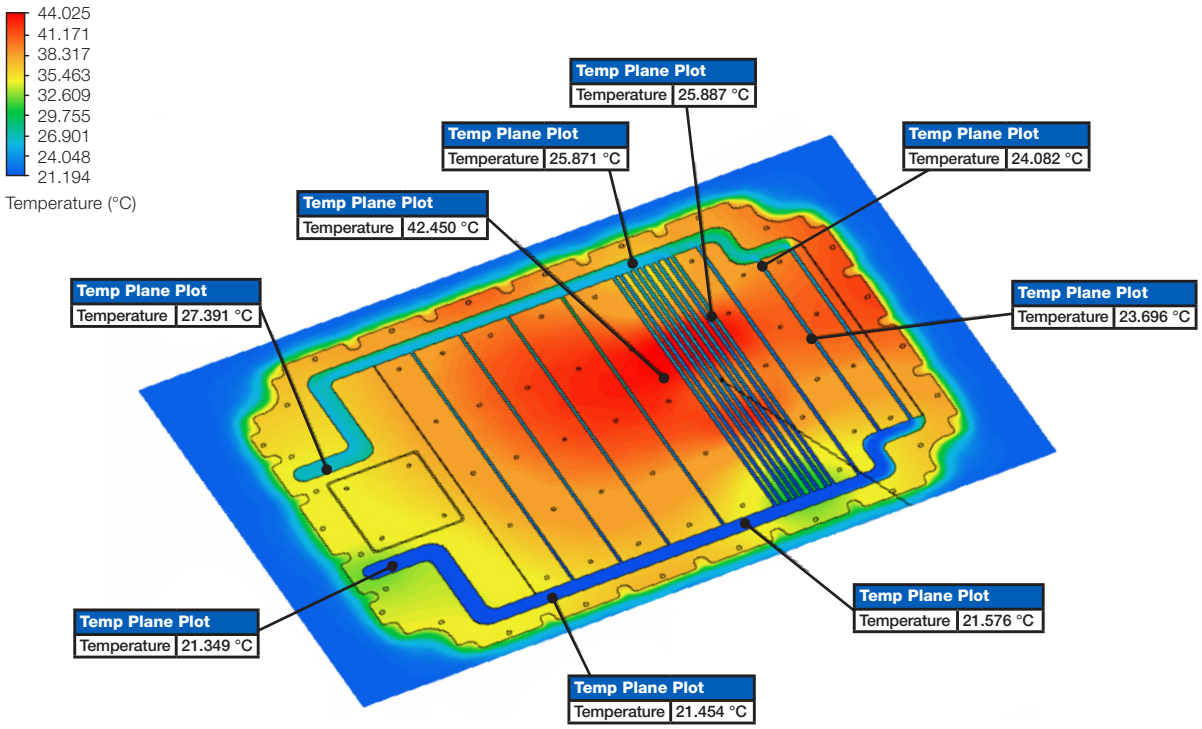
There is about 35.6°C temperature gradient on the top surface of the housing.



23°C Ambient, 21.1°C Coolant Predicted Power

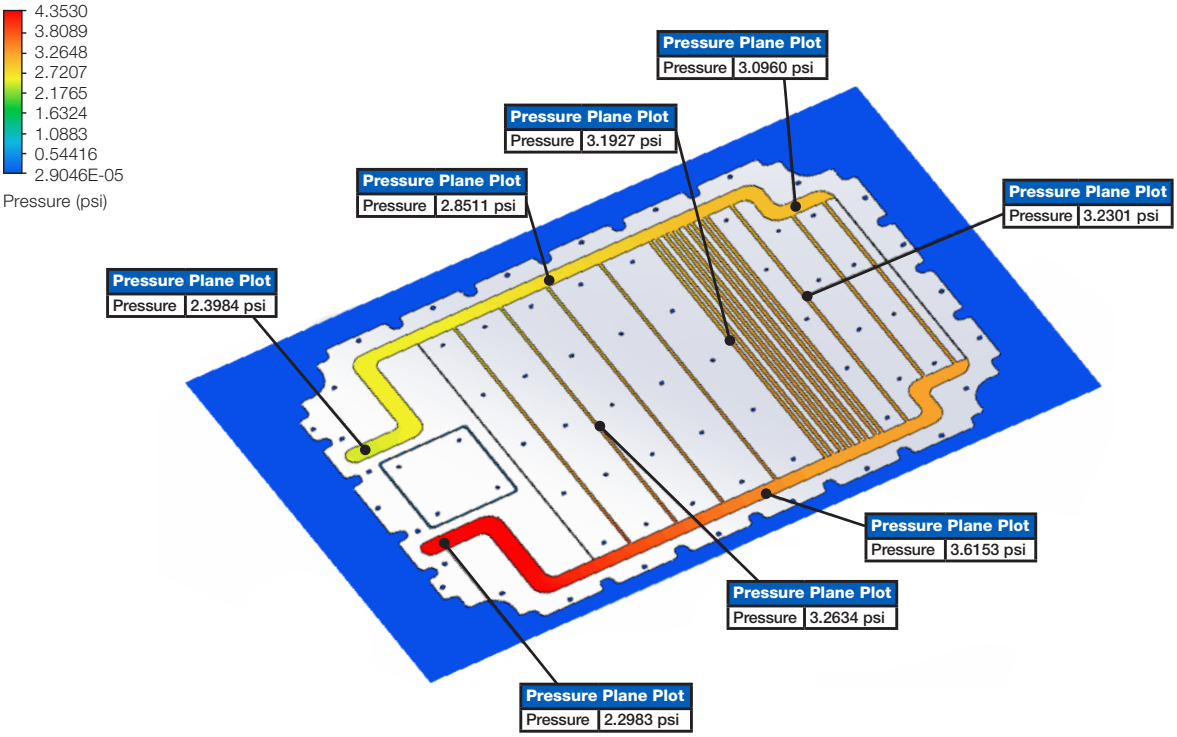
Cold Plate Channel Temperature Cutplane

23°C, Sea Level



Cold Plate Channel Pressure Cutplane

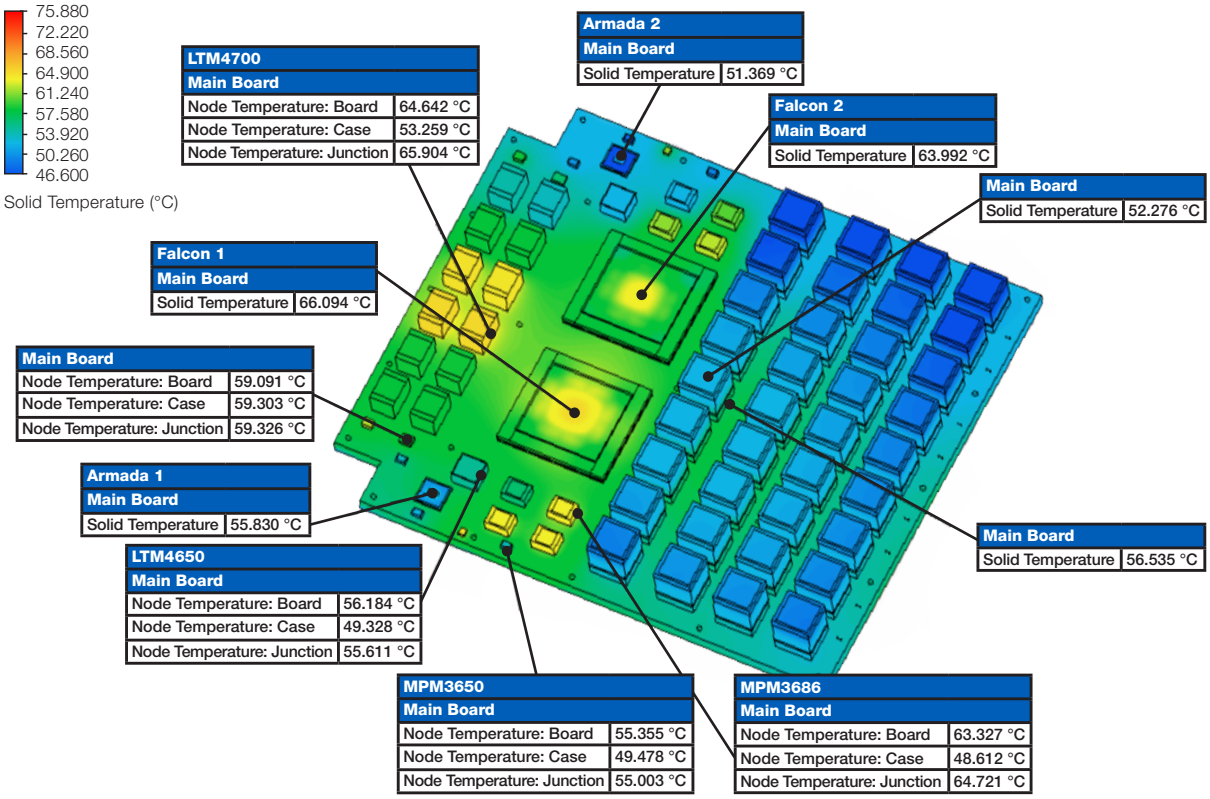
23°C, Sea Level



85°C Ambient, 30°C Coolant Predicted Power

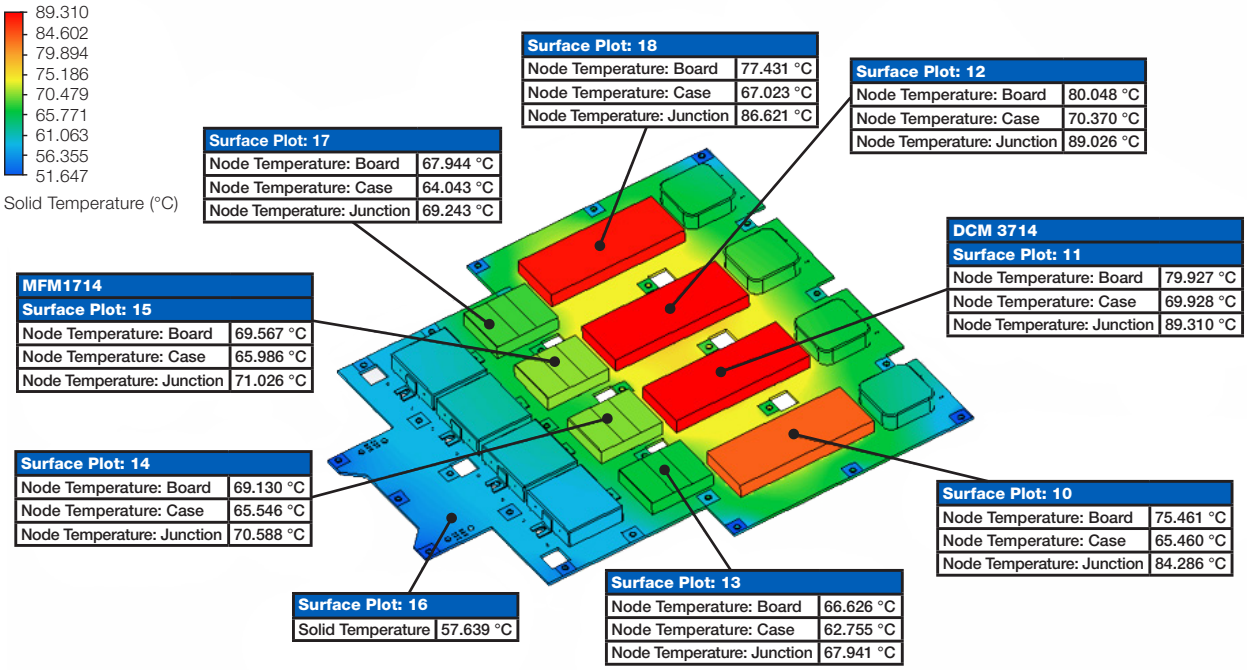
Board Surface Temperature Plot

85°C, Sea Level



Bottom Side Components Temperature Plot

85°C, Sea Level

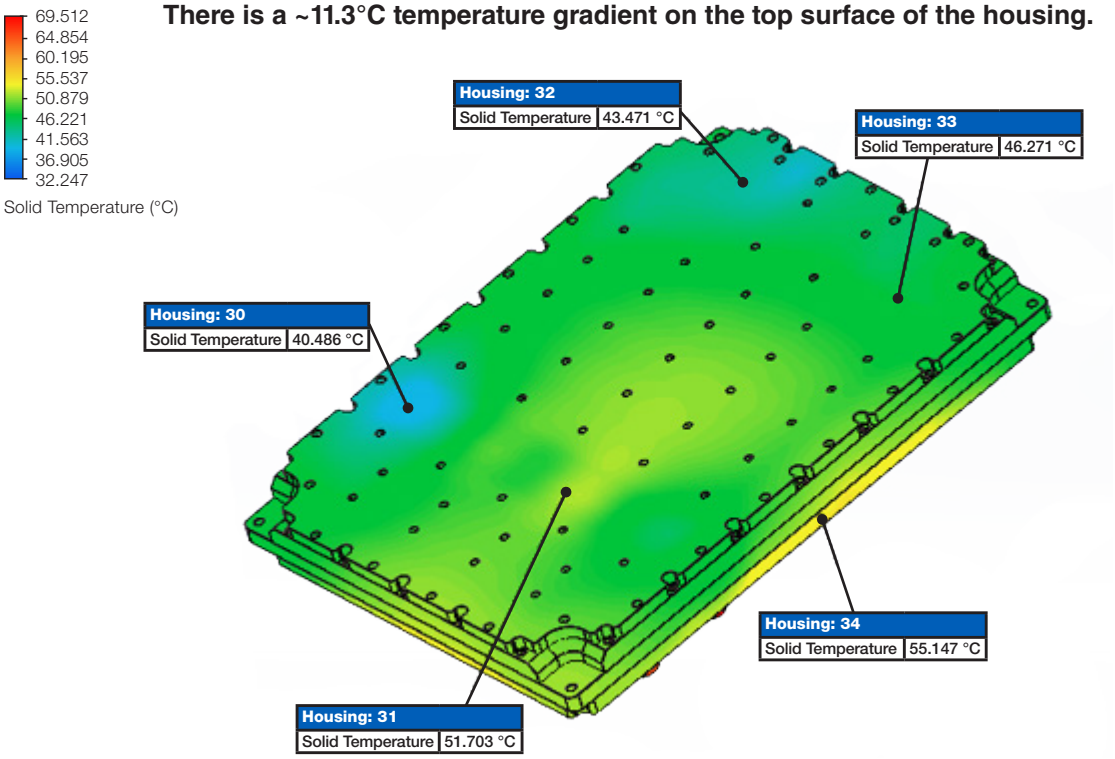


85°C Ambient, 30°C Coolant Predicted Power

Housing Top Surface Temperature Plot

85°C, Sea Level

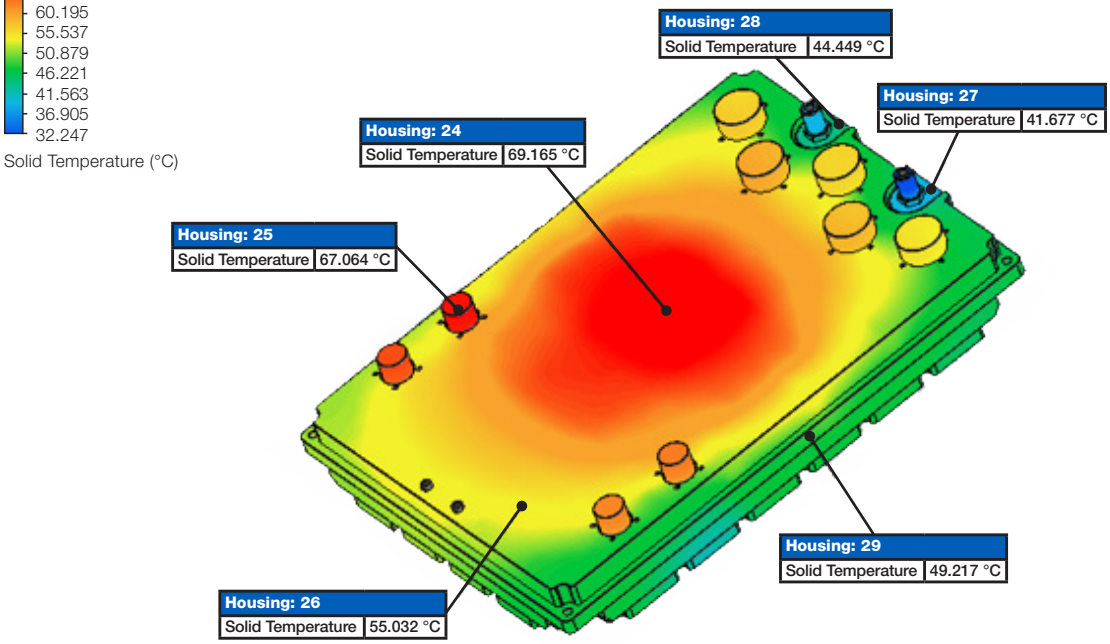
There is a ~11.3°C temperature gradient on the top surface of the housing.



Hosuing Bottom Surface Temperature Plot

85°C, Sea Level

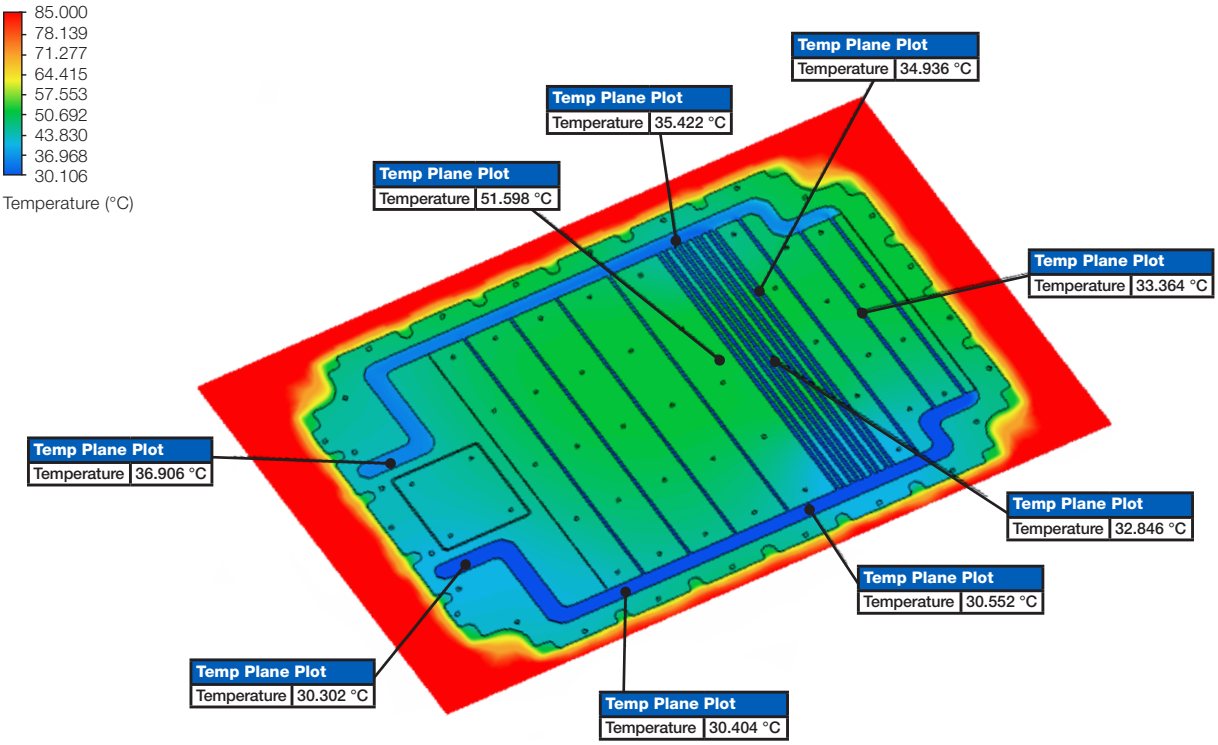
There is about 27.5°C temperature gradient on the top surface of the housing.



85°C Ambient, 30°C Coolant Predicted Power

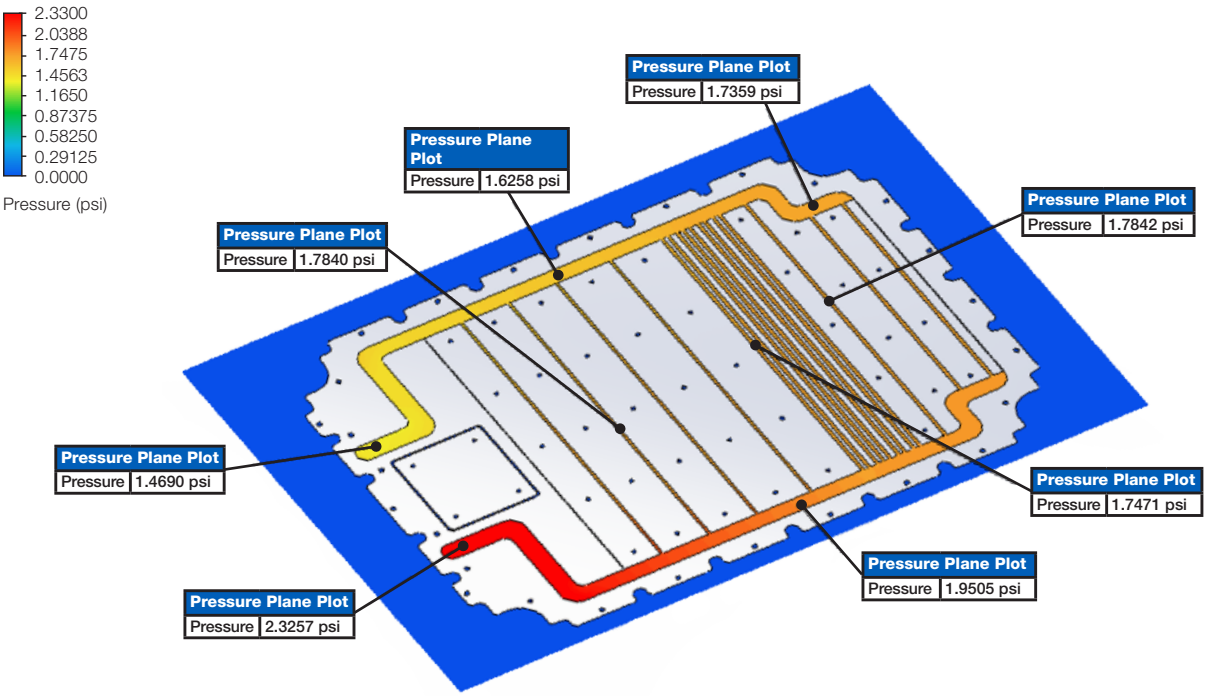
Cold Plate Channel Temperature Cutplane

85°C, Sea Level



Cold Plate Channel Pressure Cutplane

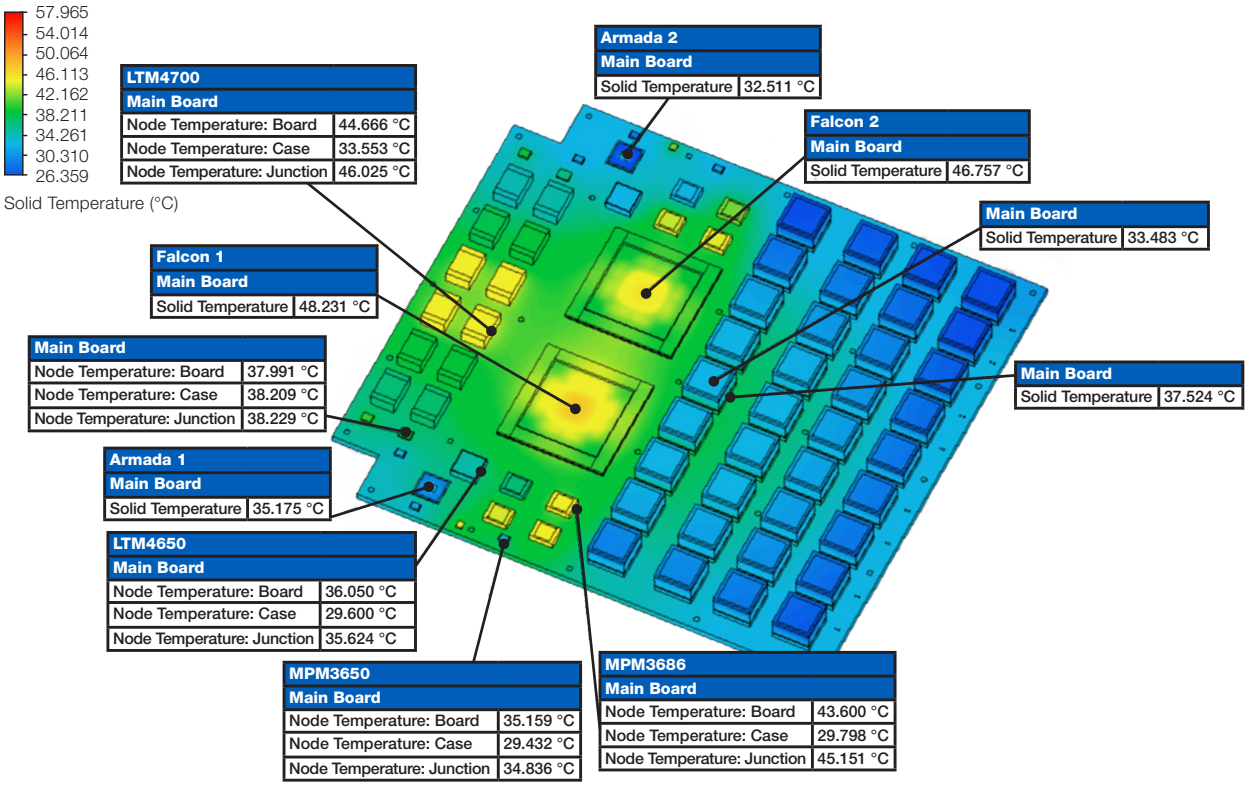
85°C, Sea Level



-40°C Ambient, 15°C Coolant Predicted Power

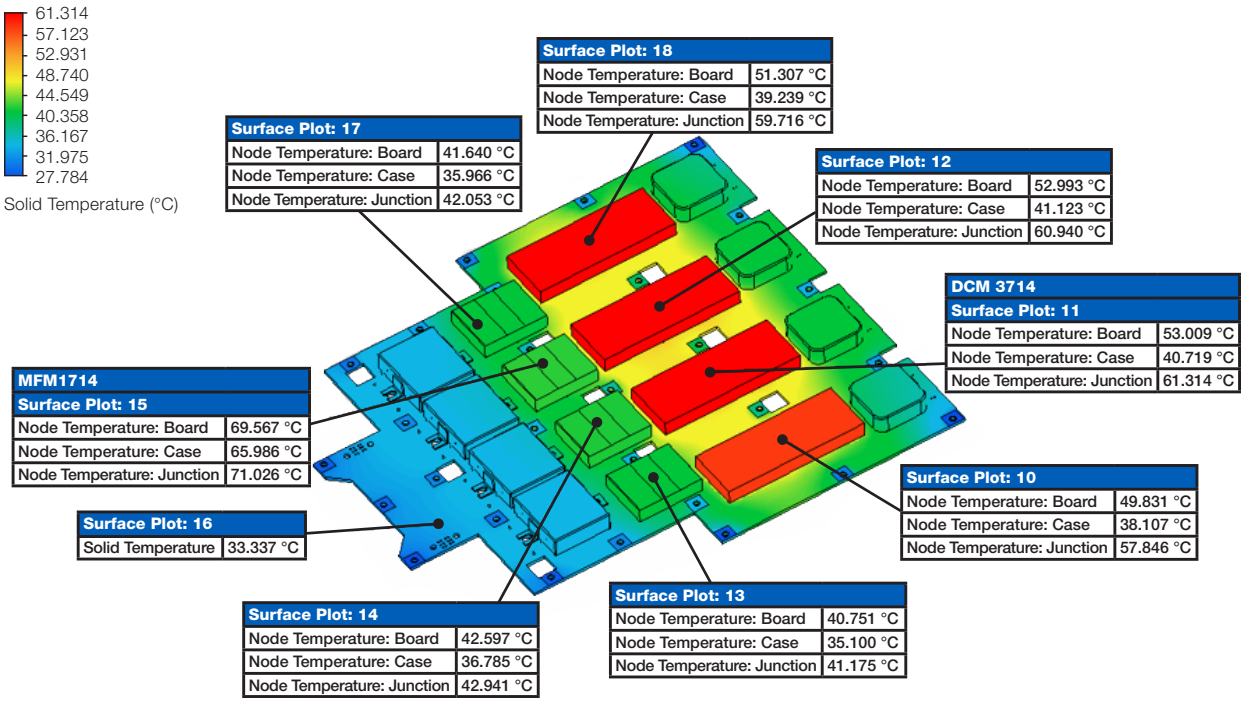
Board Surface Temperature Plot

-40°C, Sea Level



Bottom Side Components Temperature Plot

-40°C, Sea Level

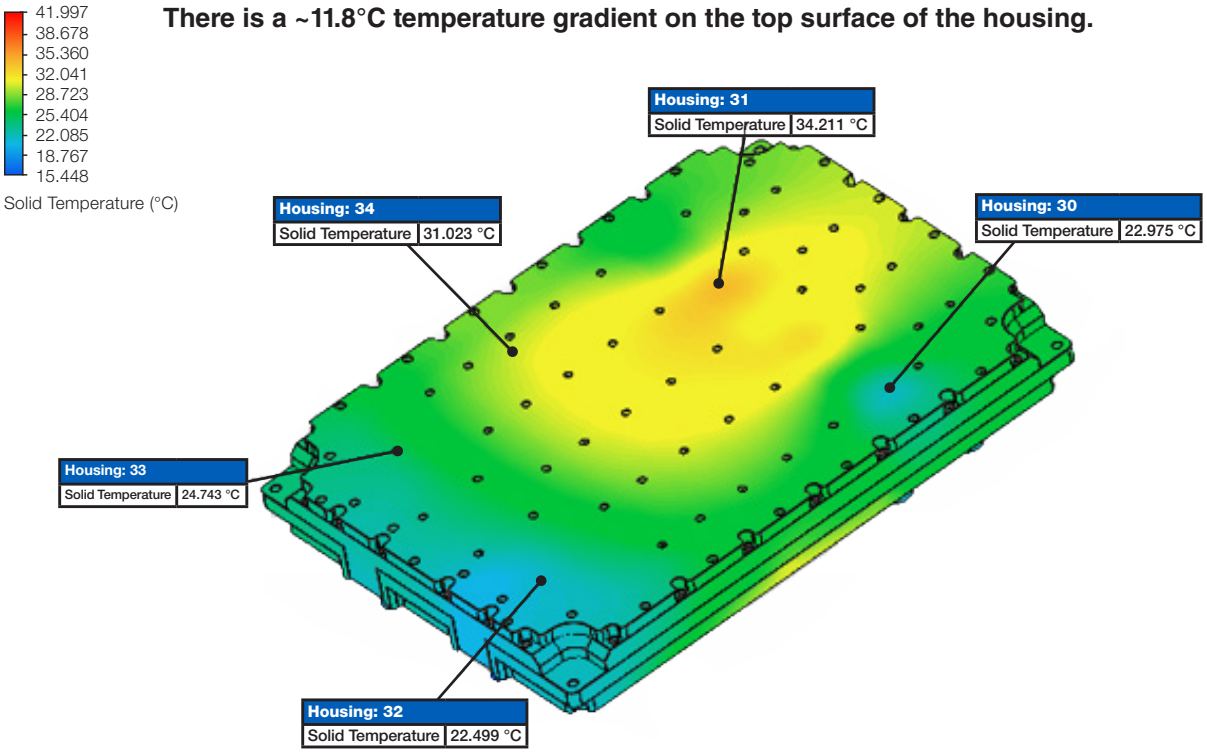


-40°C Ambient, 15°C Coolant Predicted Power

Housing Top Surface Temperature Cutplane

-40°C, Sea Level

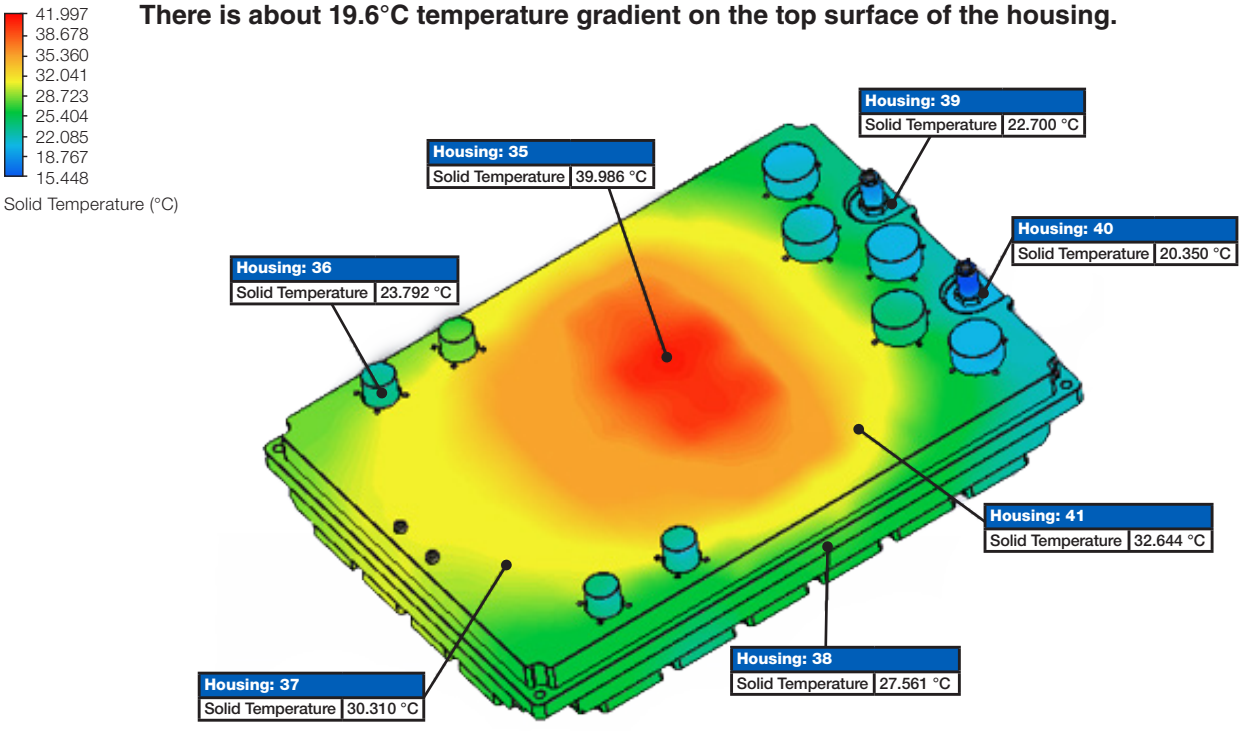
There is a ~11.8°C temperature gradient on the top surface of the housing.



Housing Bottom Surface Temperature Cutplane

-40°C, Sea Level

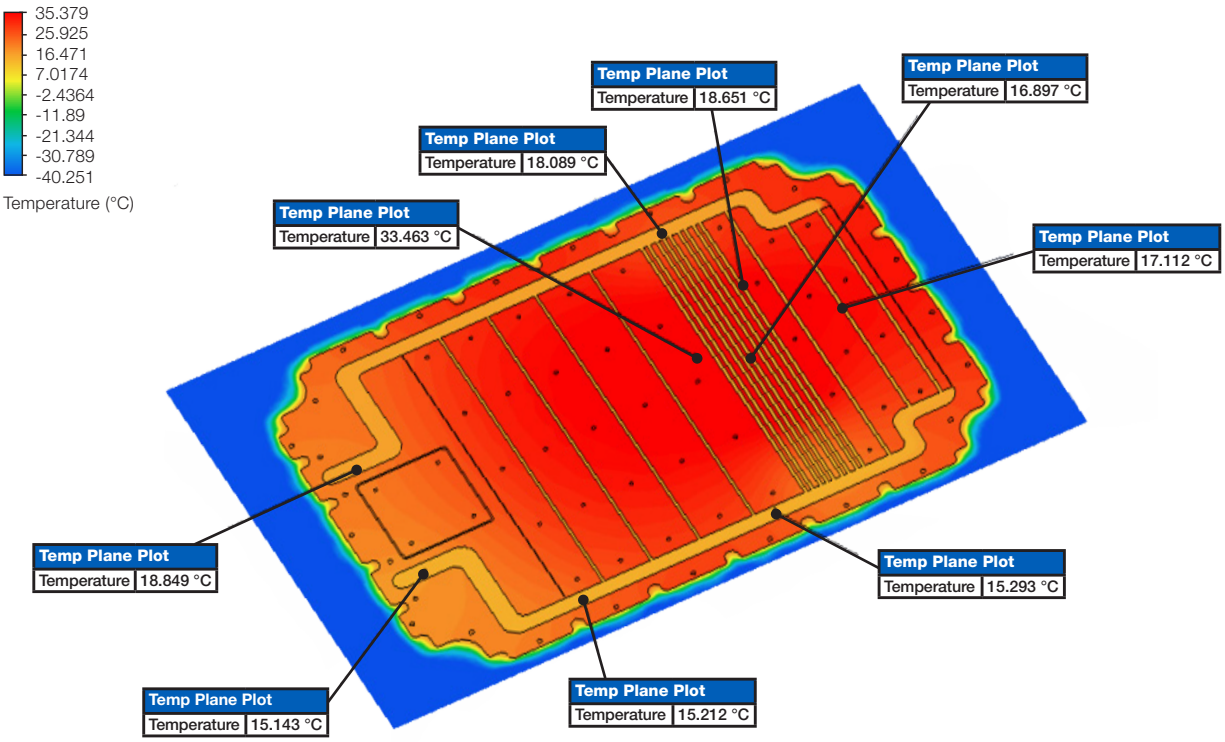
There is about 19.6°C temperature gradient on the top surface of the housing.



-40°C Ambient, 15°C Coolant Predicted Power

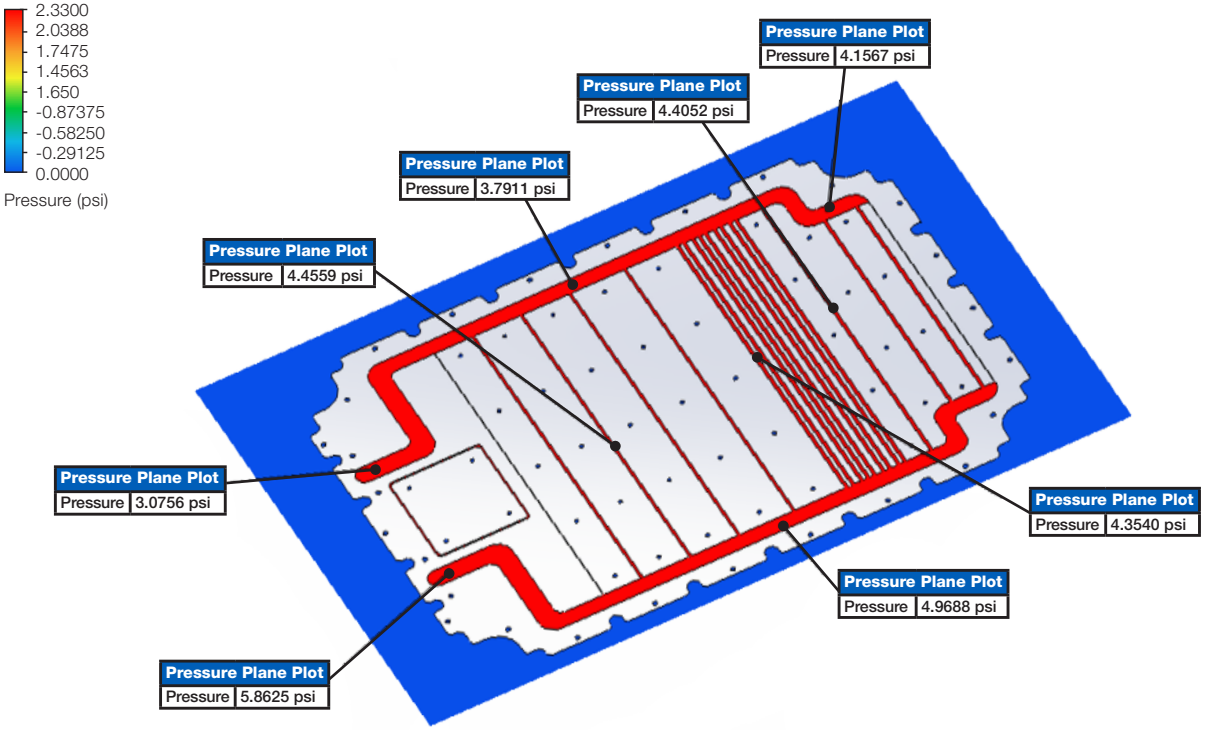
Cold Plate Temperature Cutplane

-40°C, Sea Level



Cold Plate Channel Pressure Cutplane

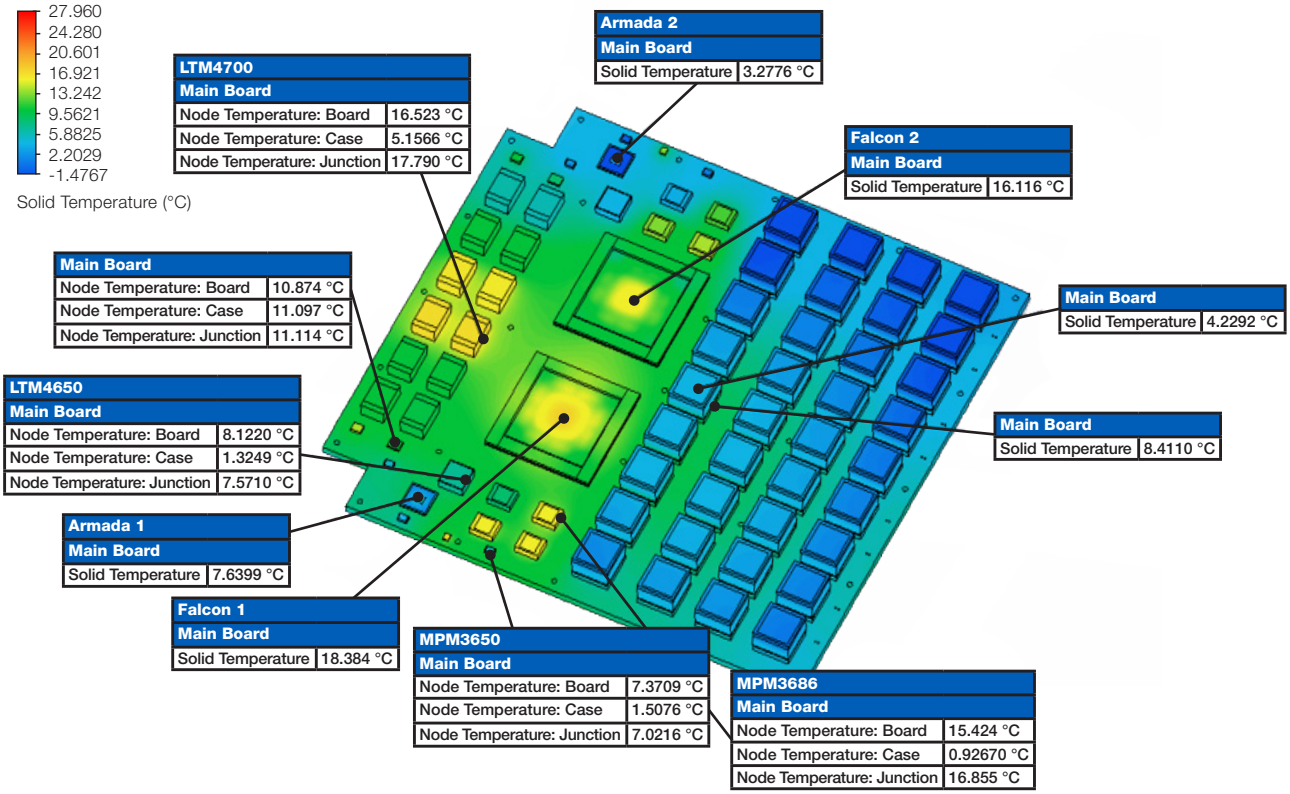
-40°C, Sea Level



-40°C Ambient, -17.77°C Coolant Predicted Power

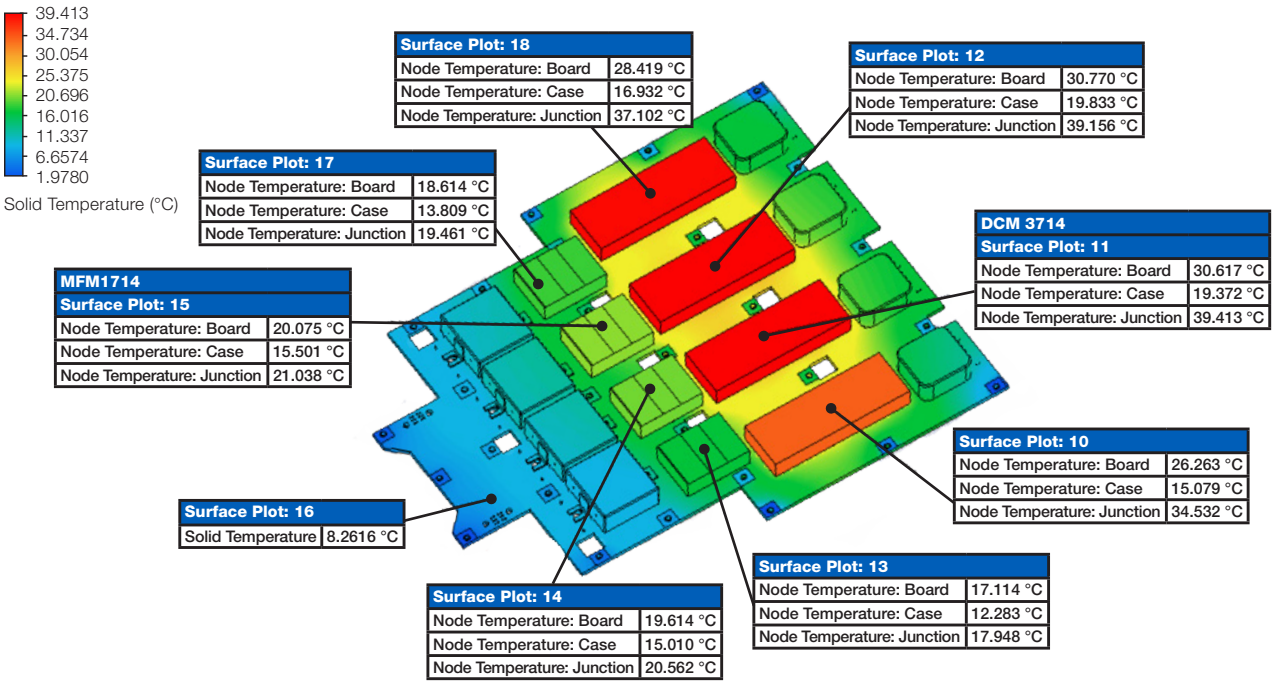
Board Surface Temperature Plot

-40°C, Sea Level



Housing Bottom Surface Temperature Cutplane

-40°C, Sea Level

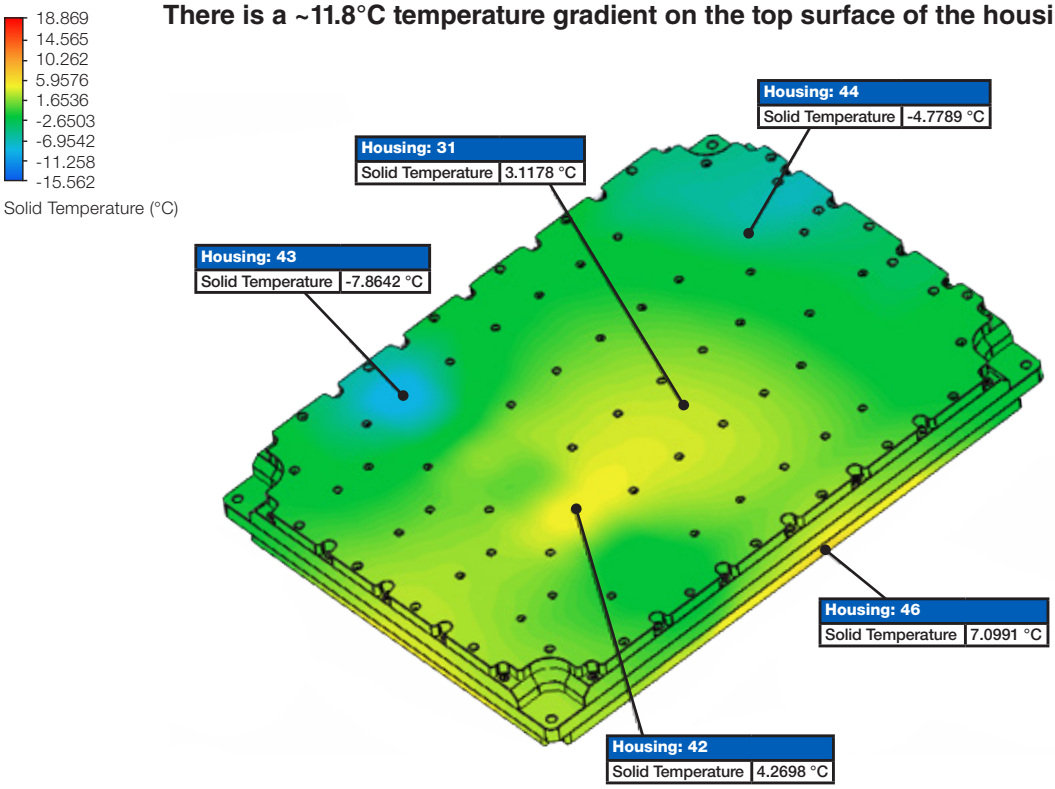


-40°C Ambient, 15°C Coolant Predicted Power

Housing Top Surface Temperature Plot

-40°C, Sea Level

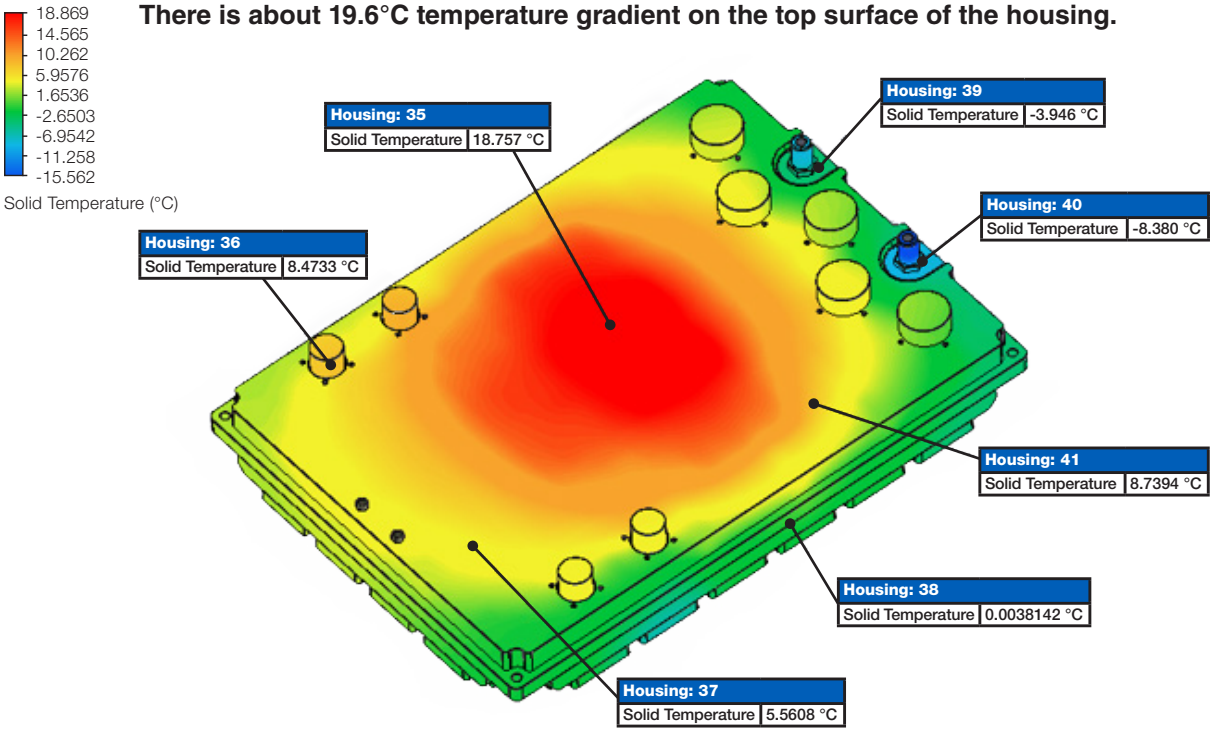
There is a ~11.8°C temperature gradient on the top surface of the housing.



Housing Bottom Surface Temperature Plot

-40°C, Sea Level

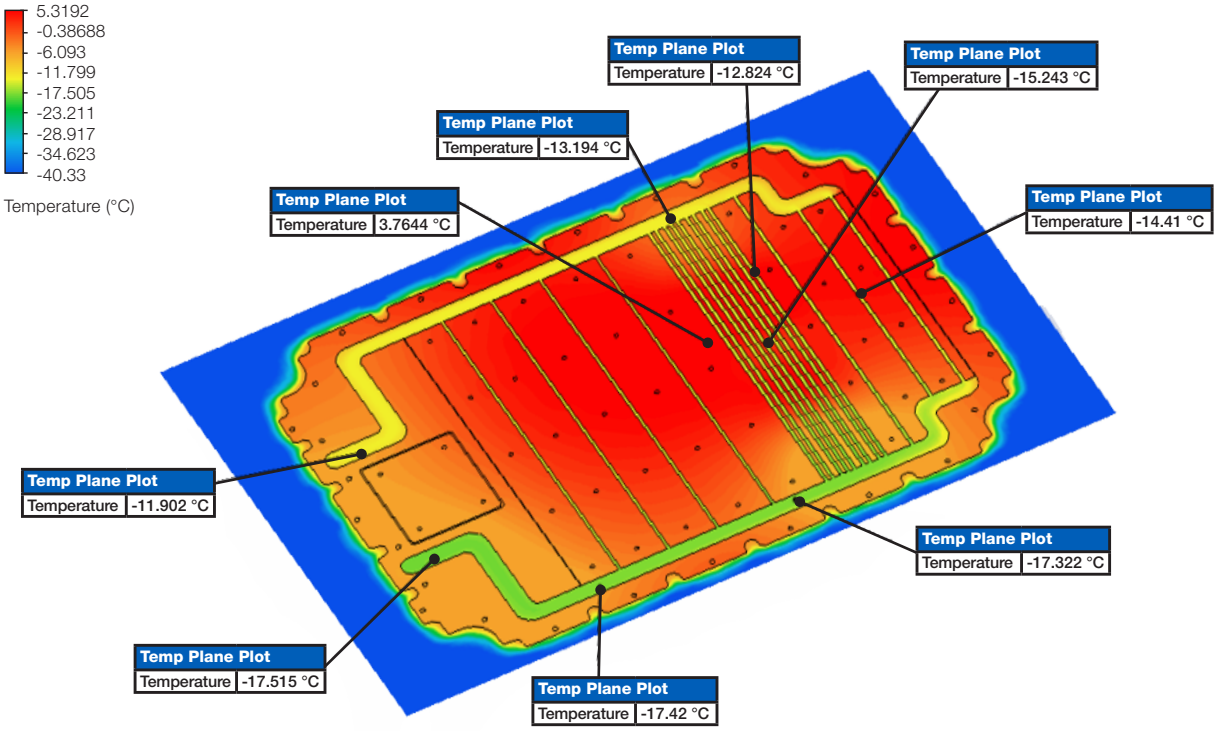
There is about 19.6°C temperature gradient on the top surface of the housing.



-40°C Ambient, -17.77°C Coolant Predicted Power

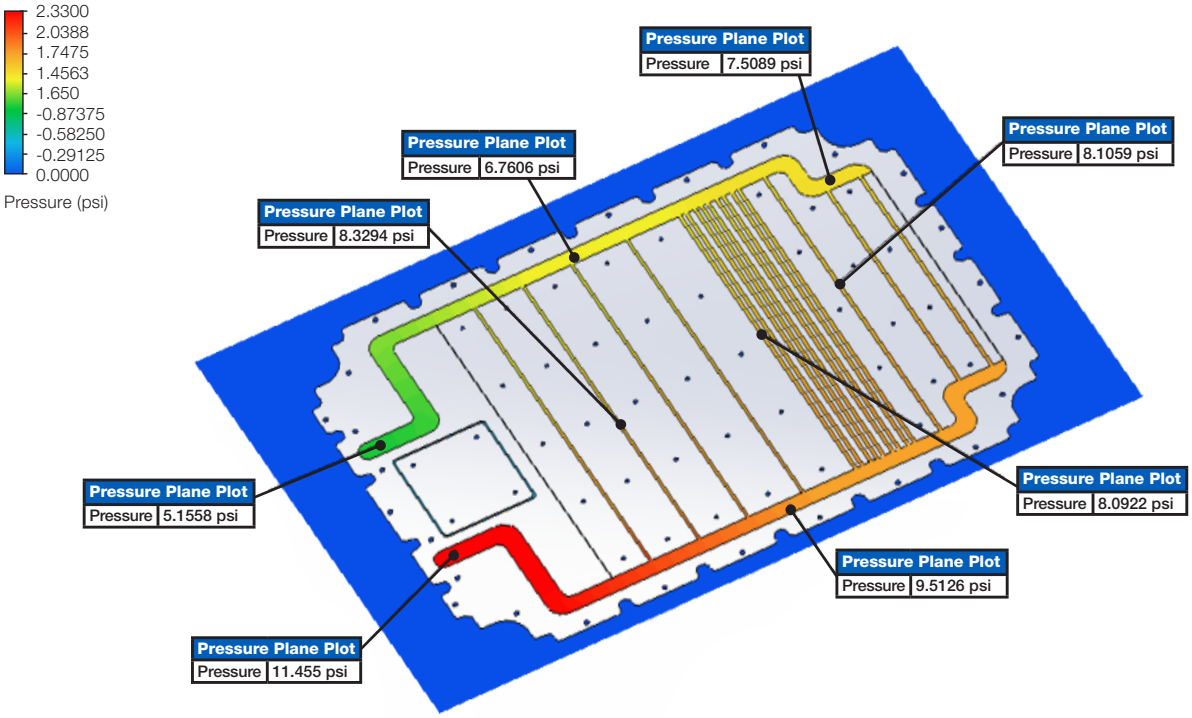
Cold Plate Channel Temperature Cutplane

-40°C, Sea Level



Cold Plate Channel Pressure Cutplane

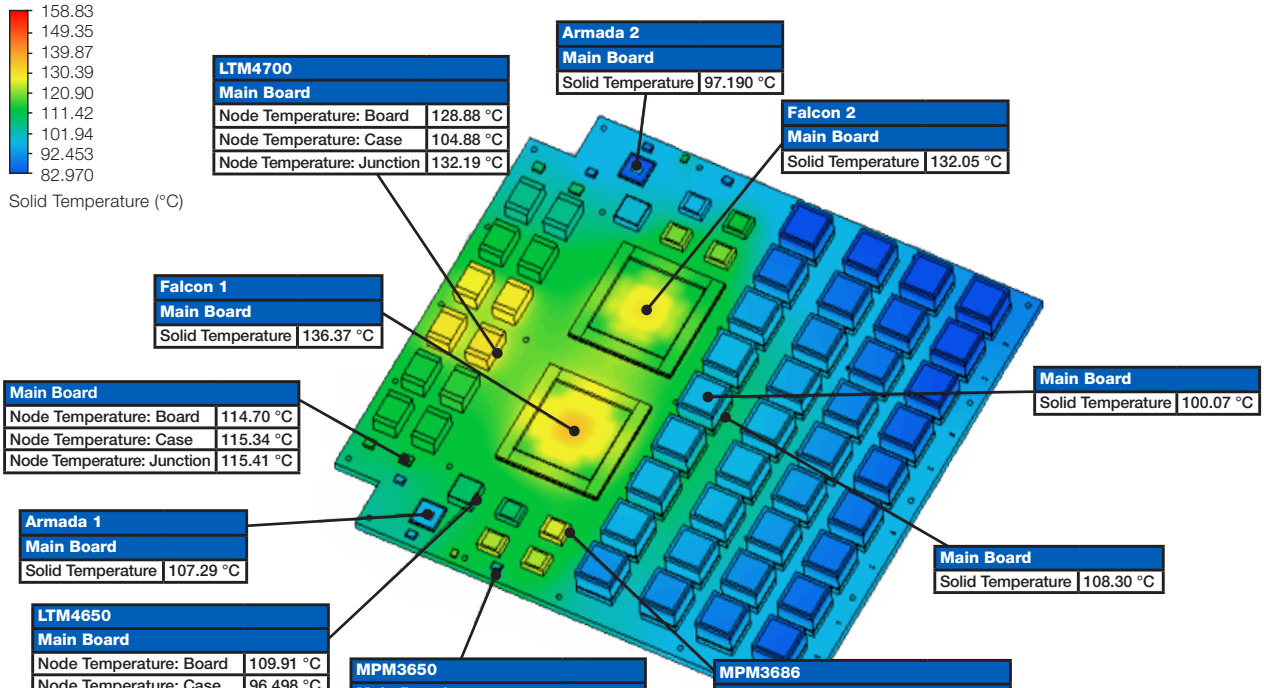
-40°C, Sea Level



Worst Case - 85°C Ambient, 60°C Coolant WC Power

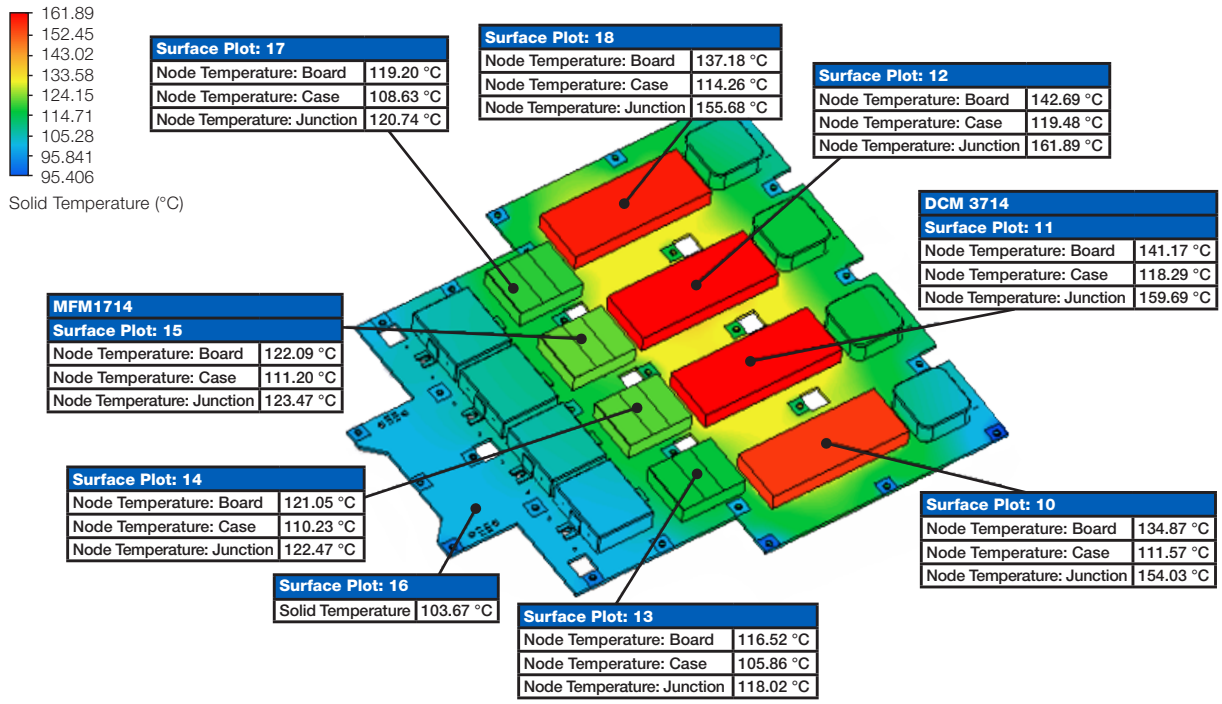
Housing Top Surface Temperature Plot

85°C, Sea Level



Housing Bottom Surface Temperature Plot

85°C, Sea Level

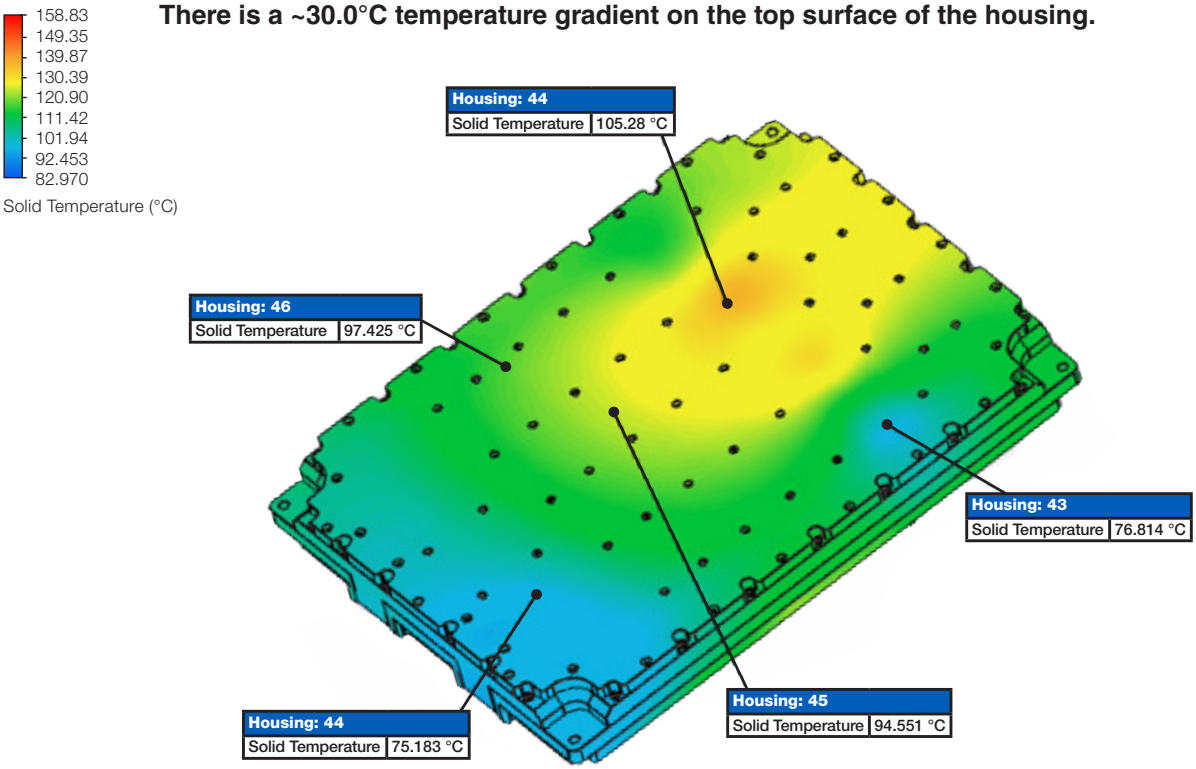


Worst Case - 85°C Ambient, 60°C Coolant WC Power

Cold Plate Channel Temperature Cutplane

85°C, Sea Level

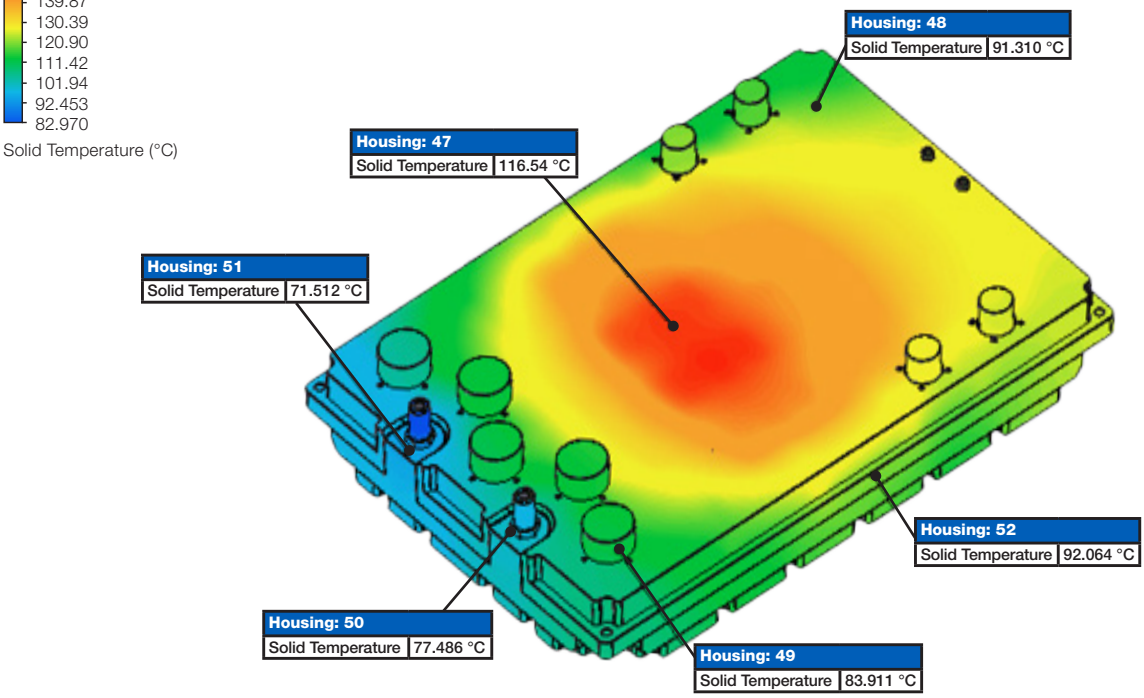
There is a ~30.0°C temperature gradient on the top surface of the housing.



Cold Plate Channel Pressure Cutplane

85°C, Sea Level

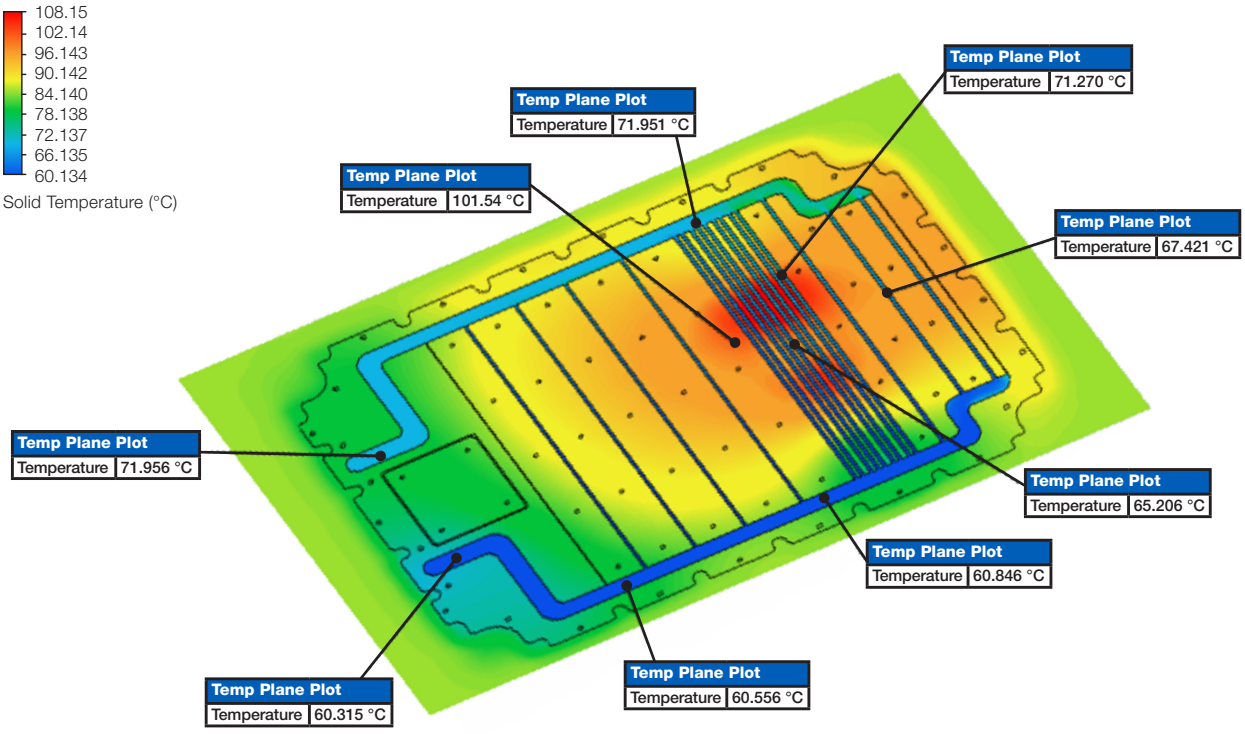
There is about 40°C temperature gradient on the top surface of the housing.



Worst Case - 85°C Ambient, 60°C Coolant WC Power

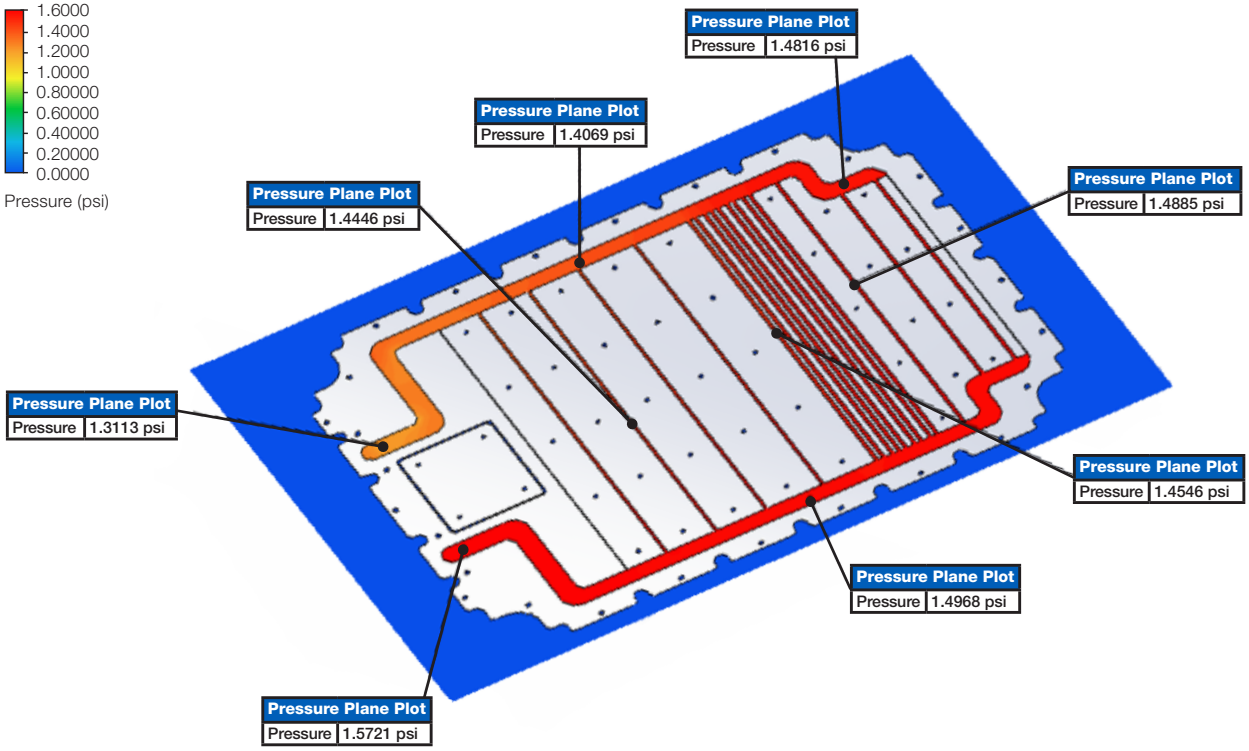
Cold Plate Channel Temperature Cutplane

85°C, Sea Level



Cold Plane Channel Pressure Cutplane

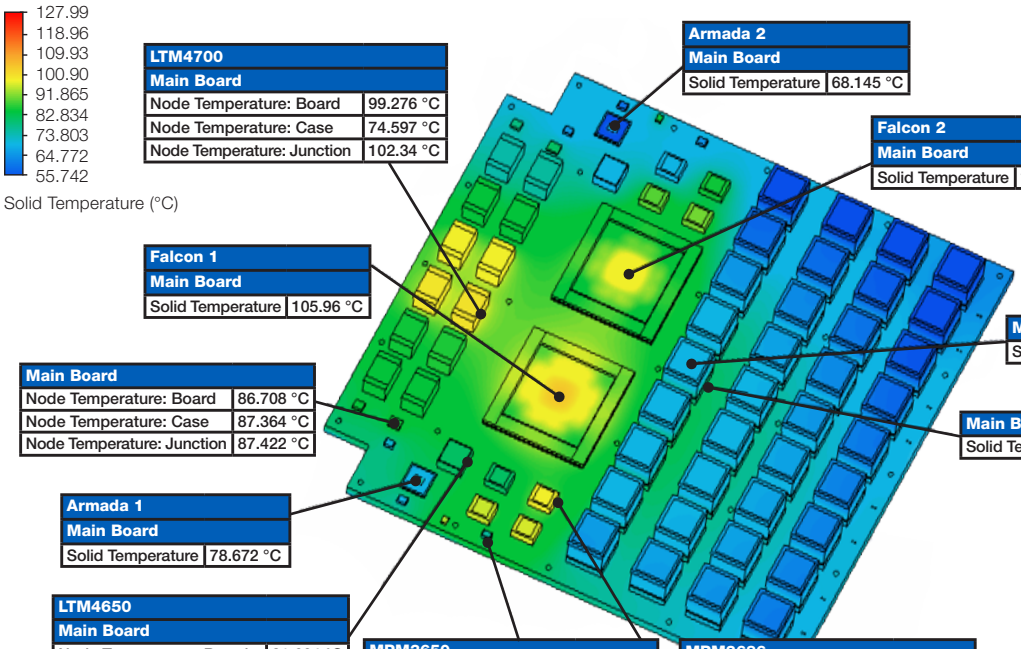
85°C, Sea Level



Worst Case - 85°C Ambient, 30°C Coolant WC Power

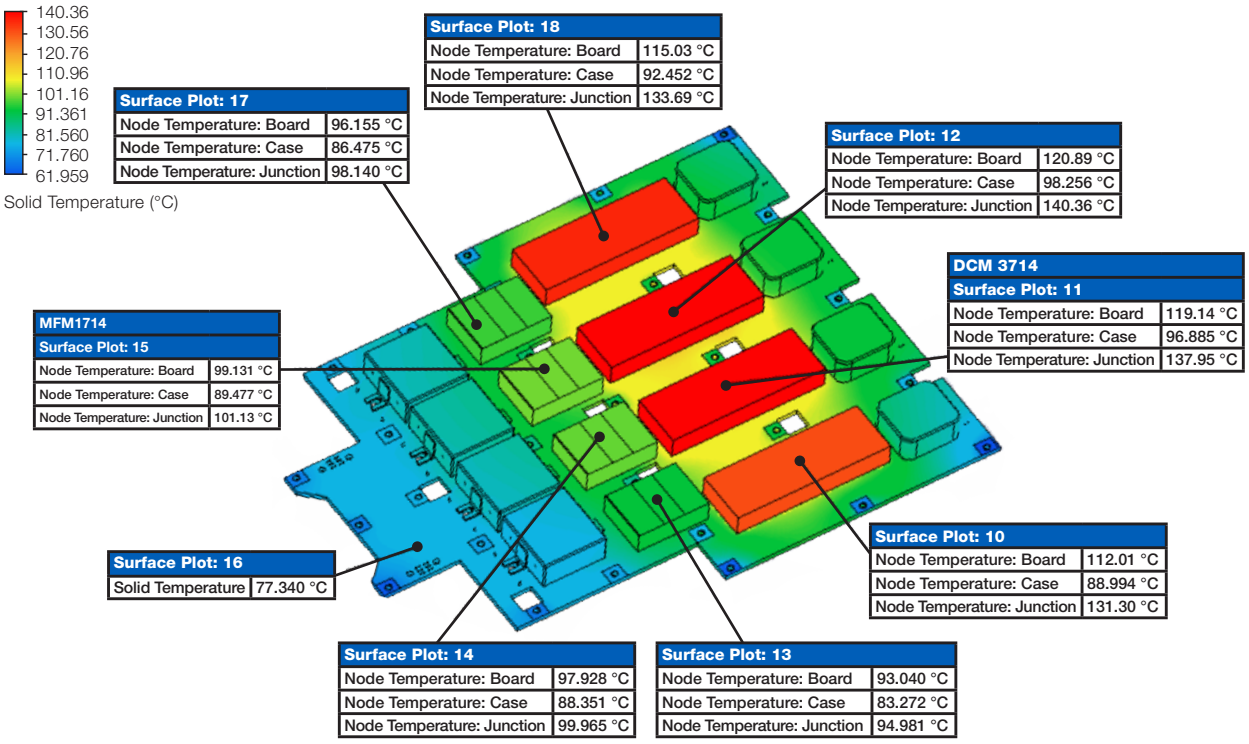
Board Surface Temperature Plot

85°C, Sea Level



Bottom Side Components Temperature Plot

85°C, Sea Level

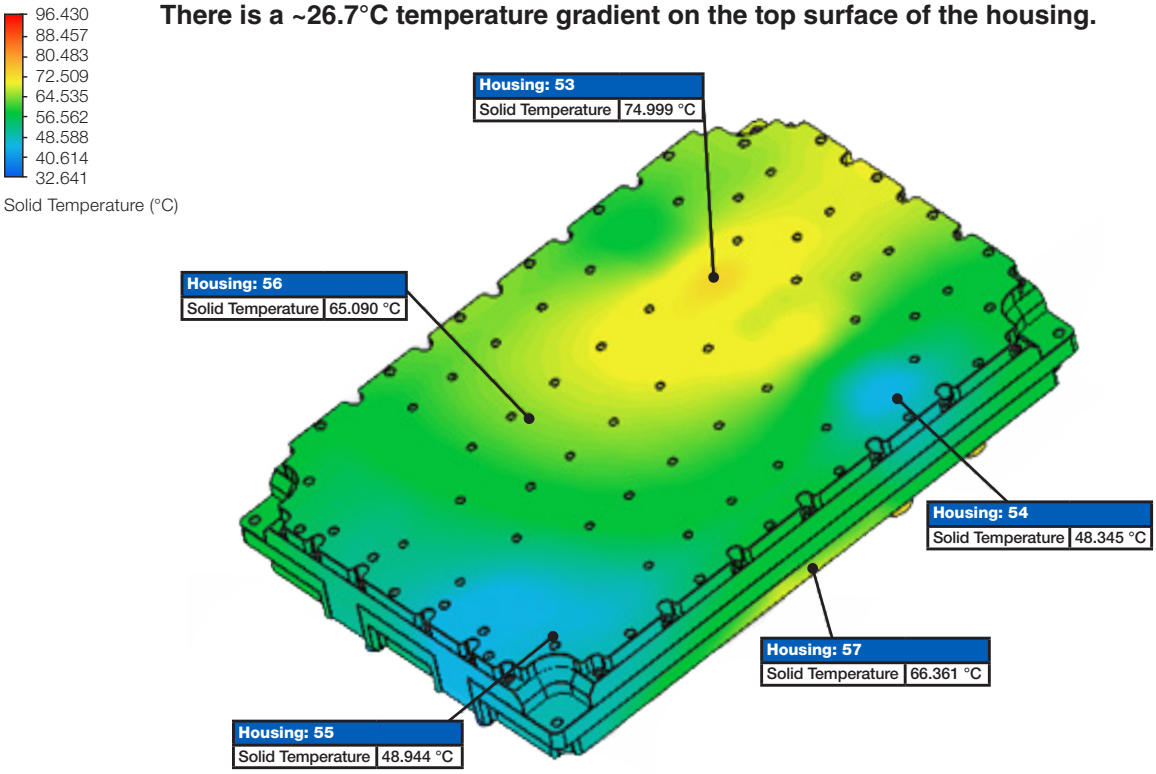


Worst Case - 85°C Ambient, 60°C Coolant WC Power

Housing Top Surface Temperature Plot

85°C, Sea Level

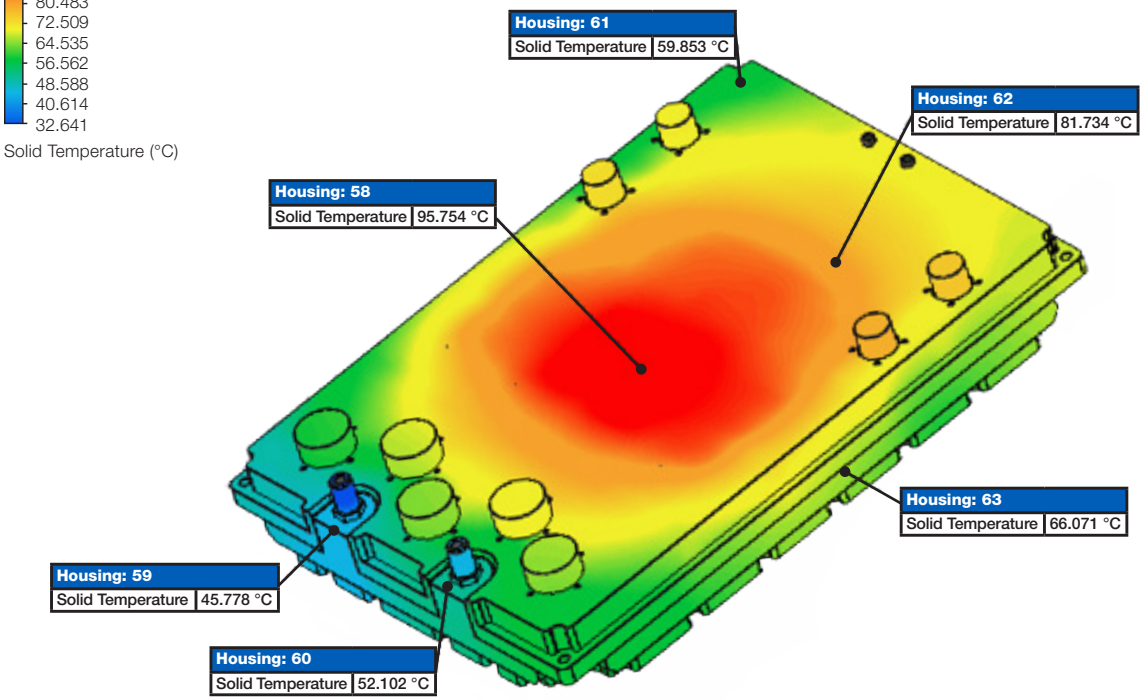
There is a ~26.7°C temperature gradient on the top surface of the housing.



Housing Bottom Surface Temperature Plot

85°C, Sea Level

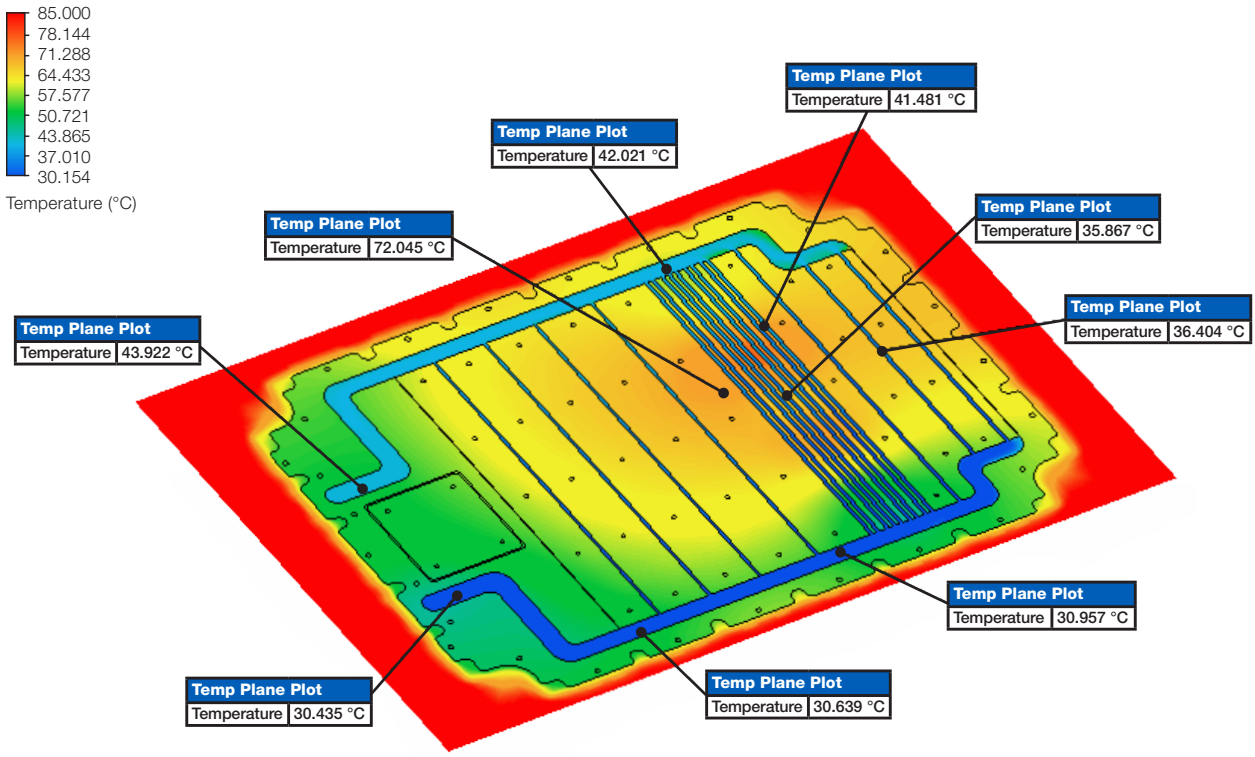
There is about 49.9°C temperature gradient on the top surface of the housing.



Worst Case - 85°C Ambient, 30°C Coolant WC Power

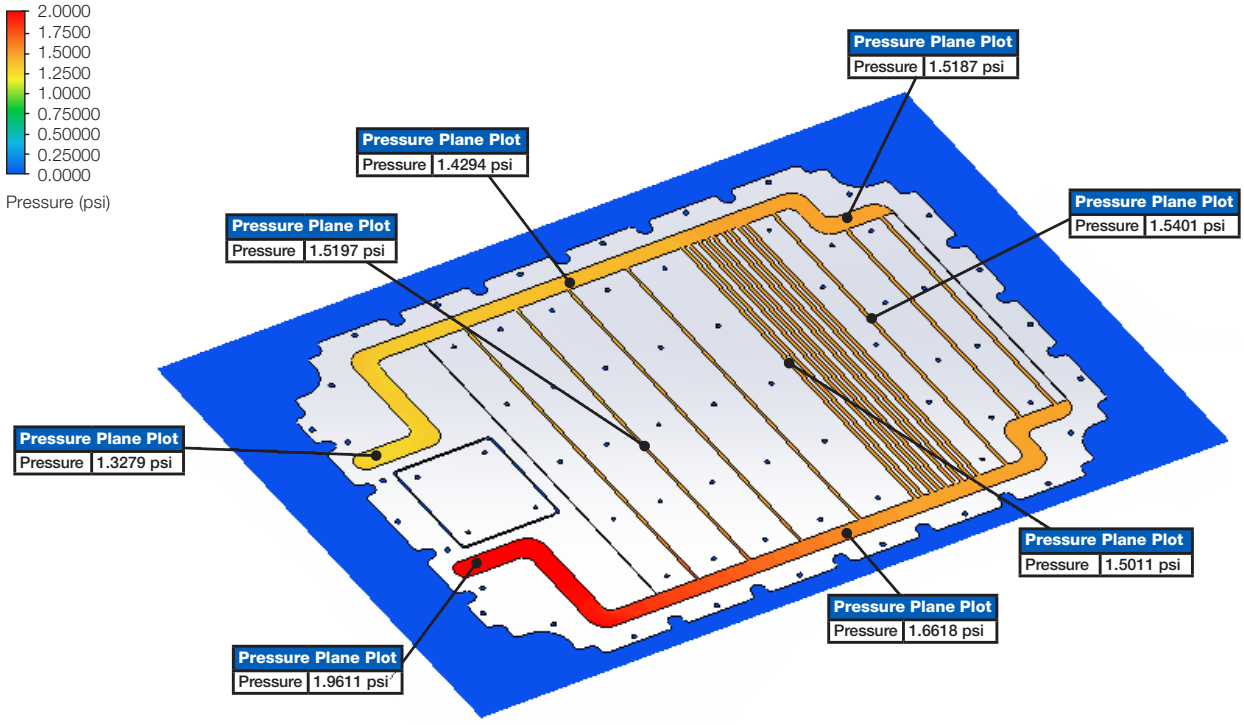
Cold Plate Channel Temperature Cutplane

85°C, Sea Level



Cold Plate Channel Pressure Cutplane

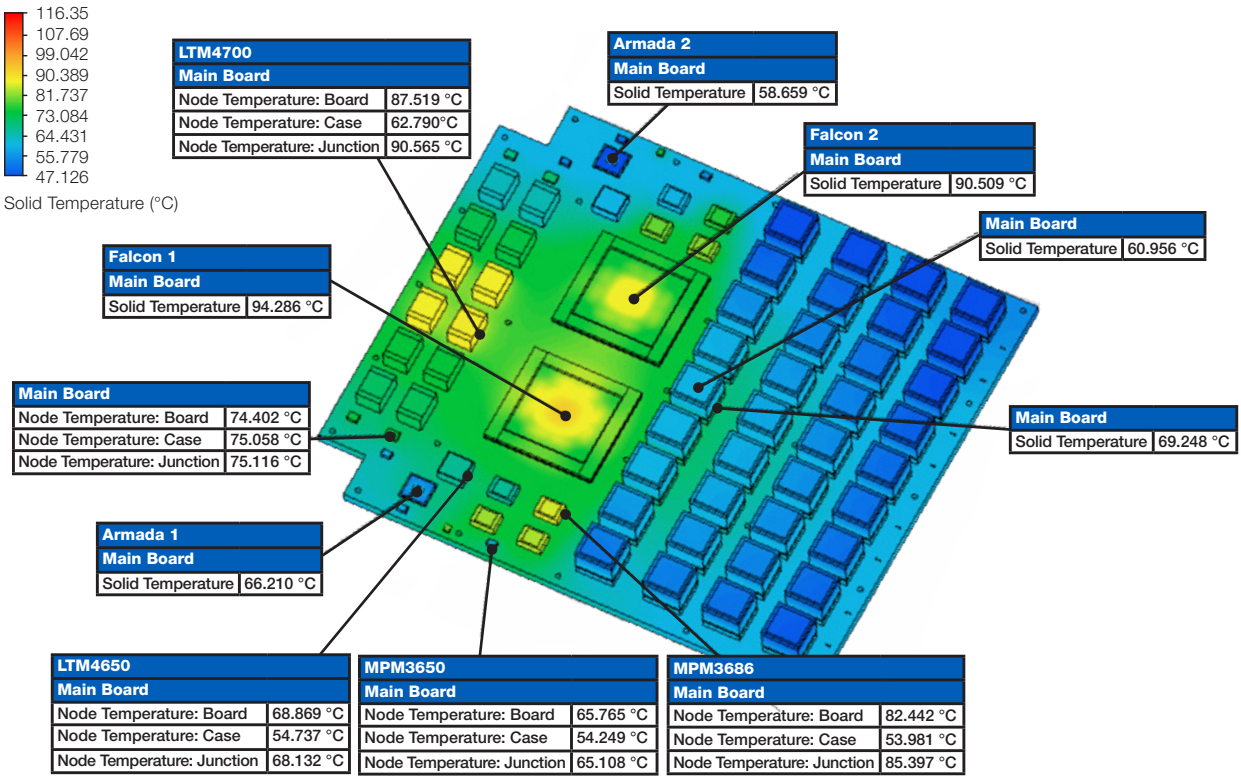
85°C, Sea Level



Worst Case - 23°C Ambient, 21.1°C Coolant WC Power

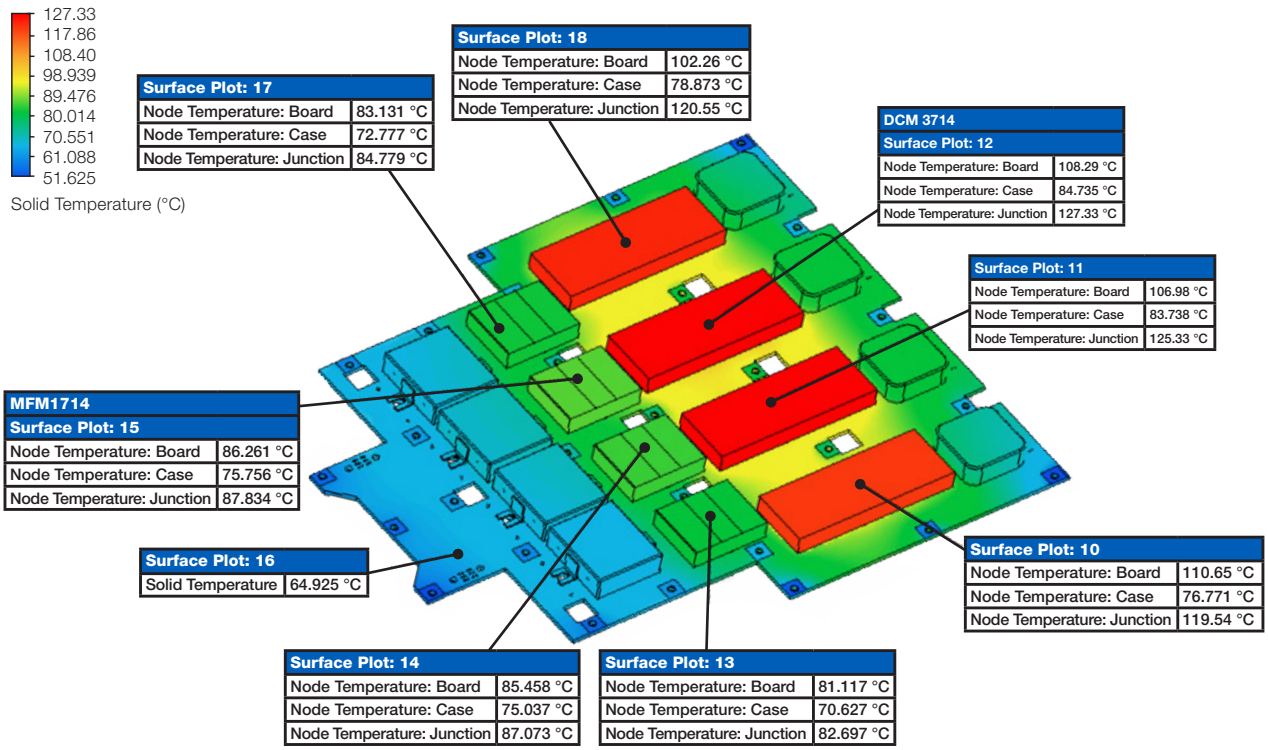
Board Surface Temperature Plot

23°C, Sea Level



Bottom Side Components Temperature Plot

23°C, Sea Level

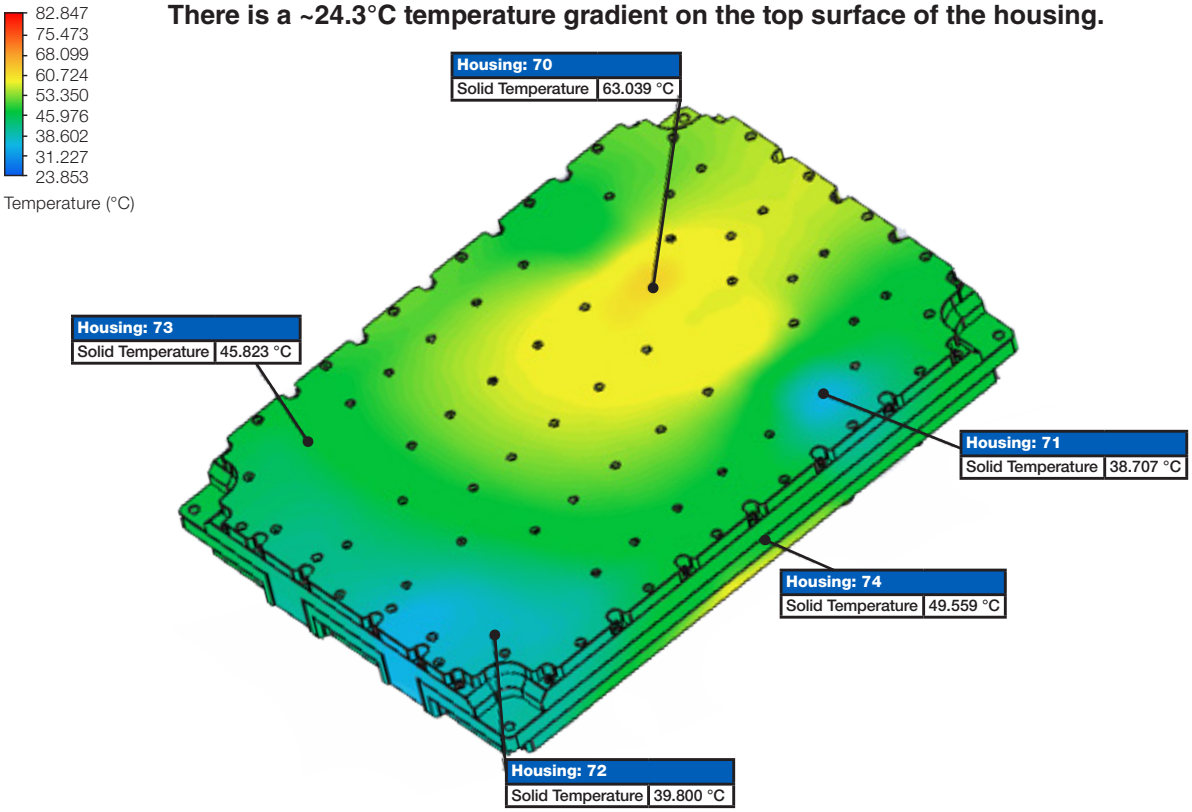


Worst Case - 23°C Ambient, 21.1°C Coolant WC Power

Housing Top Surface Temperature Plot

23°C, Sea Level

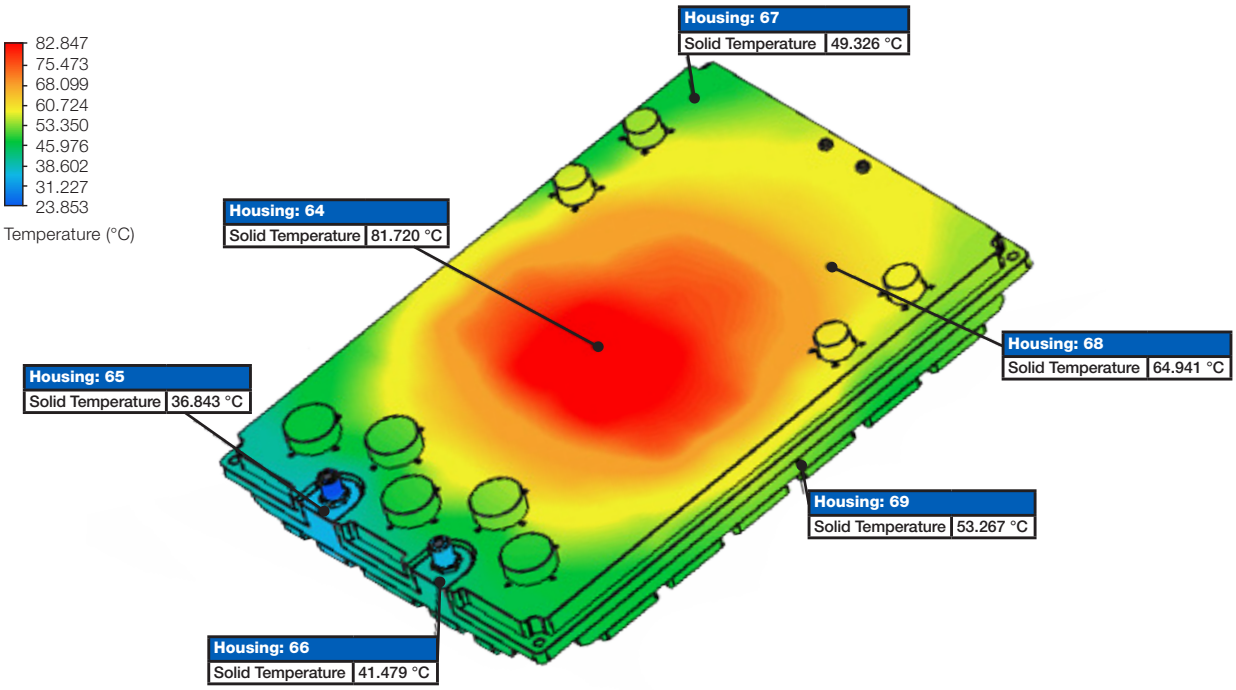
There is a ~24.3°C temperature gradient on the top surface of the housing.



Hosuing Bottom Surface Temperature Plot

23°C, Sea Level

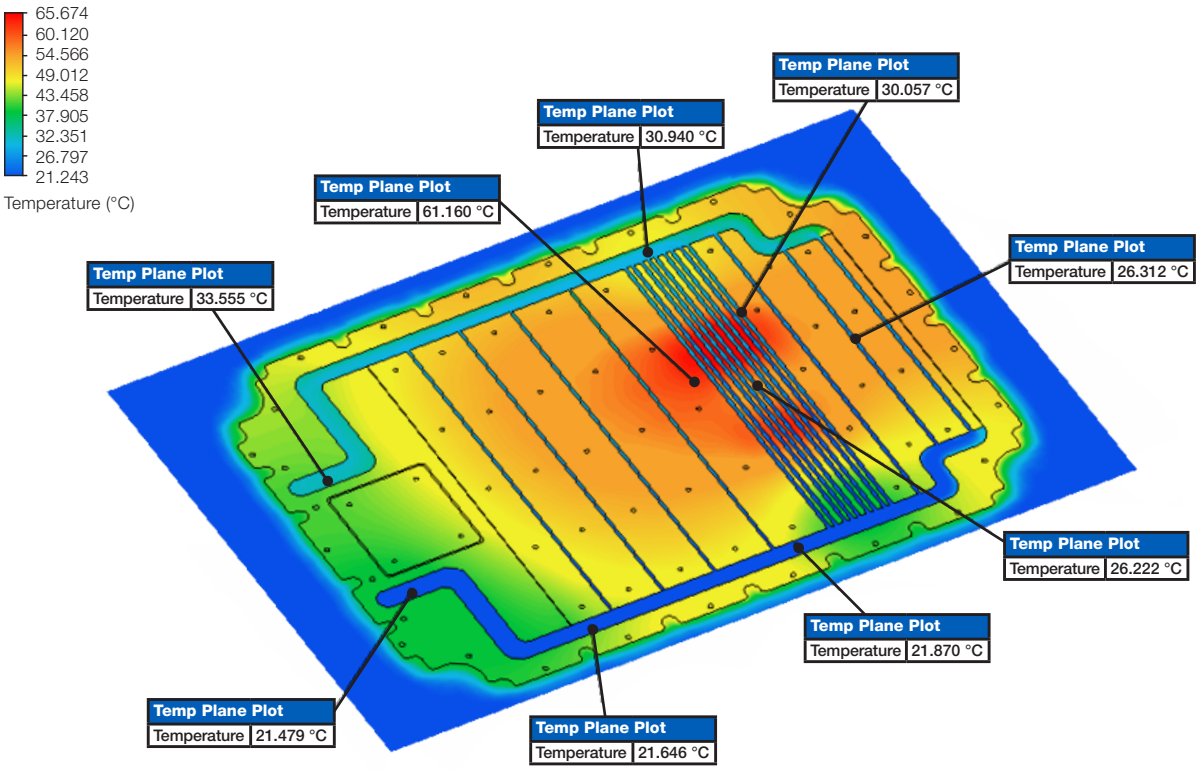
There is about 44.9°C temperature gradient on the top surface of the housing.



Worst Case - 23°C Ambient, 21.1°C Coolant WC Power

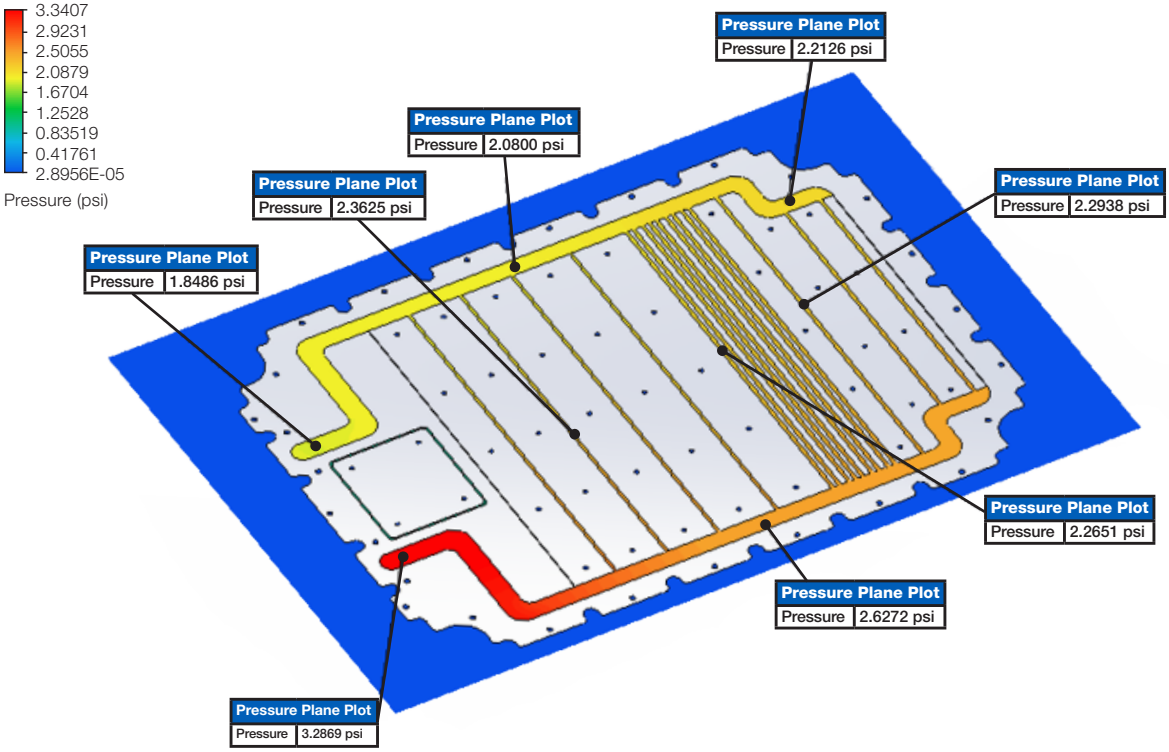
Cold Plate Channel Temperature Cutplane

23°C, Sea Level



Cold Plate Channel Pressure Cutplane

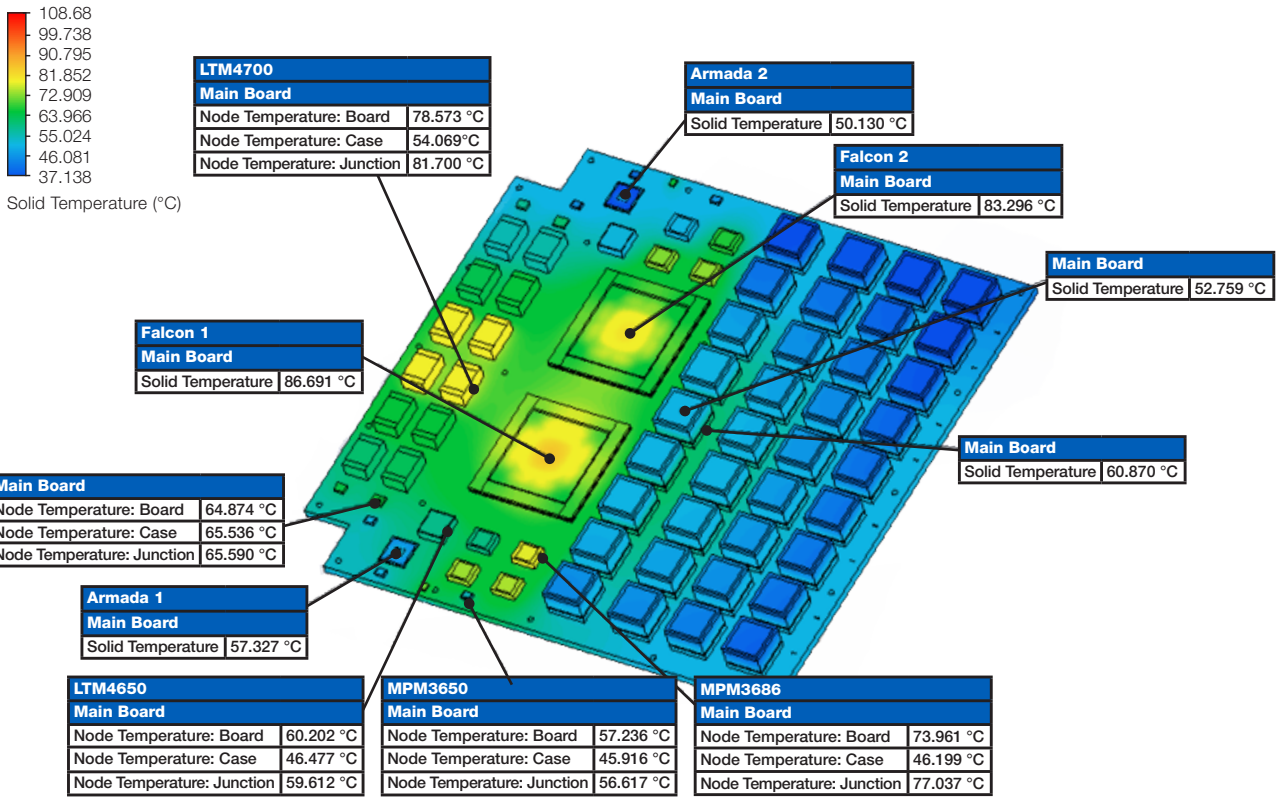
23°C, Sea Level



Worst Case - -40°C Ambient, 15°C Coolant WC Power

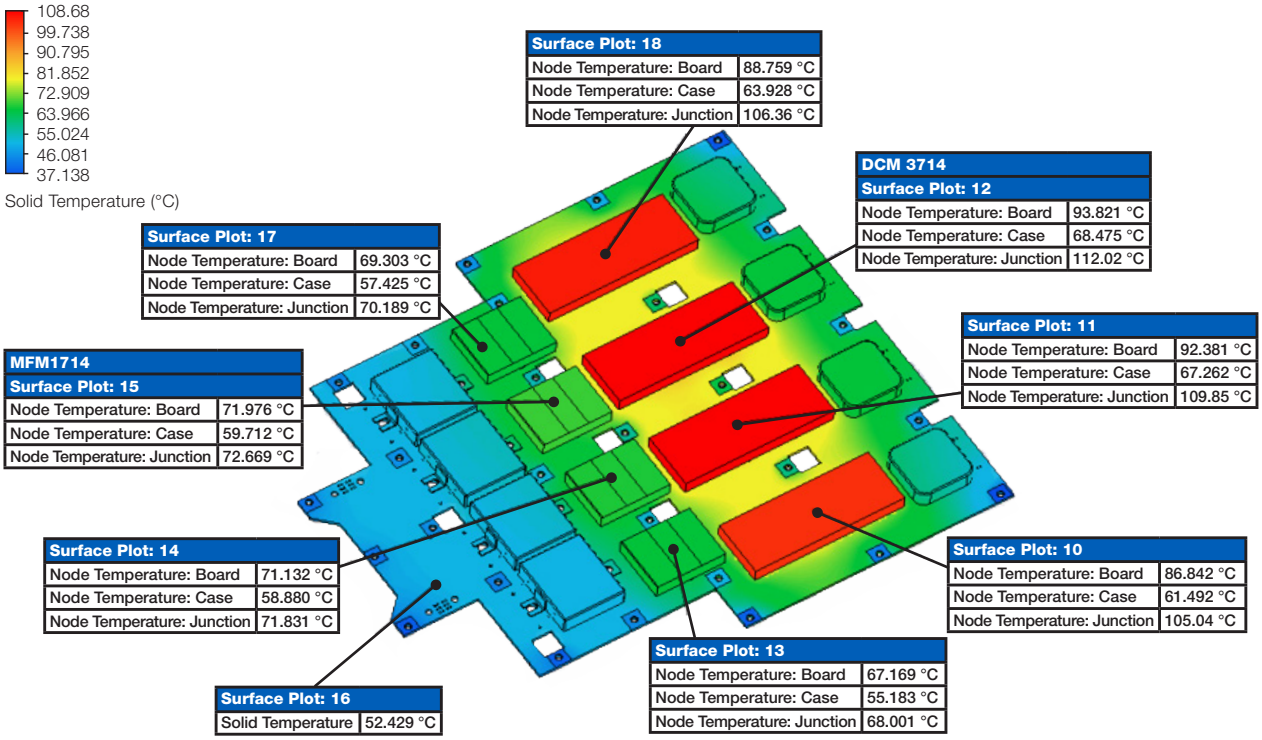
Board Surface Temperature Plot

-40°C, Sea Level



Bottom Side Components Temperature Plot

-40°C, Sea Level

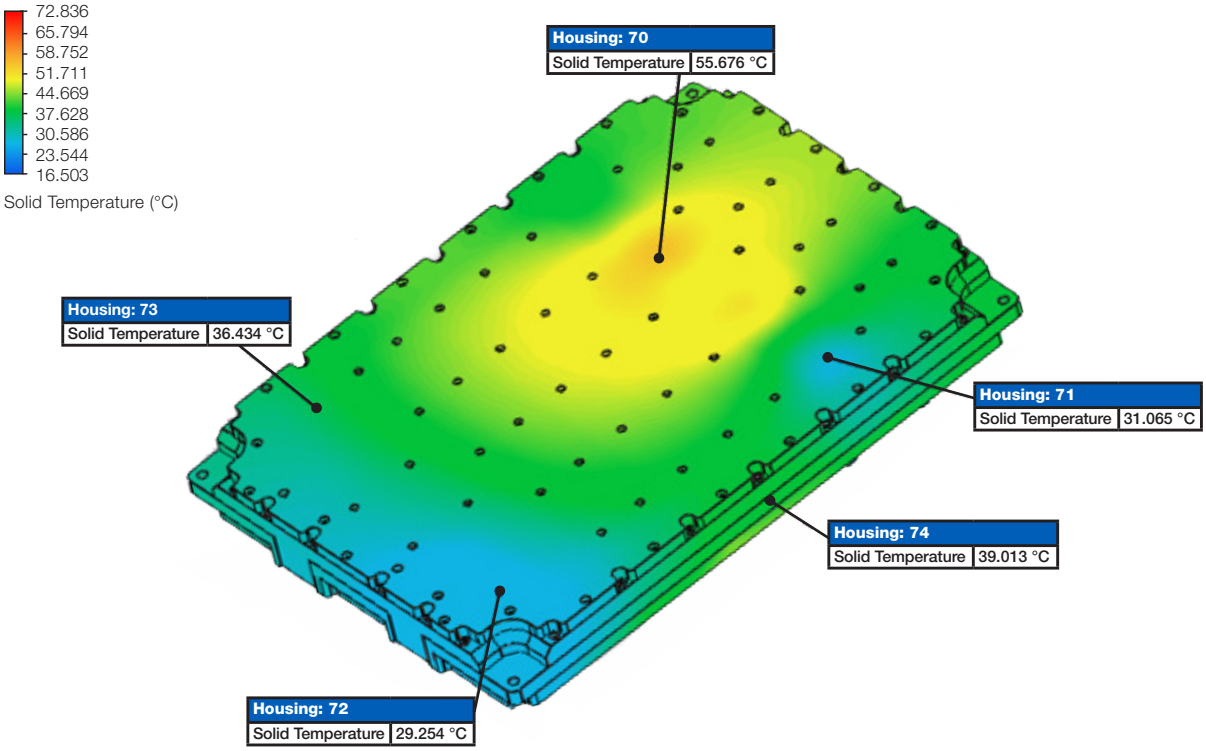


Worst Case - -40°C Ambient, 15°C Coolant WC Power

Housing Top Surface Temperature Plot

-40°C, Sea Level

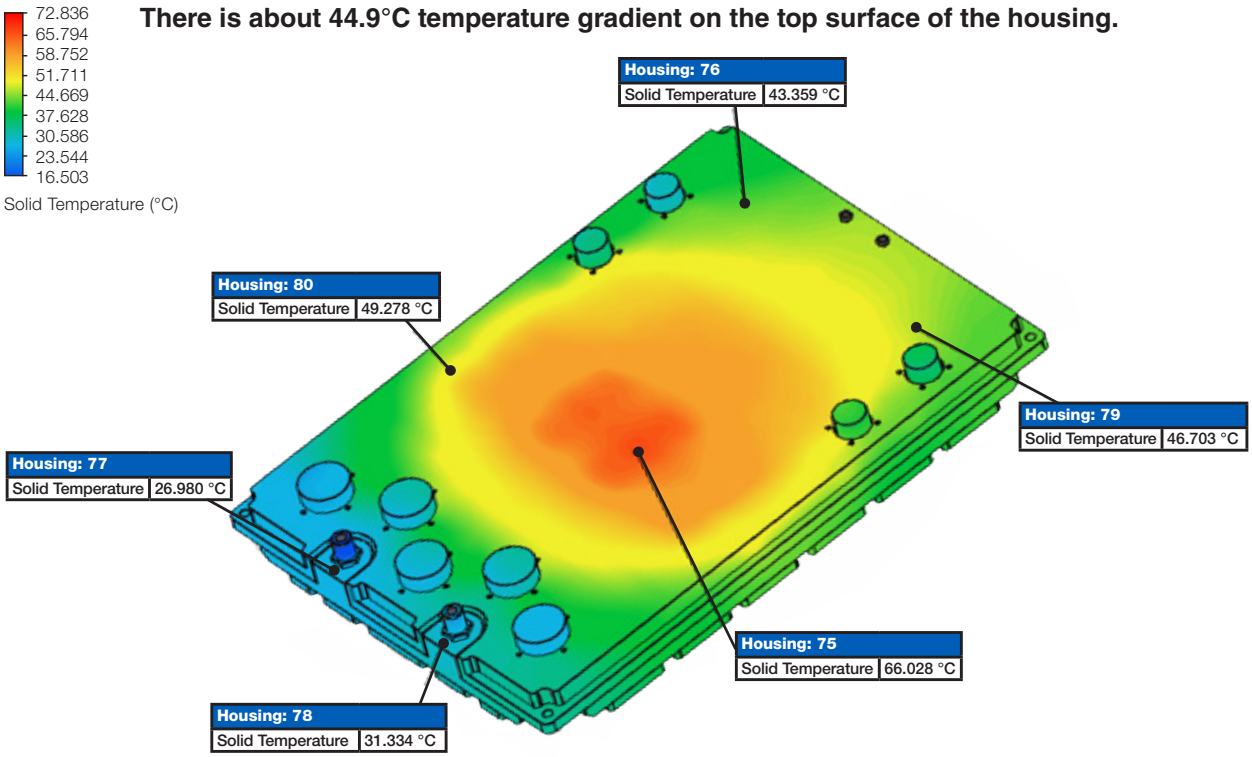
There is a ~24.3°C temperature gradient on the top surface of the housing.



Housing Bottom Surface Temperature Plot

-40°C, Sea Level

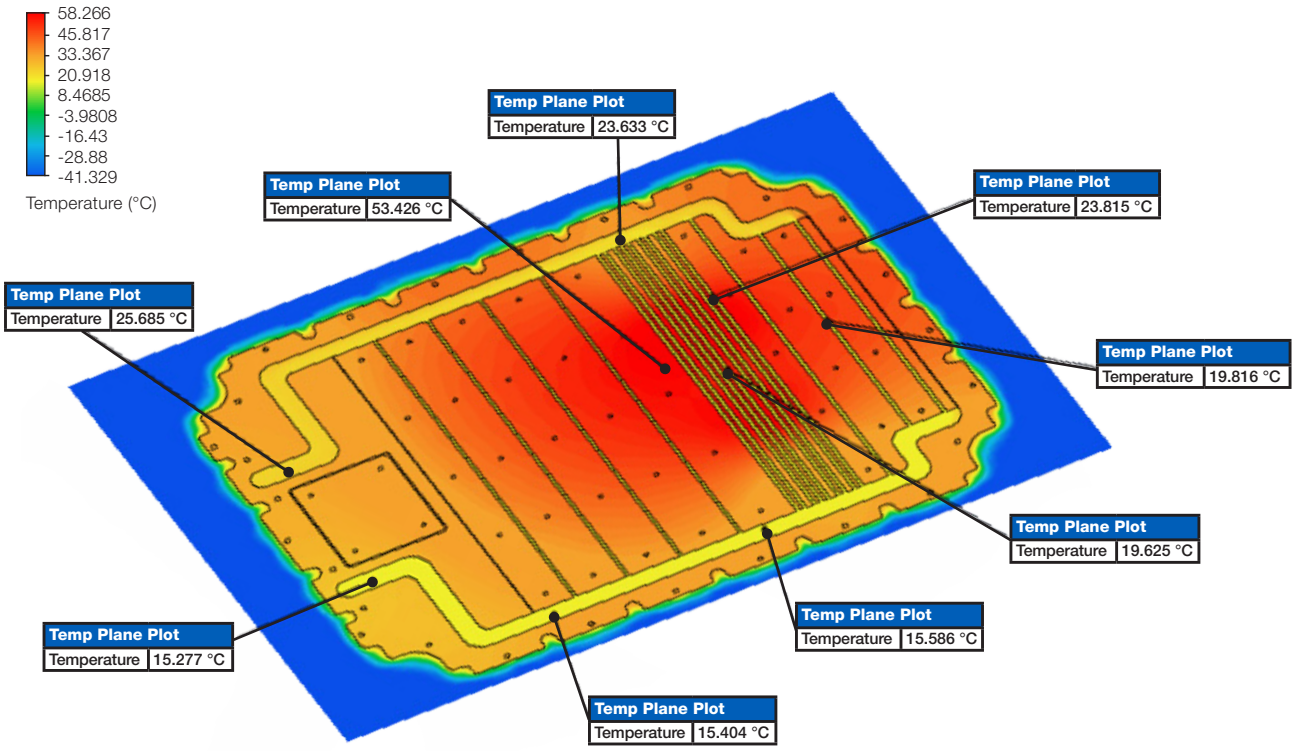
There is about 44.9°C temperature gradient on the top surface of the housing.



Worst Case - -40°C Ambient, 15°C Coolant WC Power

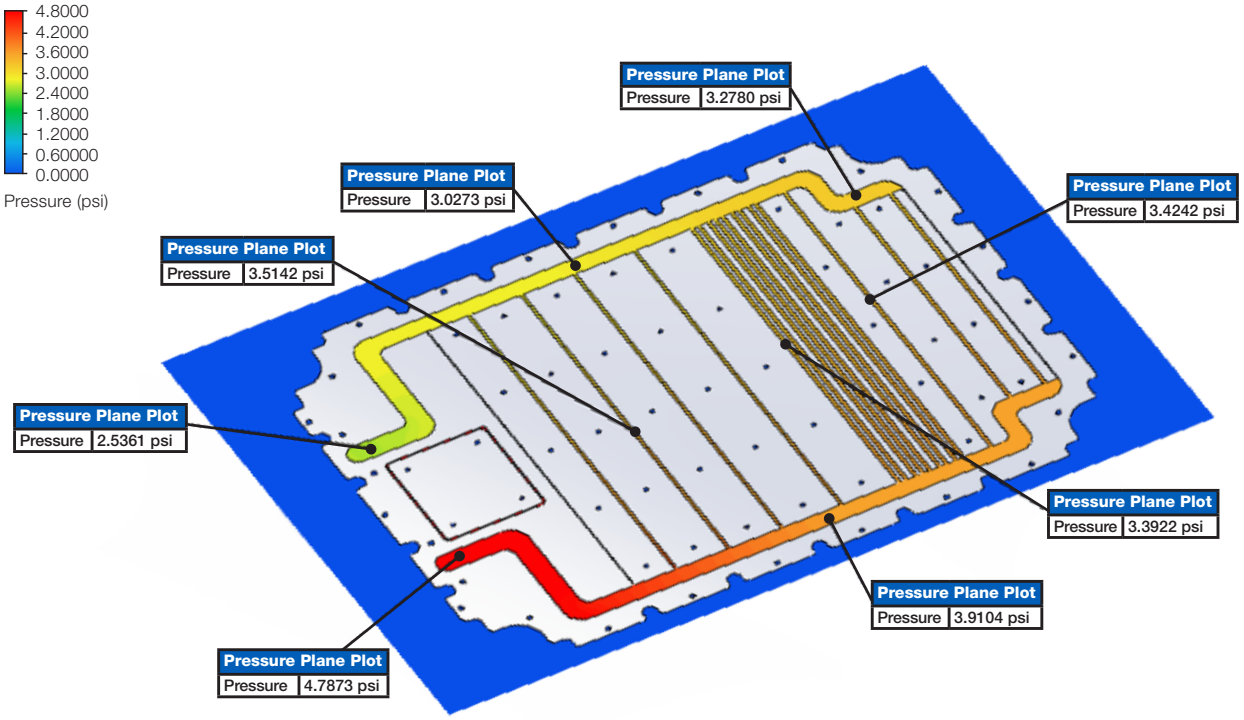
Cold Plate Channel Temperature Cutplane

-40°C, Sea Level



Cold Plate Channel Pressure Cutplane

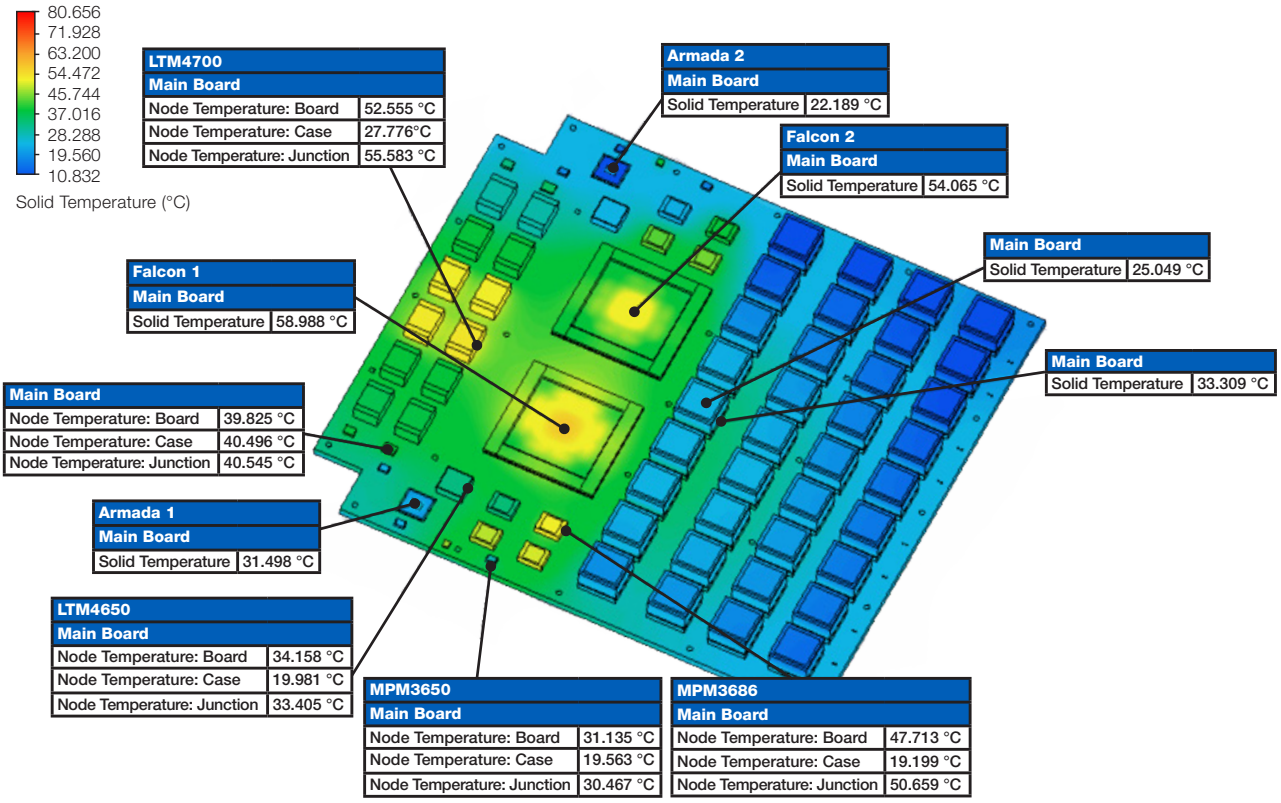
-40°C, Sea Level



Worst Case - -40°C Ambient, 17.7°C Coolant WC Power

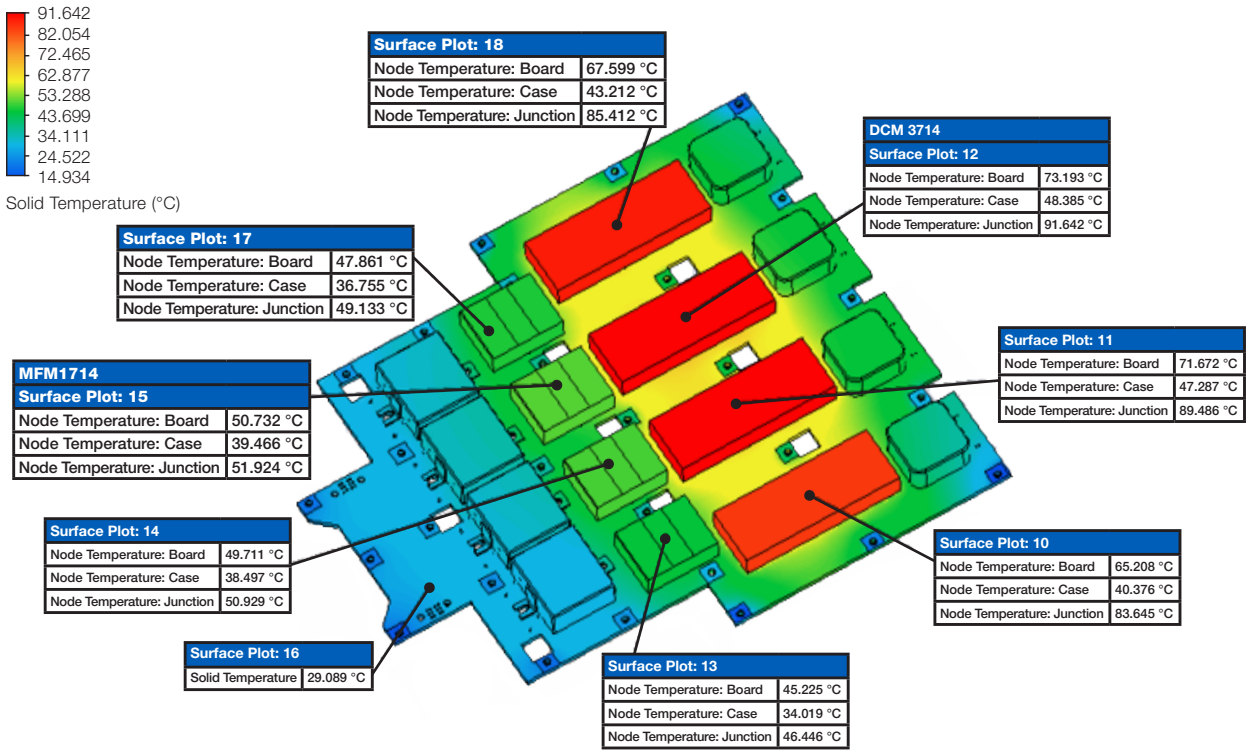
Housing Top Surface Temperature Plot

-40°C, Sea Level



Housing Bottom Surface Temperature Plot

-40°C, Sea Level

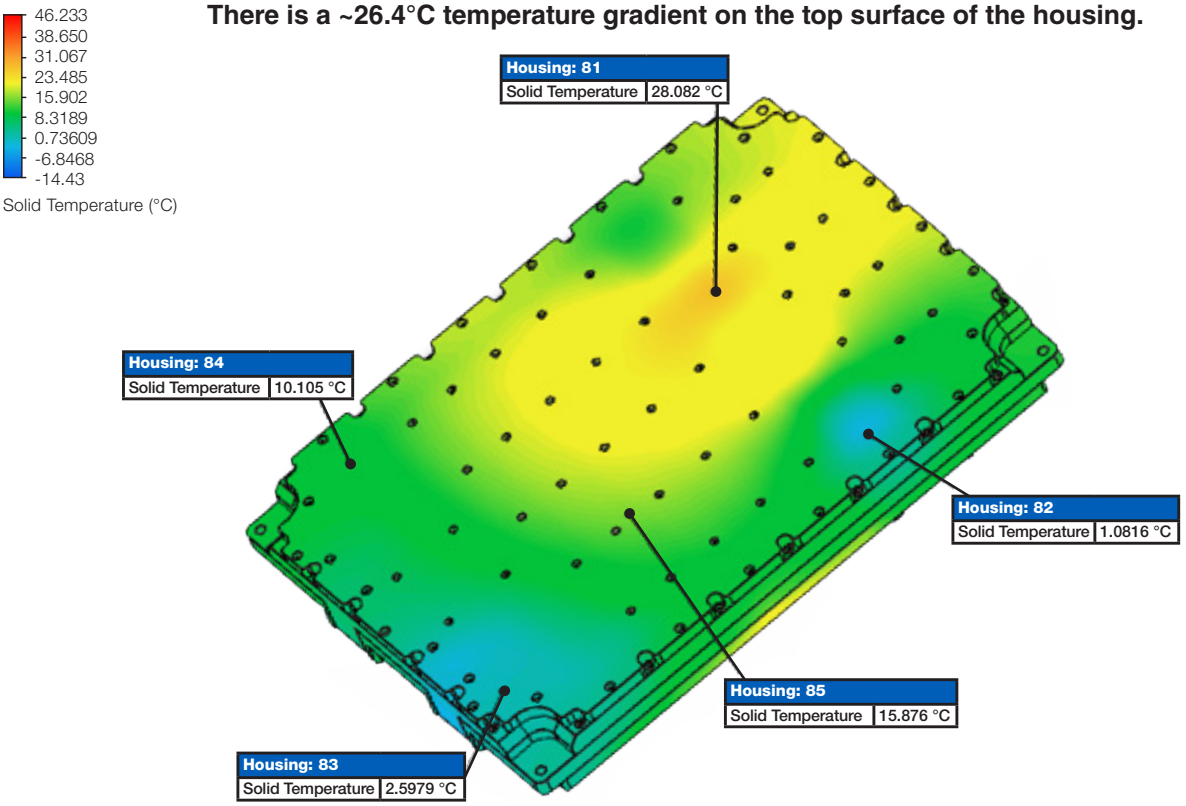


Worst Case - -40°C Ambient, 15°C Coolant WC Power

Housing Top Surface Temperature Plot

-40°C, Sea Level

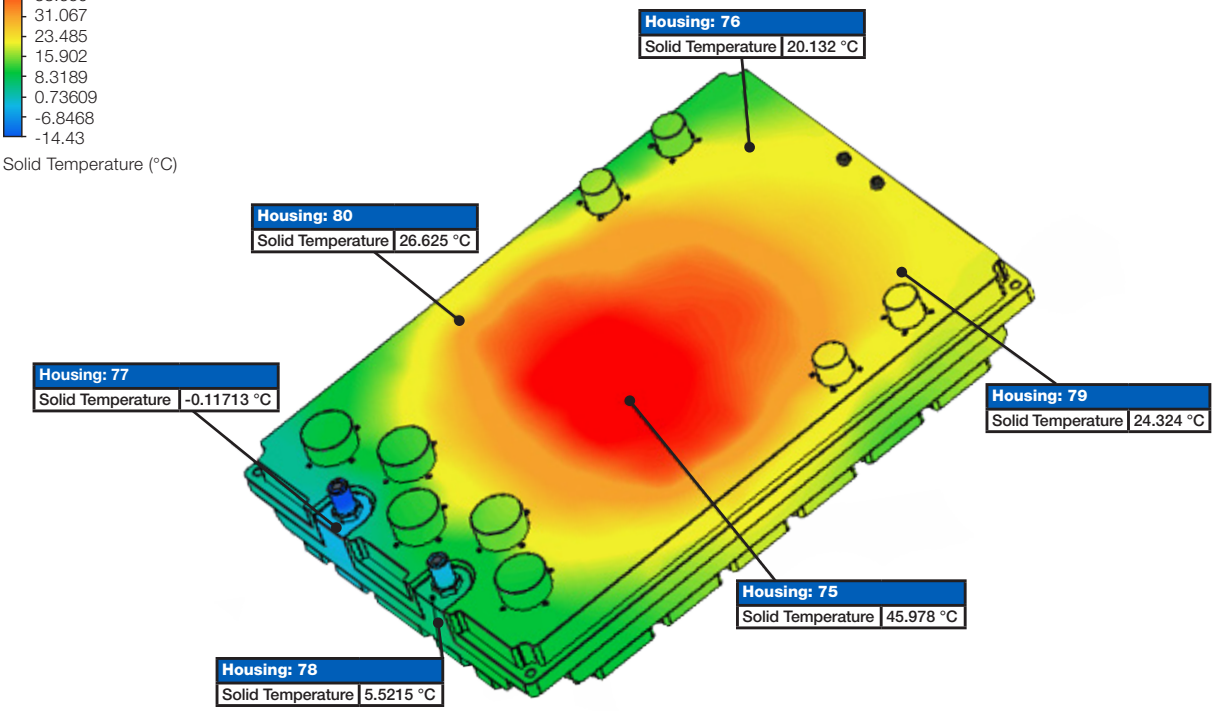
There is a ~26.4°C temperature gradient on the top surface of the housing.



Housing Bottom Temperature Plot

-40°C, Sea Level

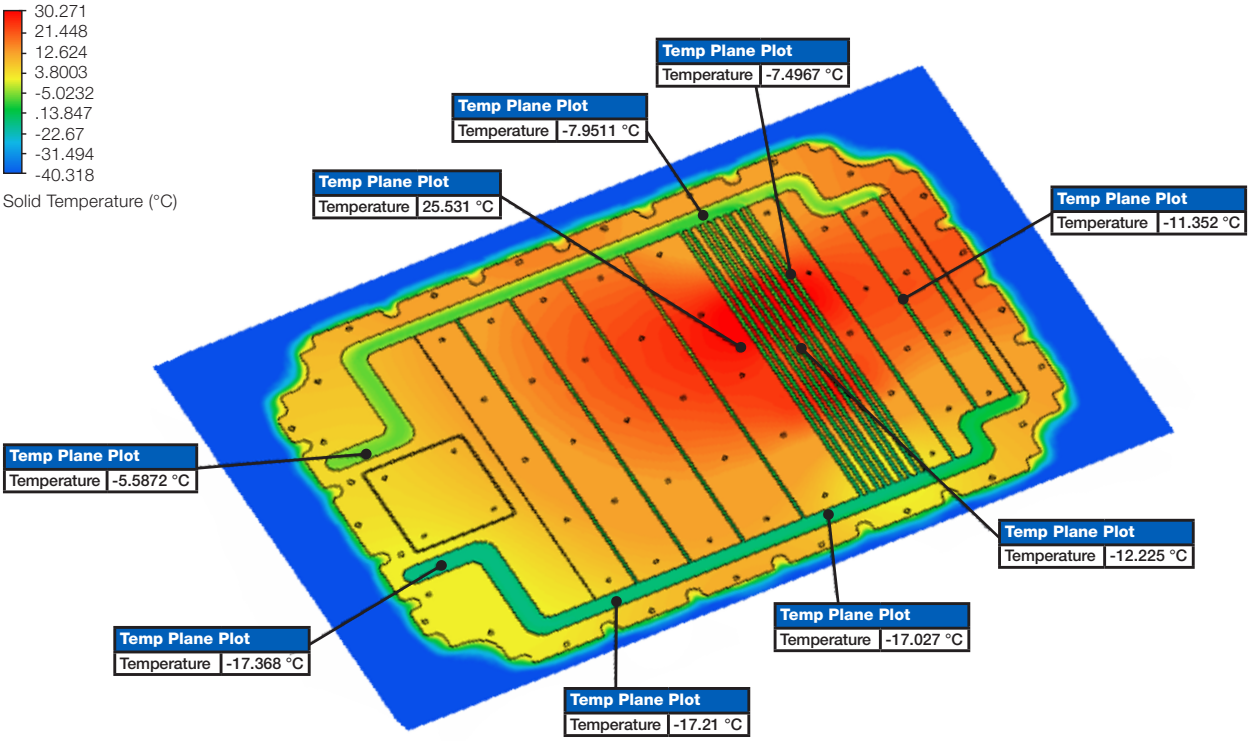
There is about 33.1°C temperature gradient on the top surface of the housing.



Worst Case - -40°C Ambient, 17.7°C Coolant WC Power

Cold Plate Temperature Cutplane

-40°C, Sea Level



Cold Plate Channel Pressure Cutplane

-40°C, Sea Level