Parametric Studies on Miniaturization of Immersion Cooling Technology for Desktop PC and Edge Devices

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Agenda

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- ❑Scope of Work & Methodology
  - Concept for Miniaturizing Immersion Cooling
  - Proof-Of-Concept Chassis
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- ❑Experimental Studies & Optimizations
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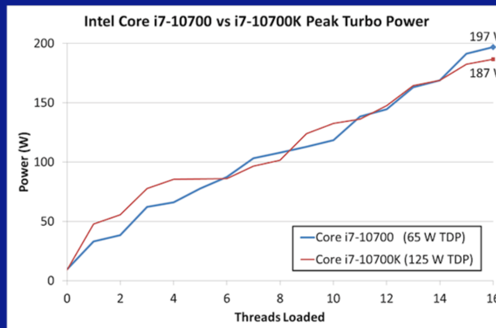
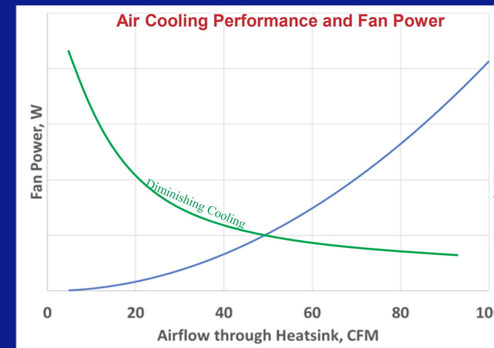
- ❑Summary / Key Takeaway

Introduction

- SFF (Small Form Factor) Desktop PC are more popular with high performance.
- High performance drives CPU power higher and requires more efficient cooling.
- Existing SFF Desktop PCs are limited to air cooling with diminishing thermal benefit.
- Innovative cooling solution needed to address high platform power with multiple heat sources.

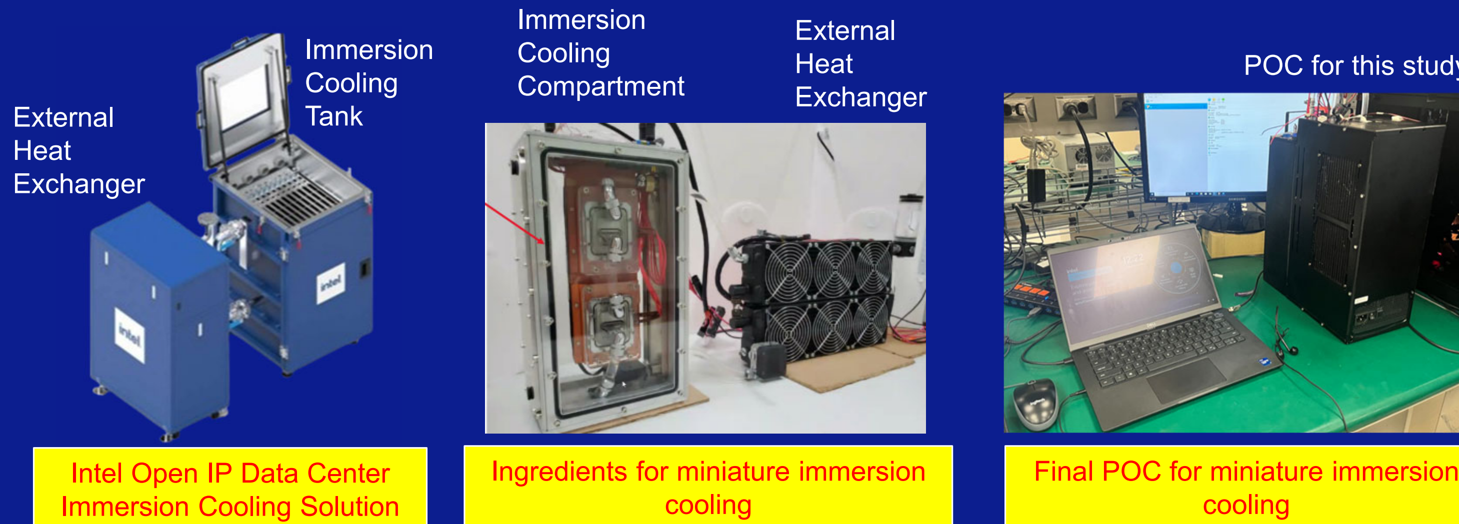


Client CPU Package Power Trend vs Number of CPU Threads



Example of a Mini-ITX desktop chassis

Concept for Miniaturizing Immersion Cooling



Intel Open IP Data Center Immersion Cooling Solution

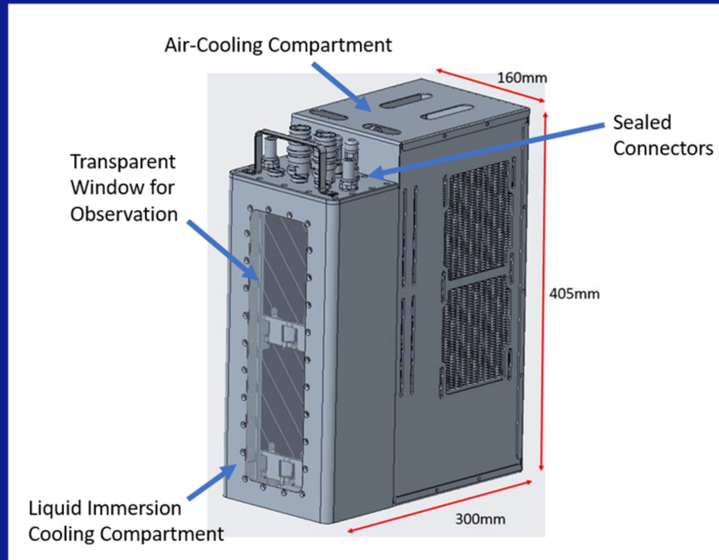
Ingredients for miniature immersion cooling

Final POC for miniature immersion cooling

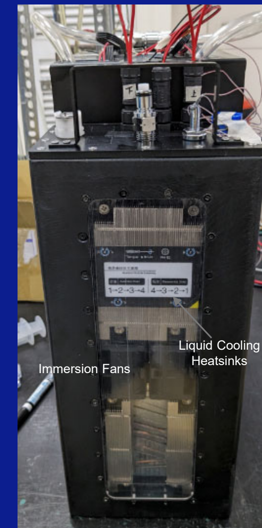
Key factors for miniaturization in this study:

- Single phase immersion cooling liquid
- Self-contained chassis
- Single board with two heat sources

Proof-Of-Concept Chassis



Experimental Setup	
Dummy Heater	51mm*67.9mm, 2pcs
Immersion Fan	40mm*40mm*56mm, 2pcs
Air-cooling Module	240mm*120mm*25mm, 2pcs
Air-cooling Fan	120mm*25mm, 4pcs
Pump	Syscooling-SC-P60A
Thermally Conductive Compound	TC-5888
Immersion Liquid	Noah3000A



Liquid Immersion Cooling Compartment

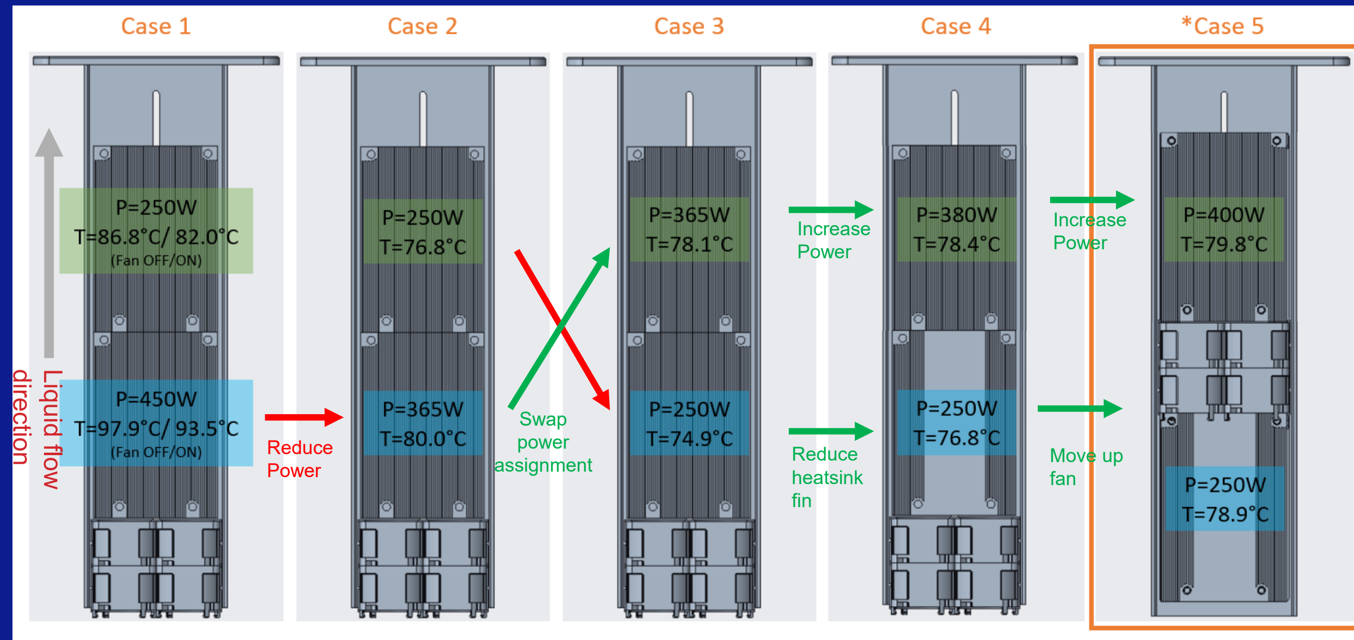
Air-Cooling Compartment

Immersion Liquid Selection

Vendor	Vendor 1	Vendor 2	Vendor 3
Model Name	Material 1	Material 2	Material 3
Density (g/mL)	1.815	1.855	0.799
Viscosity (cSt)	1.353	2.2	5.1
Cp (J/kg℃)	1176.8	1100	2260
Thermal conductivity (W/mK)	0.0623	0.065	0.14
Flash point (℃)	None	None	159

- Liquid specifications were reviewed for thermal, fluid, electric constant and resistivity, electronic compatibility, biodegradability, health and safety, etc.
- Material 1 was selected for the POC study with the above considerations

Experimental Studies & Optimization



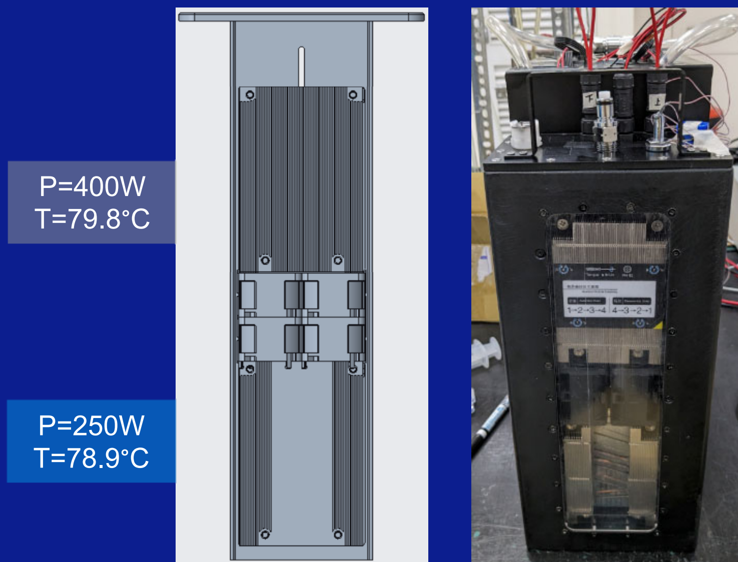
P = Power provided by heater (Unit: Watts)
T = Case temperature on heater (Unit: °C)

- Optimizing the heat sink configurations, fan placement, and max input power to achieve the required thermal target.
- We assumed the dummy heaters need to meet T_case < 80°C (typical of desktop CPU requirement).
- **Case 5** is the final optimized configuration in this study.

Results and Discussion

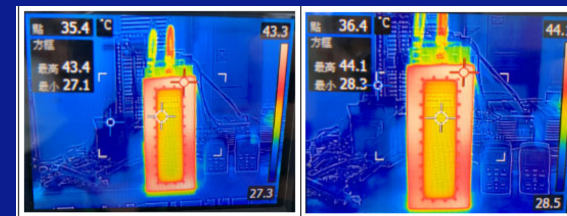
P=400W
T=79.8°C

P=250W
T=78.9°C



Item	Description	Measured Data
Heater 1	Power	400 W
Heater 2	Power	250 W
Temperature	Ta_inlet	25.4°C
	Ta_outlet	35.8°C
	Tcase_Heater1	79.8°C
	Tcase_Heater2	78.9°C
	Δ(Tcase – Ta)_Heater1	54.4°C
	Δ(Tcase – Ta)_Heater2	53.5°C
Thermal Resistance	Rca_Heater1	0.136°C/W
	Rca_Heater2	0.214°C/W

Achieved 650W total power in this compact form factor.



Summary / Key Takeaway

- First time bringing liquid immersion cooling into client/edge desktop segment
  - ❑ Self-contained immersive cooling approach
  - ❑ Compact mechanical chassis structural design of the compartmentalization
  - ❑ Optimizations of thermal load distribution, immersion fan positions & heat sinks
- Achieved an overall cooling capability of 650W applicable for high performance.
  - ❑ Pave the way for high performance CPU in SFF system
  - ❑ Premium system with thermal solution cost adder vs traditional air-cooling
- Share our study with the rest of the industry + explore collaboration opportunities.

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