# An Advanced Design of an Isothermal Coldplate

## Abstract

Coldplates are traditionally used as a heat removal system. Due to the sensible heating of the coolant, they have temperature gradients across their surfaces. If temperature control is desired (being defined as maintaining an isothermality range across the coldplate rails), traditional coldplates may not deliver the desired performance. However, by using novel approaches to coolant path configuration and channalization, the predicted isothermal profile of a coldplate can be lowered by a factor of 7 beyond the coolant temperature rise.

## Introduction

The system being investigated is a bank of nine electronics cards that are mounted between two coldplates via wedgelocks and rails. RF components on the cards have performance characteristics that are a strong function of temperature. For the entire unit to function properly, all the RF components must be maintained within a 3.6 °F/2 °C isothermality band.

The coldplates are plumbed in parallel and cooled with 60/40 EGW. Note that this analysis investigates only single phase flow. Multi-phase flow would create a nearly isothermal profile, but that flavor of cooling resource is not available.

Each coldplate has nine raised rails that provide the physical mounts for the coldplates as well as the path for heat dissipation. The cards are held in position with standard wedgelocks.

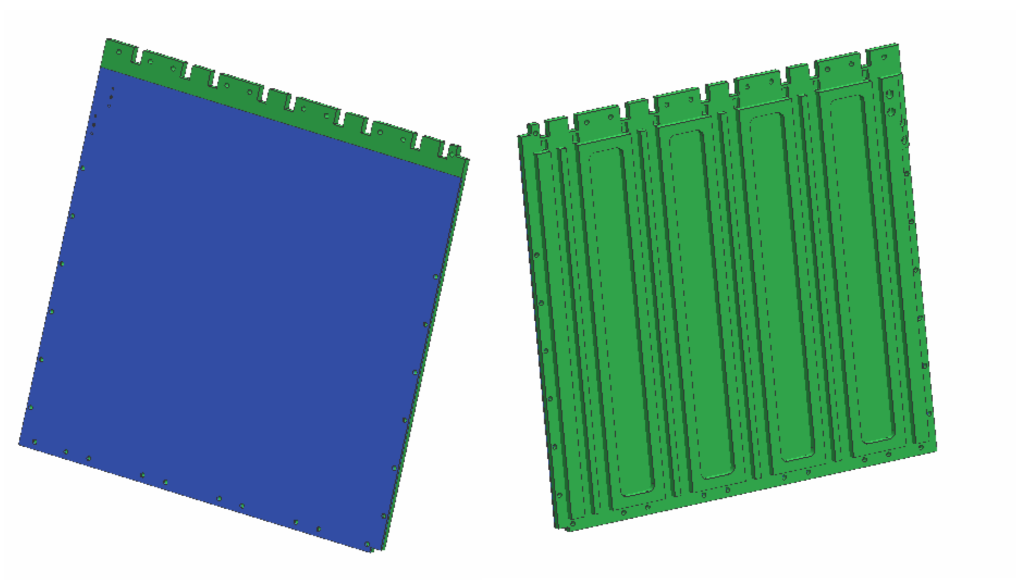

Figure I: Coldplate Backside and Frontside (with rails)

# Assumptions

The following assumptions have been used in developing the analysis models.

- Heat fluxes off the electronics cards are spread evenly on the coldplate rails.
- Each electronics card dissipates 50 watts. 25 watts per side.
- Inlet coolant rates to the coldplate are a function of the next higher assembly. For this analysis, the flow rate is 1.042 lbm/min.
- The 3.6 °F/2 °C isothermality requirement for the RF components has been flowed down to the coldplate rails.
- Coldplates are entirely aluminum construction.

The various analyses were performed in TAS, Version 8.2.11.

# Analysis

Using the stated assumptions for coolant flow and heat loads, and a Cp of 13.48 W-min/lbm-F (24.27 W-min/lbm-C, 60/40 EGW), the coolant temperature rise through the coldplate is 16.0 °F/8.9 °C.

A standard coldplate configuration has a single pass serpentine flow with finstock in the channels to augment the heat transfer. Using a coldplate of this configuration (see Figure IIa), the analysis model predicts a rail temperature variation of 15.6 °F/8.7 °C (see Figure IIb). These values correspond directly to the coolant temperature rise noted above.

Figure IIa: Single Pass Serpentine Configuration

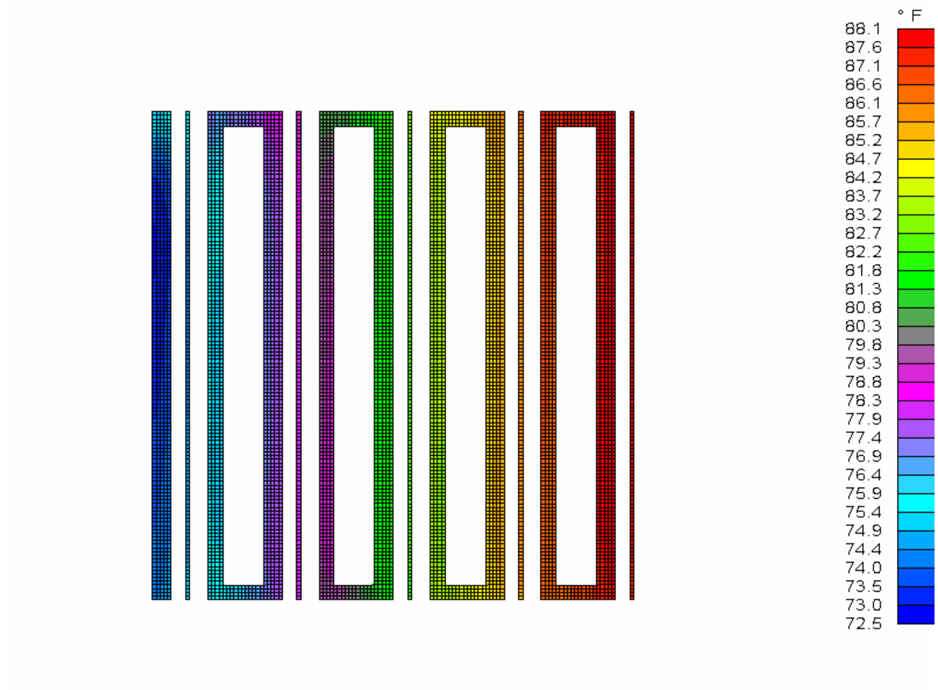


Figure IIb: Rail Temperatures for the Standard Coldplate Configuration

To reduce the temperature variation across the coldplate rails, a dual serpentine coldplate was devised. In this configuration, the flow path turns back on itself and attempts to moderate the entire coldplate at the average coolant temperature. (See Figure III.)

The dual serpentine configuration also has the advantage of putting the inlet and the exit ports next to each other. There is a significantly longer path length creating more pressure drop. But even with this extra pressure drop, the system is within its requirement (< 30 psi).

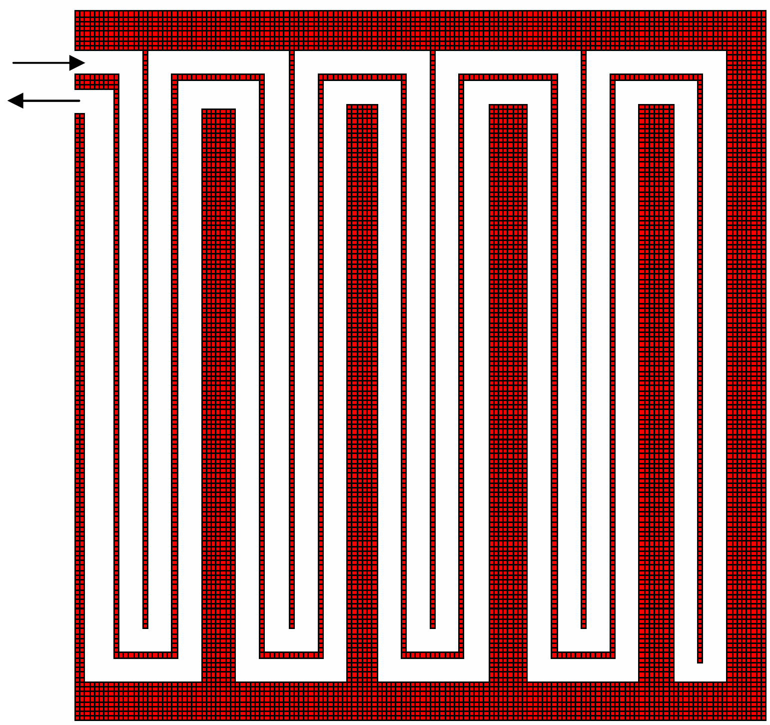

Figure III: Dual Serpentine Configuration

However, thermal analysis of the dual serpentine configuration shows that the rail temperatures (shown in Figure IV) still demonstrate an isothermality of 10.1 °F/5.6 °C.  This still does not meet requirements but is an improvement.

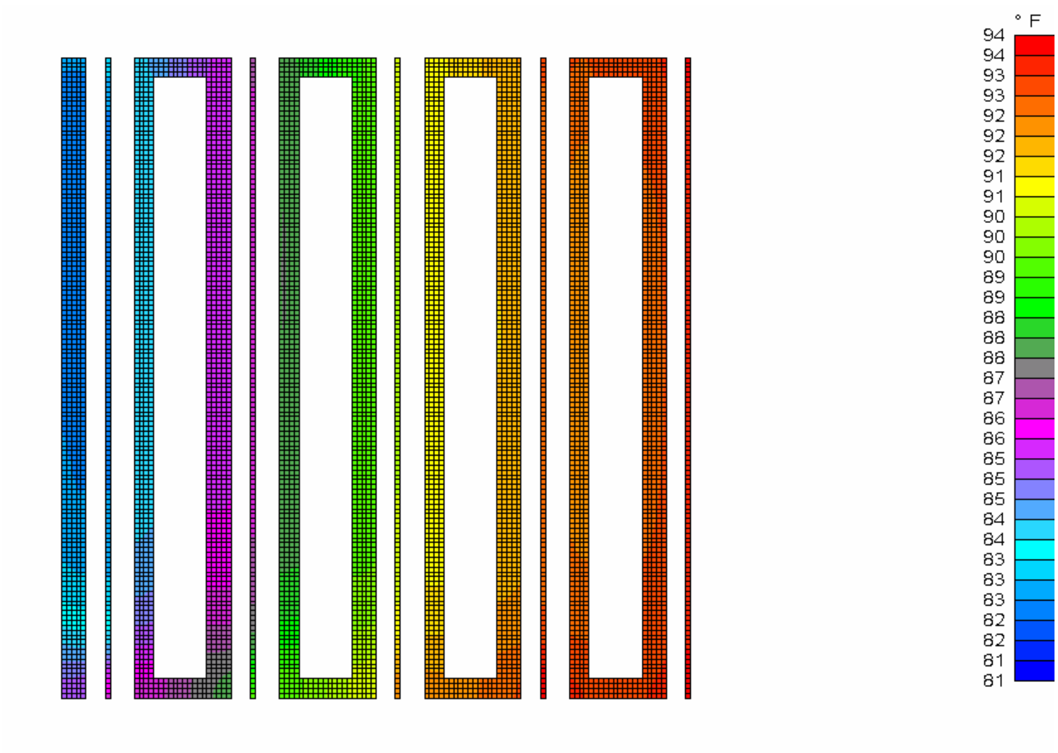


Figure IV:  Rail Temperatures for the Dual Serpentine Configuration (Reference Figure III)

A deeper analysis of the above model revealed that the colder inlet flow was picking up the heat from the rails too fast. In effect, all the heat in the system was being channeled over to the left side of the coldplate and into the coolant at the inlet, creating, unwanted isotherms. Knowing this, a mechanism was sought that would “slow down” the heat transfer into the inlet fluid section.

Removing the finstock is one method of slowing down the heat transfer rate in the coolant flow channels. This would make the overall temperatures of the electronics components warmer, but they were still well within their absolute temperature specification because of margin. Another added effect of removing the fin stock would be a reduction the pressure drop.

Figure V shows the thermal profile of the coldplate rails for a dual serpentine coldplate with no fin stock. The isothermality across the rails has been reduced to 6.0 °F/3.3 °C. This still does not meet the isothermality requirement of 3.6 °F/2 °C but it is further improvement. Removing the finstock also had the secondary effect of reducing the overall cost of the coldplate.

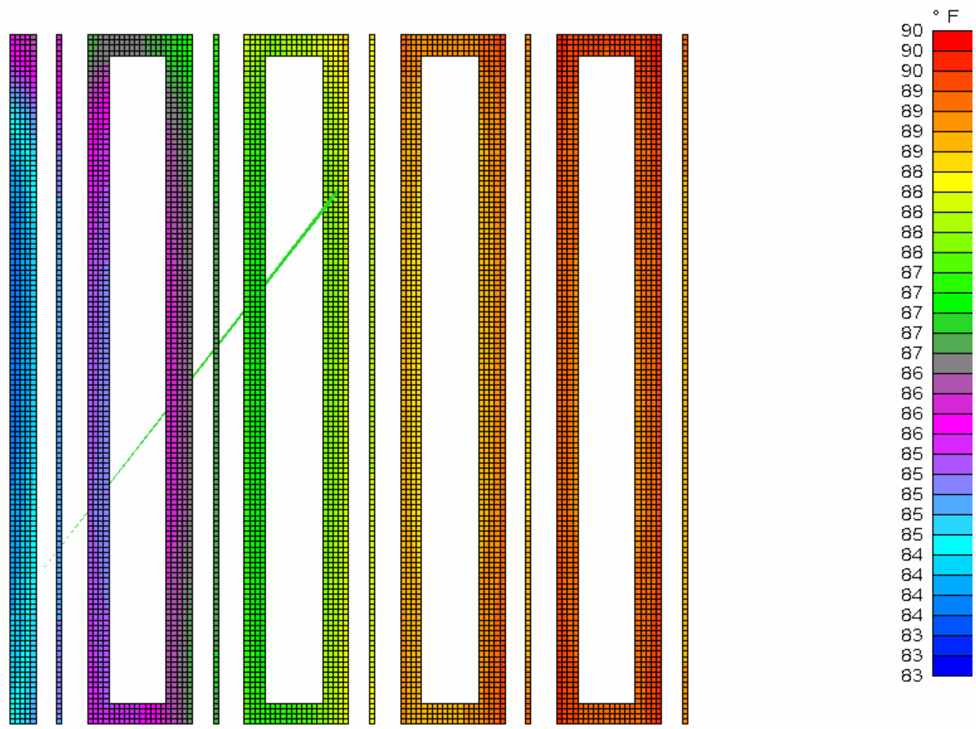


Figure V: Rail Temperatures for the Dual Serpentine, No Fin Stock Configuration
(Reference Figure III)

The last available option is to modify the channel heights. If the velocity of the inlet fluid is reduced by making the channel taller, the (laminar) heat transfer coefficients would be reduced. In effect, the coolant nearer the entrance would be less efficient at absorbing heat than the coolant nearing the exit.

Channel heights for coolant exiting the coldplate were maintained at 0.075" while channel heights for the coolant entering the coldplate were increased to 0.145". The results can be seen in Figure VI. The isothermality across the coldplate rails is now 2.2 °F/1.2 °C. This meets the isothermality requirement and leaves margin for error.

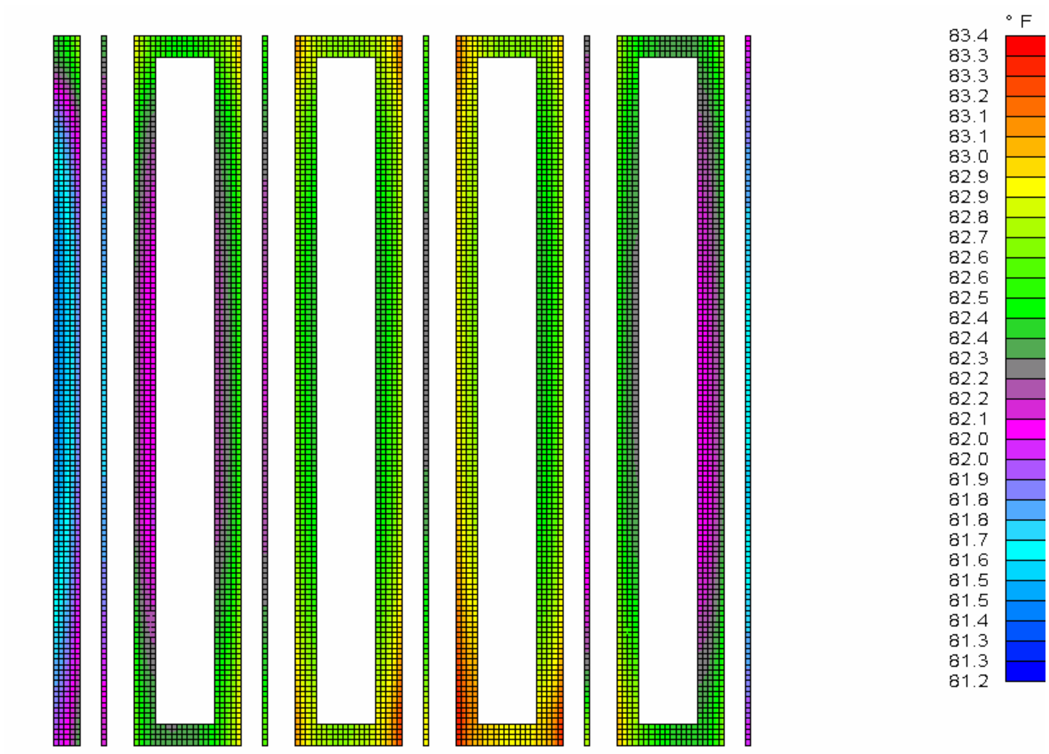


Figure VI: Rail Temperatures for the Dual Serpentine, No Fin Stock, Variable Channel Height Configuration (Reference Figure III)

## Summary

Table I summarizes the isothermality of each coldplate design.

Table I: Coldplate Configuration Isothermality

| Coldplate Configuration | Isothermality |
|---|---|
| Single Pass/Baseline | 15.6 °F/8.7 °C |
| Dual Serpentine | 10.1 °F/5.6 °C |
| Dual Serpentine/No Finstock | 6.0 °F/3.3 °C |
| Dual Serpentine/No Finstock/Variable Channel Height | 2.2 °F/1.2 °C |

## Conclusions

The various modifications to the configuration have had their contributions quantized and charted.

- By modifying a standard coldplate configuration, rail temperature isothermality can be lowered by a factor of 7 over the coolant flow temperature rise.
- The isothermality requirements of the RF electronics are now met.
- The coldplate provides temperature control in addition to heat removal.
- The cost of the coldplate has been reduced.

## Acronyms

| | |
|---|---|
| Cp | Specific Heat |
| EGW | Ethylene Glycol/Water |
| TAS | Thermal Analysis System (A commercial thermal analysis software code) |
| RF | Radio Frequency |