ElectronicCooling Solutions inc

Amphenol Aerospace

CF-020400-026

Thermal Analysis Update 2

January 9, 2020

Ceferino Sanchez, Arjan Kole
Electronic Cooling Solutions Inc.

ElectronicCooling Solutions inc

Contents

Objectives 3

Updates 4

Thermal Model Setup Details ....5 - 10

Overview

Thermal Data

Thermal Analysis .... 11 - 18

Results Summary

Plots

Recommendations

ElectronicCooling Solutions inc

Objectives

1. Determine how the CF-170200-233 board performs with the frame [CF-0200400-026] for conduction cooling for the following environments and fixed temperatures on the side surfaces of the secondary frame:

   a) -40°C

   b) 23°C

   c) 85°C

   At the three different power levels:

   a) Sandia Config. – Total Power of 37.93W

   b) 10G Op. - Total Power of 61.12W

   c) Worst-case – Total Power of 87.91W

2. Generate recommendations to improve thermal performance.

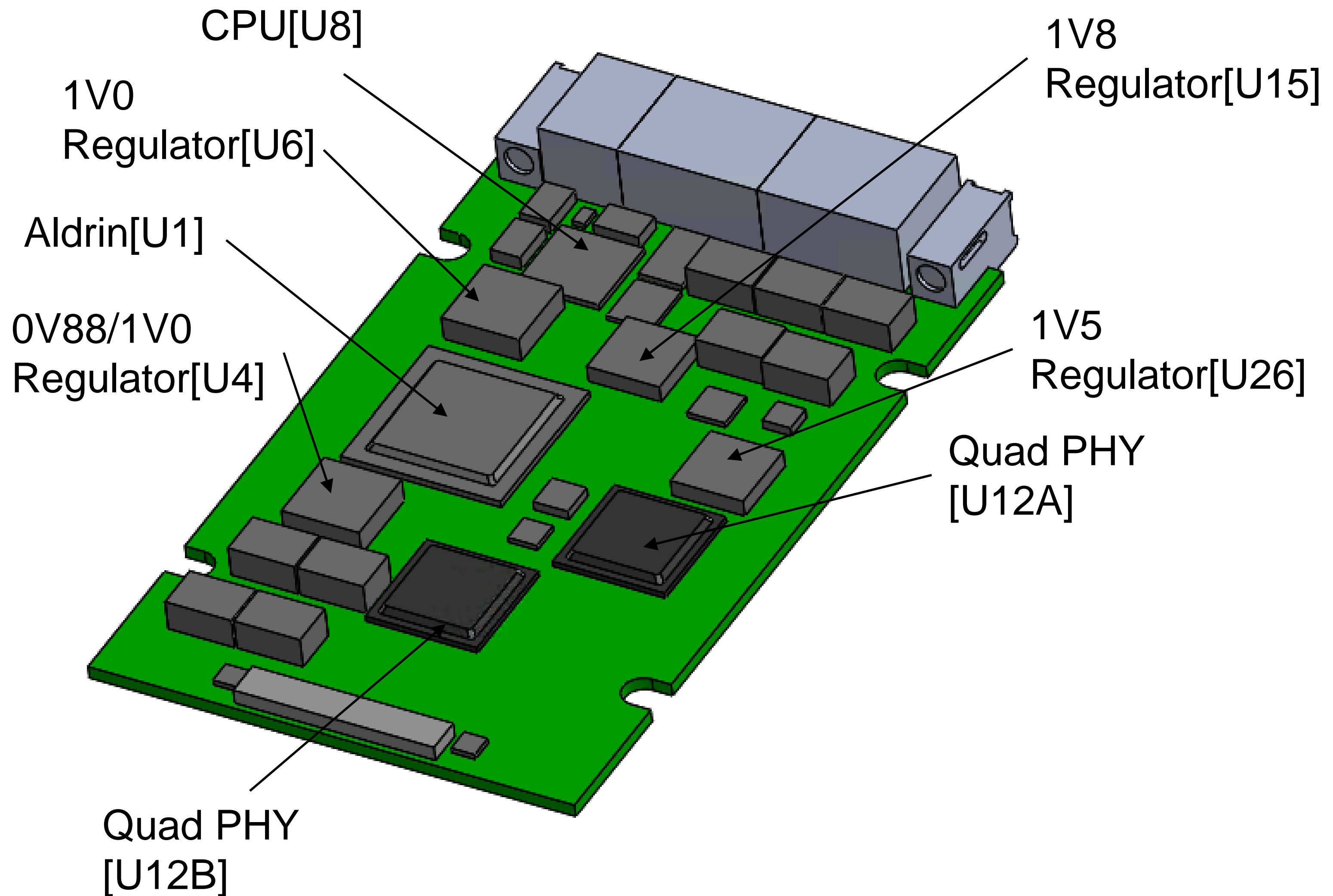
Updates

1. The updates for this thermal model are based on changes on the CAD model provided, cf-020400-026m__asm_010720.stp and includes the following:
   a) The primary frame was revised to remove fins above the Aldrin and increase pedestal heights to allow for thinner gap pads on the critical components.
   b) The thermal gap pads on the primary frame coupled to the critical components are SilPad2000 with k=3.5W/mK at 0.015” thick (was: Therm-A-Gap 579, k=3W/mK, 0.2” thick). This was also used to couple surfaces between frames.
   c) The thermal gap pad on the secondary frame coupled to the secondary side (bottom) of the PCB is Gap Pad V0 Ultra Soft with k=1W/mK, 0.1” thick.
   d) Additional cooling surfaces (fixed temperature surfaces) on the top surfaces of the wedges were added.

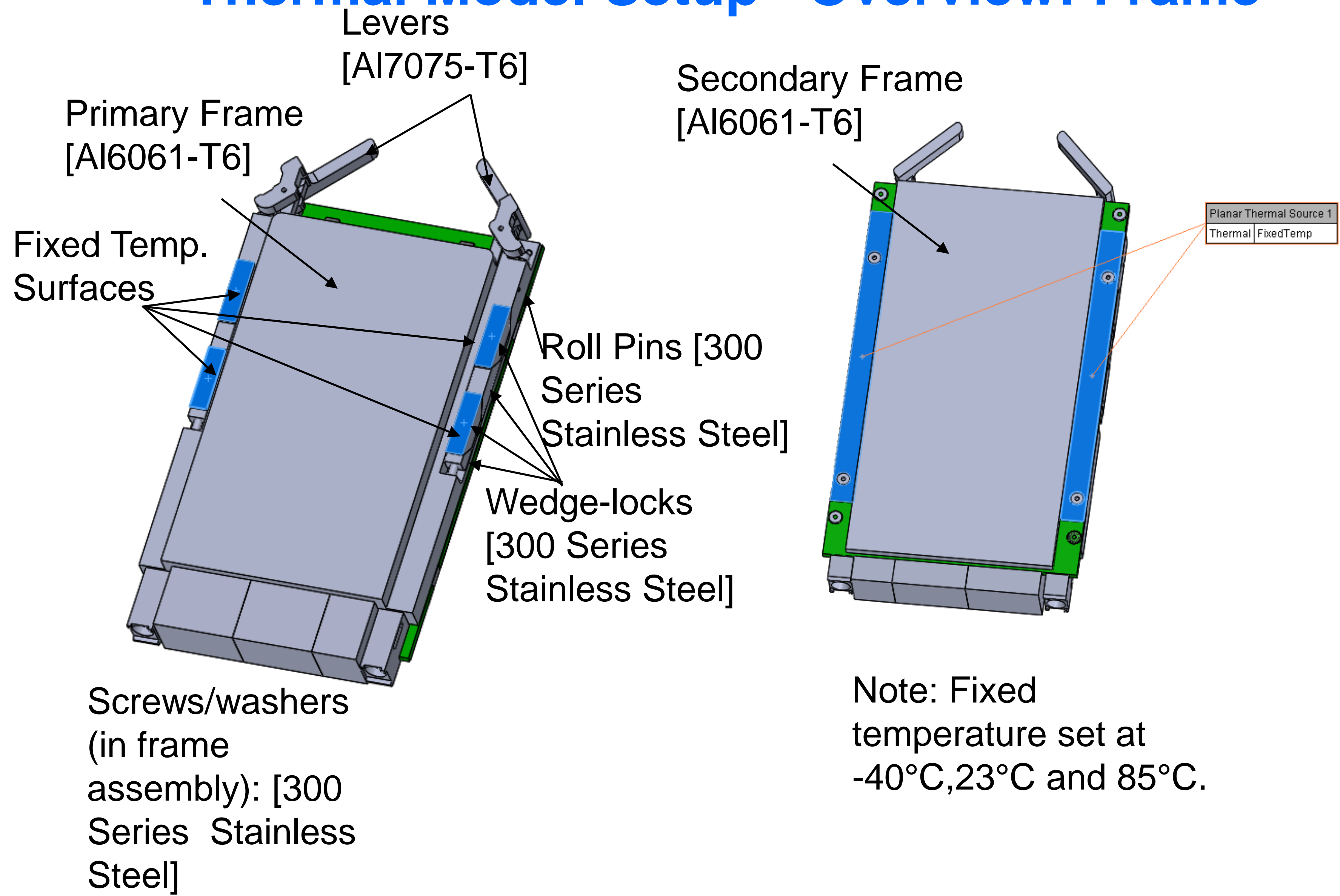
Thermal Model Setup

ElectronicCooling Solutions inc

Thermal Model Setup –Overview: Board



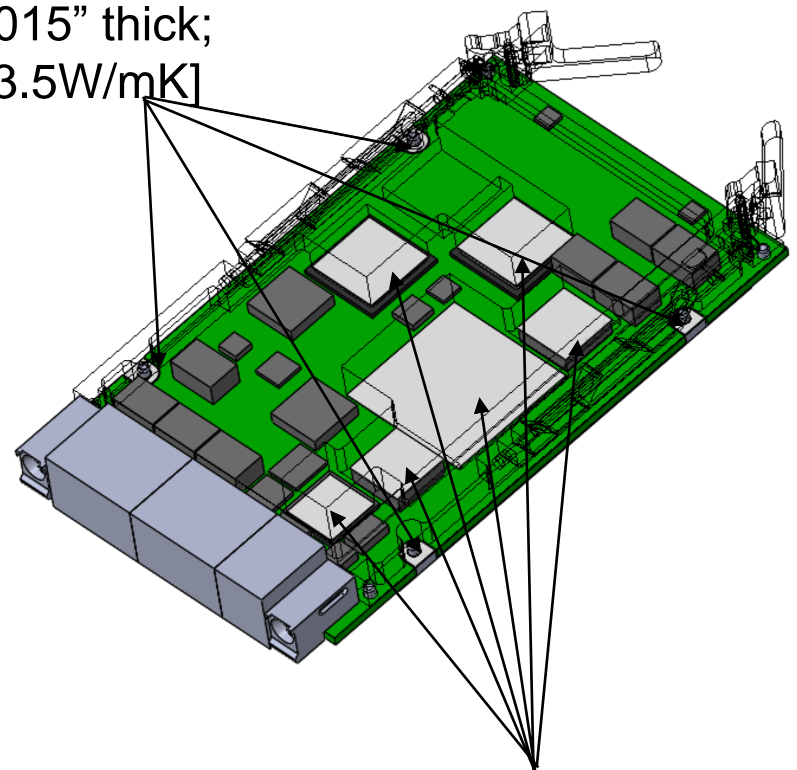
Thermal Model Setup –Overview: Frame

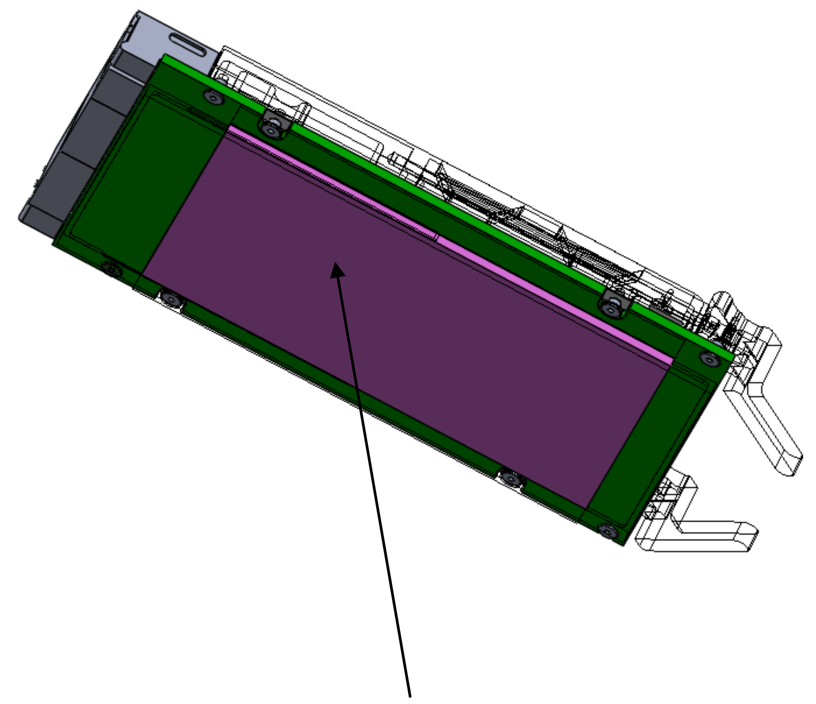


Note: Fixed temperature set at -40°C,23°C and 85°C.

Thermal Model Setup –Overview: Thermal Gap Pads

Thermal Gap Pads (SilPad2000) [0.015" thick; k=3.5W/mK]





Thermal Gap Pads (SilPad2000) [0.015" thick; k=3.5W/mK]

Thermal Gap Pad (Gap Pad V0 Ultra Soft) [0.1" thick; k=1W/mK]

ElectronicCooling Solutions inc

Thermal Data

CF-170300-233	Sandia Config. (W)			Thermal Resistance (ºC/W)/Model		Maximum Temperature (ºC)
Component [Ref. Des.]	Qty	Per Component	Total	R_{JC}	R_{JB}	
Aldrin [U1]	1	20.5	20.50	0.16	1.72	110 (junction)
CPU [U8]	1	4.67	4.67	2.57	6.89	115 (junction)
Quad PHY [U12A,U12B]	2	4.2	8.40	0.3	2.6	105 (junction)
0V88 / 1V0 Regulator [U4]	1	2.05	2.05	3.7	1.5	125 (junction)
1V0 Regulator [U6]	1	0.6	0.60	3.7	1.5	125 (junction)
1V8 Regulator [U15]	1	0.11	0.11	5	2	125 (junction)
1V5 Regulator [U26]	1	0.19	0.19	5	2	125 (junction)
Spread on the Board (Misc.)	1	1.41	1.41			
		Total	**37.93**			

CF-170300-233	10G Op.(W)			Thermal Resistance (ºC/W)/Model		Maximum Temperature (ºC)
Component [Ref. Des.]	Qty	Per Component	Total	R_{JC}	R_{JB}	
Aldrin [U1]	1	23.18	23.18	0.16	1.72	110 (junction)
CPU [U8]	1	4.67	4.67	2.57	6.89	115 (junction)
Quad PHY [U12A,U12B]	2	13.12	26.24	0.3	2.6	105 (junction)
0V88 / 1V0 Regulator [U4]	1	2.32	2.32	3.7	1.5	125 (junction)
1V0 Regulator [U6]	1	1.52	1.52	3.7	1.5	125 (junction)
1V8 Regulator [U15]	1	0.12	0.12	5	2	125 (junction)
1V5 Regulator [U26]	1	0.59	0.59	5	2	125 (junction)
Spread on the Board (Misc.)	1	2.48	2.48			
		Total	**61.12**			

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.pdf”. Items in red were based on typical values for a similar package (15 Ld QFN).

ElectronicCooling Solutions inc

Thermal Data (continued)

CF-170300-233	Worst-case Power (W)			Thermal Resistance (ºC/W)/Model		Maximum Temperature (ºC)
Component [Ref. Des.]	Qty	Per Component	Total	R_{JC}	R_{JB}	
Aldrin [U1]	1	43	43.00	0.16	1.72	110 (junction)
CPU [U8]	1	7.8	7.80	2.57	6.89	115 (junction)
Quad PHY [U12A,U12B]	2	13.5	27.00	0.3	2.6	105 (junction)
0V88 / 1V0 Regulator [U4]	1	4.3	4.30	3.7	1.5	125 (junction)
1V0 Regulator [U6]	1	1.74	1.74	3.7	1.5	125 (junction)
1V8 Regulator [U15]	1	0.22	0.22	5	2	125 (junction)
1V5 Regulator [U26]	1	0.61	0.61	5	2	125 (junction)
Spread on the Board (Misc.)	1	3.24	3.24			
		Total	**87.91**			

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.pdf". Items in red were based on typical values for a similar package (15 Ld QFN).

Thermal Analysis

ElectronicCooling Solutions inc

Results Summary

Scenario					Thermal-026		Thermal-026		Thermal-026	
Parameters										
Wedges and Secondary Frame Surfaces Fixed Temp., °C					-40		23		85	
Remarks					Sandia Config.		Sandia Config.		Sandia Config.	
RESULTS										
Component [Ref. Des]	Power, W	Min. Limit, °C	Max. Limit, °C	Limit Type	Result,°C	Margin,°C	Result,°C	Margin,°C	Result,°C	Margin,°C
Aldrin [U1]	20.5	-40	110	junction	-18.5	128.5	44.0	66.0	105.7	4.3
CPU [U8]	4.67	-	115	junction	-15.8	130.8	46.8	68.2	108.5	6.5
Quad PHY [U12A]	4.2	-	105	junction	-26.5	131.5	36.2	68.8	98.0	7.0
Quad PHY [U12B]	4.2	-	105	junction	-26.0	131.0	36.7	68.3	98.5	6.5
0V88 / 1V0 Regulator [U4]	2.05	-40	125	junction	-27.4	152.4	35.4	89.6	97.2	27.8
1V0 Regulator [U6]	0.6	-40	125	junction	-28.5	153.5	34.3	90.7	96.1	28.9
1V8 Regulator [U15]	0.11	-	125	junction	-33.8	158.8	29.1	95.9	91.1	33.9
1V5 Regulator [U26]	0.19	-	125	junction	-35.7	160.7	27.2	97.8	89.2	35.8

Scenario					Thermal-026		Thermal-026		Thermal-026	
Parameters										
Wedges and Secondary Frame Surfaces Fixed Temp., °C					-40		23		85	
Remarks					10G Op.		10G. Op.		10G Op.	
RESULTS										
Component [Ref. Des]	Power, W	Min. Limit, °C	Max. Limit, °C	Limit Type	Result,°C	Margin,°C	Result,°C	Margin,°C	Result,°C	Margin,°C
Aldrin [U1]	23.18	-40	110	junction	-10.9	120.9	51.5	58.5	113.1	-3.1
CPU [U8]	4.67	-	115	junction	-10.3	125.3	52.2	62.8	113.9	1.1
Quad PHY [U12A]	13.12	-	105	junction	-11.9	116.9	50.5	54.5	112.1	-7.1
Quad PHY [U12B]	13.12	-	105	junction	-11.0	116.0	51.4	53.6	113.0	-8.0
0V88 / 1V0 Regulator [U4]	2.32	-40	125	junction	-22.3	147.3	40.4	84.6	102.2	22.8
1V0 Regulator [U6]	1.52	-40	125	junction	-22.5	147.5	40.1	84.9	101.9	23.1
1V8 Regulator [U15]	0.12	-	125	junction	-31.0	156.0	31.8	93.2	93.8	31.2

- For the Sandia Config. and 85°C, Aldrin has a 4°C margin.

ElectronicCooling Solutions inc

Results Summary (continued)

Scenario					Thermal-026		Thermal-026		Thermal-026	
Parameters										
Wedges and Secondary Frame Surfaces Fixed Temp., °C					-40		23		85	
Remarks					Worst-Case Power		Worst-Case Power		Worst-Case Power	
RESULTS										
Component [Ref. Des]	**Power, W**	**Min. Limit, °C**	**Max. Limit, °C**	**Limit Type**	**Result,°C**	**Margin,°C**	**Result,°C**	**Margin,°C**	**Result,°C**	**Margin,°C**
Aldrin [U1]	43	-40	110	junction	7.0	103.0	69.0	41.0	130.3	-20.3
CPU [U8]	7.8	-	115	junction	7.0	108.0	69.2	45.8	130.6	-15.6
Quad PHY [U12A]	13.5	-	105	junction	-5.0	110.0	57.3	47.7	118.8	-13.8
Quad PHY [U12B]	13.5	-	105	junction	-3.7	108.7	58.6	46.4	120.0	-15.0
0V88 / 1V0 Regulator [U4]	4.3	-40	125	junction	-12.0	137.0	50.5	74.5	112.1	12.9
1V0 Regulator [U6]	1.74	-40	125	junction	-14.1	139.1	48.3	76.7	109.9	15.1
1V8 Regulator [U15]	0.22	-	125	junction	-26.3	151.3	36.4	88.6	98.4	26.6
1V5 Regulator [U26]	0.61	-	125	junction	-29.0	154.0	33.8	91.2	95.8	29.2

ElectronicCooling Solutions inc

Board Surface Temperature Plot

Sandia Config., 23°C

CPU-U8	
Node Temperature: Board	32.6 °C
Node Temperature: Case	40.1 °C
Node Temperature: Junction	46.8 °C

1V0 Regulator-U6	
Node Temperature: Board	31.9 °C
Node Temperature: Case	37.9 °C
Node Temperature: Junction	34.2 °C

Aldrin-U1	
Node Temperature: Board	32.6 °C
Node Temperature: Case	41.8 °C
Node Temperature: Junction	44.0 °C

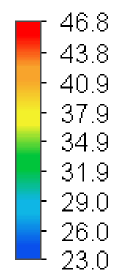
0V88 / 1V0 Regulator -U4	
Node Temperature: Board	31.7 °C
Node Temperature: Case	36.7 °C
Node Temperature: Junction	35.3 °C

1V8 Regulator-U15	
Node Temperature: Board	28.8 °C
Node Temperature: Case	29.1 °C
Node Temperature: Junction	29.1 °C

1V5 Regulator-U26	
Node Temperature: Board	26.8 °C
Node Temperature: Case	27.3 °C
Node Temperature: Junction	27.2 °C

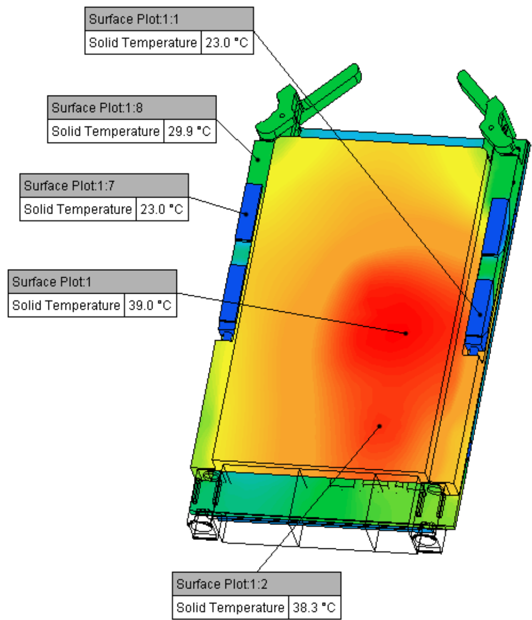
Quad PHY-U12A	
Node Temperature: Board	29.2 °C
Node Temperature: Case	35.8 °C
Node Temperature: Junction	36.2 °C

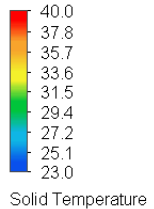
Quad PHY -U12B	
Node Temperature: Board	30.4 °C
Node Temperature: Case	36.2 °C
Node Temperature: Junction	36.7 °C

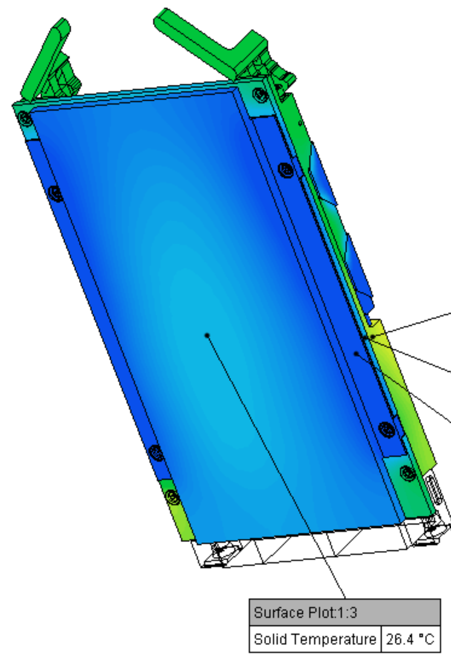


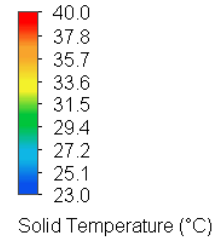
Frame/Board Surface Temperature Plot

Sandia Config., 23°C







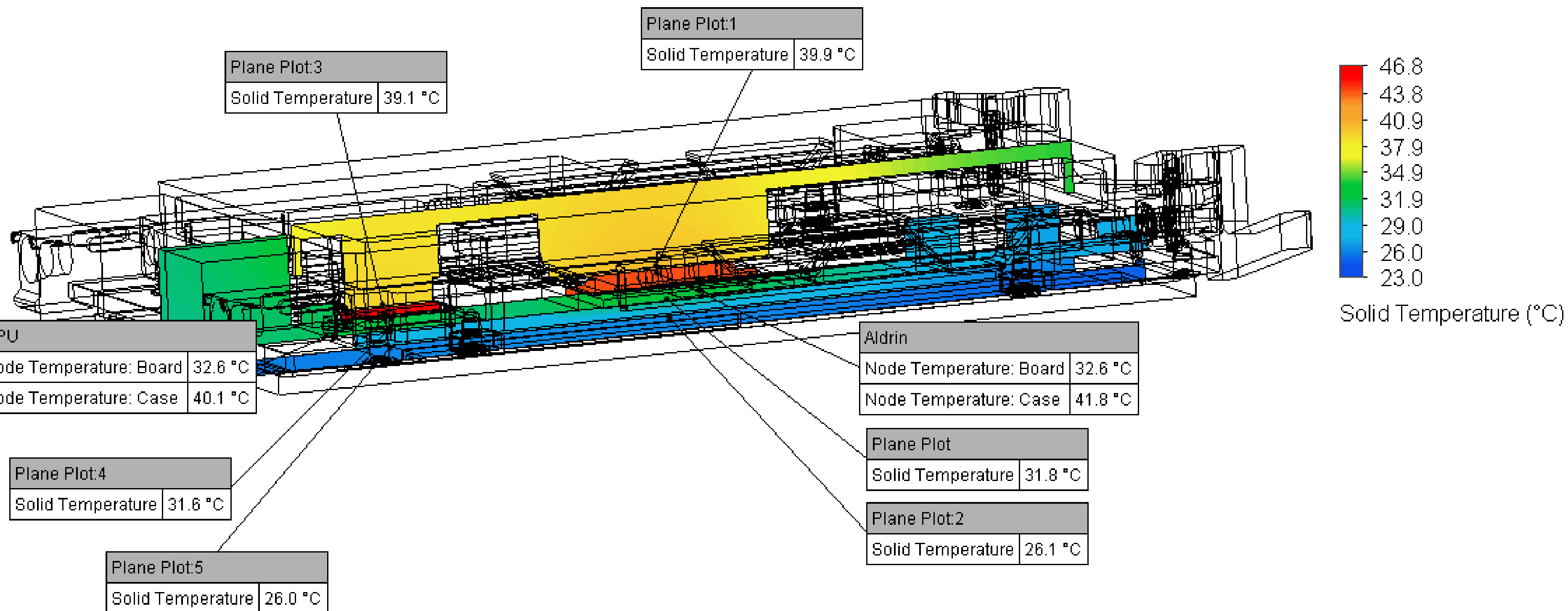


- There is a 9°C temperature gradient from the secondary frame to the primary frame which is a 5°C decrease compared to the baseline.

ElectronicCooling Solutions inc

CutplaneTemperature Plot: Mid-width of Aldrin

Sandia Config., 23°C

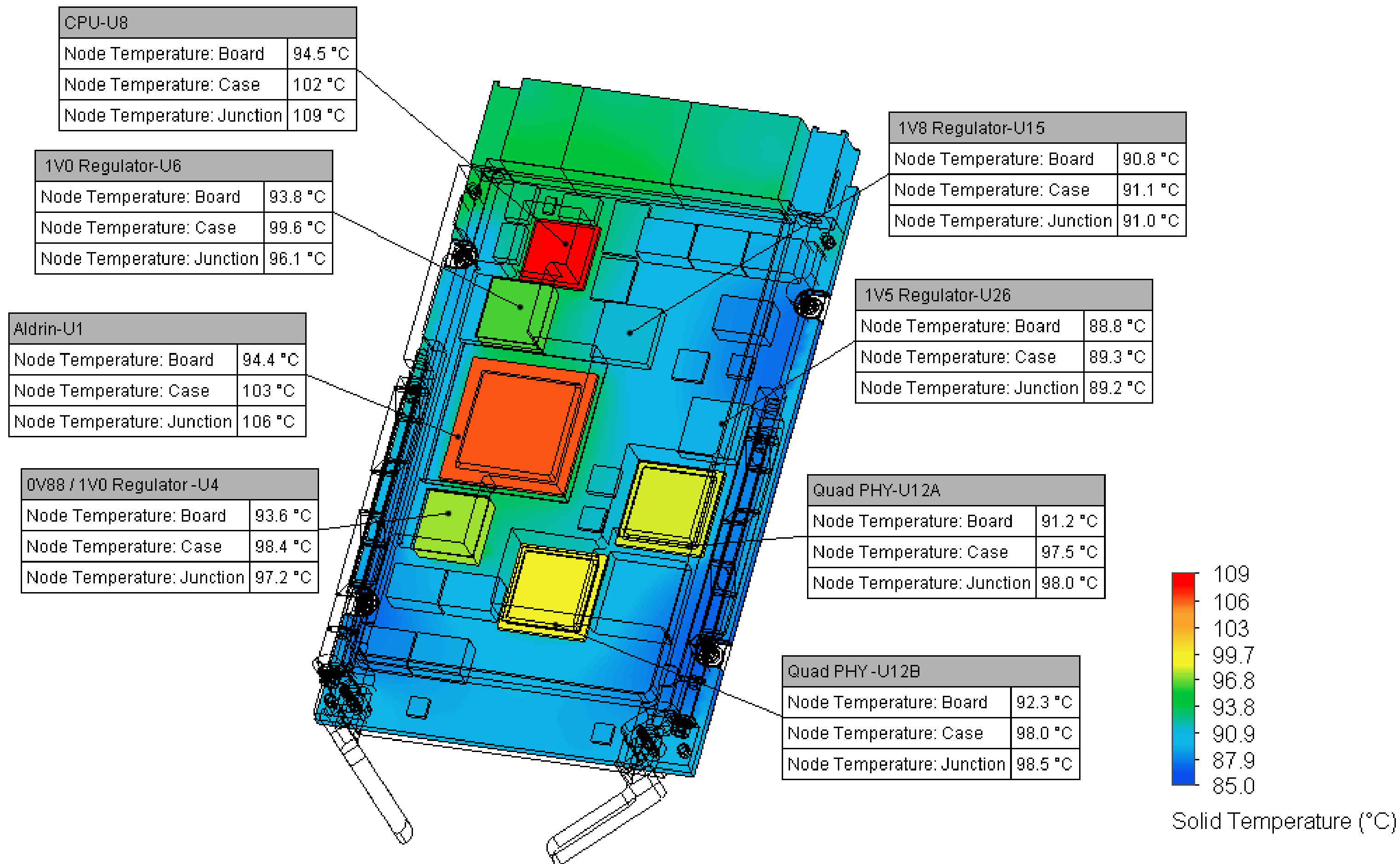


- There is a 2°C temperature gradient from the Aldrin top case to the primary frame.
- There is a 1°C temperature gradient from the CPU top case to the primary frame.
- These temperature gradients are significantly lower than the baseline.
- There is a 6°C temperature gradient from the board to the secondary frame that can be improved with a higher thermal conductivity gap pad.

ElectronicCooling Solutions inc

Board Surface Temperature Plot

Sandia Config., 85°C



ElectronicCooling Solutions inc

Recommendations

- The reduction in the thickness of the thermal gap pads for the Aldrin, CPU and Quad PHYs improved the junction temperatures such that all critical components are within their limits for Sandia Config. at the maximum operating temperature of 85°C. Implementation of this is highly recommended.
- Consider a higher thermal conductivity thermal gap pad (say k=3W/mK) coupling the PCB to the secondary frame to further improve the critical component temperatures.
- The contact areas between the primary frame and the secondary frame ideally must be increased. The addition of thermal gap pads on the contact areas between the primary and secondary frames helped reduce the temperature gradient between the two frames.
- For the 10G Op., the Quad PHYs exceed their limit by as much as 8°C at 85°C. It is recommended to limit the operating temperature to 70°C for this power scenario.
- For worst-case power, the Aldrin is 20°C over the limit at 85°C. It is recommended to limit the operating temperature for this scenario with this current configuration to 60°C.