ENGG 114 Heat Transfer Design Report
Project B: Heat Sink for a CPU Chip

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This report presents the design of a forced-convection heat sink for a desktop CPU chip dissipating 100 W at steady state. The official project requirement is to keep a vertically mounted 50.8 mm by 50.8 mm chip at or below 85 °C in 25 °C ambient air while interfacing with existing mounting hardware. A stricter derated design target of 70 °C was also used to guide concept development. Three concepts were considered: a copper pin-fin natural-convection heat sink, an aluminum folded-fin heat-pipe concept, and an Al-6061 forced-convection plate-fin heat sink. The selected final design is a 15-fin Al-6061 plate-fin heat sink developed from an idealized 17-fin thermal baseline. MATLAB predicts a total thermal resistance of 0.4485 °C/W for the final 15-fin design, corresponding to a chip temperature of 69.85 °C without an added thermal interface/contact penalty. Fusion 360 predicts a maximum temperature of 69.775 °C for the final 15-fin model under the modeled boundary conditions. A 17-fin ideal baseline is thermally superior, with Fusion 360 predicting a maximum temperature of 61.487 °C, but the 15-fin design is selected because it improves fin spacing, tool access, lower mass, airflow practicality, and manufacturability. The final 15-fin design is predicted to satisfy the official 85 °C requirement and narrowly meet the 70 °C derated target in simplified modeling. Prototype validation is required before making real-world performance claims.

Declaration of Original Work

I, Adriel Ventura, am registered for ENGG 114 Heat Transfer in the Spring 2026 semester. I submit this report, “Project B: Heat Sink for a CPU Chip,” to Professor Nicholas DiZinno for assessment. The design calculations, MATLAB analysis, CAD modeling, Fusion 360 simulation interpretation, and project conclusions presented here are my own work except where sources, software, course materials, or external references are explicitly cited. I understand that Hofstra University may take disciplinary action if this work is not my own.

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I. Introduction

A. Background

Microprocessors and compact electronic devices dissipate electrical power as heat. As electronic packages become smaller and more powerful, heat flux increases and thermal management becomes essential to prevent failure, reduce performance throttling, and maintain reliability. The assigned design problem concerns a desktop PC CPU chip whose current cooling system is inadequate. The replacement cooling system must remove 100 W of steady-state heat while keeping the chip below the specified temperature limit.

Forced-convection heat sinks are commonly used for CPU cooling because they offer high heat rejection capability, low cost, and simpler packaging compared with heat-pipe or liquid-cooling systems. A plate-fin heat sink was selected for this project because it provides a practical balance between thermal performance, manufacturability, fan-assisted airflow, and compatibility with a compact square footprint.

B. Project Objective

The objective of this project is to design a cooling system for a vertically mounted desktop PC CPU chip. The chip is 50.8 mm on a side, dissipates 100 W, and operates in case air at 25 °C. The official requirement is that the chip remain at or below 85 °C. A stricter derated target of 70 °C is also used as an internal design goal. The final design must interface with existing mounting hardware and must be supported by calculations, plots, CAD drawings, a bill of materials, and a prototype validation plan.

C. Design Strategy

The design process used a two-part engineering approach. First, an idealized 17-fin Al-6061 plate-fin baseline was developed to understand the thermal potential of a compact forced-convection heat sink. This baseline performed well thermally but created tighter fin spacing and less tool access. Second, the design was refined into a final 15-fin DFMA design. The 15-fin version has slightly reduced thermal performance but improves spacing, tool access, lower mass, airflow practicality, and manufacturability.

D. Physical 3D-Printed Demonstration Models

In addition to the MATLAB model, Fusion 360 simulation, and SolidWorks drawing package, two physical demonstration models were produced: one for the idealized 17-fin baseline and one for the final 15-fin DFMA design. These 3D prints are not used as thermal validation because they are not manufactured from Al-6061 and do not reproduce the final thermal conductivity of the actual heat sink. Instead, they are used as physical design-review tools to compare geometry, fin spacing, tool access, mounting practicality, and assembly clearance.

Passing both prints around during the presentation helps connect the analytical design story to the physical design constraints.

II. Problem Definition and Specifications

A. Official Requirements

The official Project B requirements define the physical and thermal constraints used throughout the design. Table 1 summarizes the main requirements and their engineering implications.

Table 1 Project Specifications and Engineering Implications

Parameter	Value	Engineering Implication
CPU footprint	50.8 mm × 50.8 mm	Hard boundary for chip contact area
Orientation	Vertical	Fan-assisted flow is preferred
Heat load, Q	100 W	Steady-state heat rejection requirement
Ambient air, T_∞	25 °C	Reference temperature for convection
Official chip limit	≤ 85 °C	Project pass/fail temperature limit
Derated design target	≤ 70 °C	Internal engineering target
Mounting	Existing hardware interface	Requires practical hole/access geometry
Validation	Prototype demonstration	Required before real-world claims

The official maximum total thermal resistance is calculated from the allowable temperature rise:

$$R_{failure} = \frac{T_{max} - T_\infty}{Q} \tag{1}$$

$$R_{failure} = \frac{85\,^\circ\text{C} - 25\,^\circ\text{C}}{100\,\text{W}} = 0.6000\,^\circ\text{C/W} \tag{2}$$

The stricter derated design target is:

$$R_{derated} = \frac{70\,^\circ\text{C} - 25\,^\circ\text{C}}{100\,\text{W}} = 0.4500\,^\circ\text{C/W} \tag{3}$$

Therefore, a design with total thermal resistance below 0.6000 °C/W is predicted to satisfy the official requirement. A design at or below 0.4500 °C/W is predicted to satisfy the stricter 70 °C design target.

B. Rubric Alignment

The report was structured around the ENGG 114 design report rubric. The rubric weights the report according to Problem Definition, Design Concepts, Concept Development, Drawing Package, and Technical Writing.

Table 2 Report Alignment with the 400-Point Design Rubric

Rubric Category	Max Points	Report Response
Problem Definition	20	Defines official thermal, geometric, ambient, and mounting requirements.
Design Concepts	120	Compares three cooling concepts and justifies concept selection.
Concept Development	160	Develops the selected concept using MATLAB calculations, Fusion 360 results, BOM, and test planning.
Drawing Package	80	Specifies required SolidWorks drawing views, dimensions, notches, and mass properties.
Technical Writing	20	Uses organized sections, equations, tables, figures, and conservative engineering wording.

III. Conceptual Design and Evaluation

Three design concepts were evaluated: a copper pin-fin natural-convection design, an aluminum folded-fin/heat-pipe design, and an Al-6061 forced-convection plate-fin design. The concepts were evaluated using thermal performance, manufacturability, airflow practicality, tool access, mass, cost, and prototype readiness.

A. Concept A: Copper Pin-Fin / Natural Convection

Concept A used a copper pin-fin heat sink relying primarily on natural convection. Copper has high thermal conductivity and would improve heat spreading, but the lack of forced airflow makes this concept weak for a compact 100 W heat load. Copper also increases mass and cost compared with aluminum. This concept was rejected because natural convection was not considered sufficient for the project footprint and heat load.

B. Concept B: Aluminum Folded-Fin with Heat Pipes

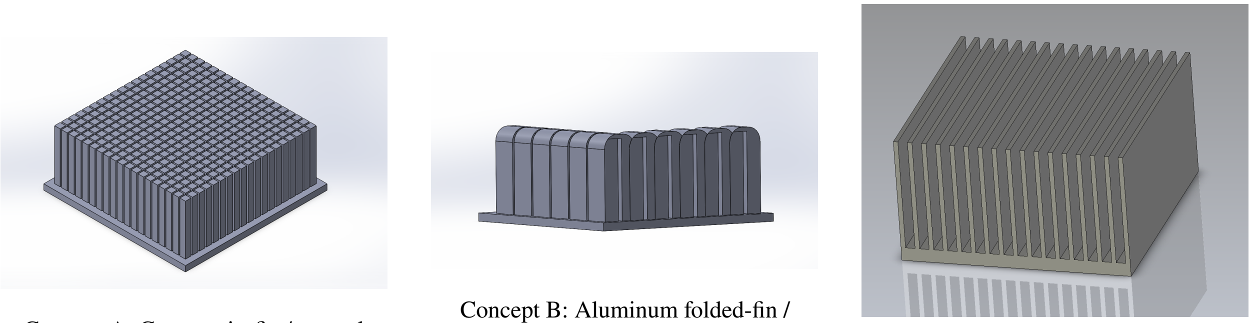
Concept B used an aluminum folded-fin geometry with heat pipes or vapor-chamber-style spreading. This concept has strong thermal potential, but it adds cost, complexity, packaging difficulty, and additional interfaces. For a small-business desktop PC heat sink, the complexity was not justified. This concept was rejected because the design objective could be met more simply using a forced-convection plate-fin design.

C. Concept C: Al-6061 Plate-Fin / Forced Convection

Concept C used an Al-6061 plate-fin heat sink with a 50 mm fan. Aluminum 6061 provides a practical balance of thermal conductivity, low mass, machinability, corrosion resistance, and cost. Forced convection improves the effective heat transfer coefficient and makes the 100 W cooling requirement achievable in the compact footprint. This concept was selected for further development.

Table 3 Concept Screening and Assessment

Concept	Description	Assessment	Decision
A	Copper pin-fin / natural convection	Heavy and insufficient for 100 W passive cooling	Rejected
B	Aluminum folded-fin with heat pipes	Strong but complex and costly	Rejected
C	Al-6061 plate-fin / forced convection	Best balance of performance and manufacturability	Selected



Concept A: Copper pin-fin / natural convection

Concept B: Aluminum folded-fin / heat-pipe concept

Concept C: Accepted Al-6061 forced-convection plate-fin concept

Fig. 1 Concept images used for the three design alternatives. Concept C was selected because forced-convection plate fins best balance thermal performance, cost, manufacturability, and mounting practicality.

IV. Selected Design Development

A. Two-Stage Design Story

The selected concept was developed in two stages. The first stage was an idealized 17-fin thermal baseline. The second stage was the final 15-fin DFMA design.

The 17-fin baseline was used to determine how much thermal performance could be achieved using a compact plate-fin geometry. Fusion 360 predicts a maximum temperature of 61.487 °C for this model under the modeled boundary conditions. However, this design has narrower spacing and reduced tool access.

The final design uses 15 fins instead of 17. This sacrifices some thermal performance but increases spacing, improves assembly access, lowers mass, and better supports manufacturability. The final 15-fin design is the selected design.

B. Final 15-Fin Geometry

The final selected geometry is summarized in Table 4.

Table 4 Final 15-Fin DFMA Geometry

Component / Metric	Final Value
Material	Al-6061 / Al-6061-T6
Number of fins	15
Fin height	29.29 mm
Fin thickness	1.00 mm
Clear spacing	2.557 mm
Base thickness	1.00 mm
Corrected fin length	0.029 79 m
Estimated mass	54.6 g
Footprint	50.8 mm × 50.8 mm
Tool access notches	7 mm access notches

C. Thermal Resistance Network

The thermal path is modeled as a chip-to-ambient resistance network. Heat flows from the CPU through the thermal interface, the aluminum base, and the fin array before reaching the ambient air.

```
        [ CPU: 100 W ]
               |
               v
[ TIM / Contact Resistance ]
               |
               v
  [ Al-6061 Base Conduction ]
               |
```

```
                v
   [ 15-Fin Convection to Air ]
                |
                v
        [ Ambient Air: 25 C ]
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The predicted chip temperature is calculated using:

$$T_{chip} = T_\infty + QR_{total} \tag{4}$$

For the final 15-fin design:

$$T_{chip} = 25\,^\circ\mathrm{C} + 100\,\mathrm{W}\,(0.4485\,^\circ\mathrm{C/W}) \tag{5}$$

$$T_{chip} = 69.85\,^\circ\mathrm{C} \tag{6}$$

The margin to the official limit is:

$$Margin_{85} = 85\,^\circ\mathrm{C} - 69.85\,^\circ\mathrm{C} = 15.15\,^\circ\mathrm{C} \tag{7}$$

The margin to the derated target is:

$$Margin_{70} = 70\,^\circ\mathrm{C} - 69.85\,^\circ\mathrm{C} = 0.15\,^\circ\mathrm{C} \tag{8}$$

This result shows that the analytical model predicts a pass for the official requirement and a marginal pass for the derated target.

V. MATLAB Analysis

MATLAB was used to evaluate fin count, fin height, spacing, thermal resistance, temperature, and mass trade-offs. The final 15-fin design was compared with the 17-fin ideal baseline. The baseline assumed convection coefficient was:

$$h = 65\,\mathrm{W/(m^2\,K)} \tag{9}$$

This value is an assumed modeling input. It is not treated as proven real fan performance unless fan P-Q data, pressure-drop calculations, CFD, or prototype measurements support it.

A. Final 15-Fin MATLAB Output

Table 5 MATLAB Console Proof for Final 15-Fin DFMA Design

Quantity	Value
Fin count	15
Fin height	29.29 mm
Fin thickness	1.00 mm
Clear spacing	2.557 mm
Base thickness	1.00 mm
Corrected fin length	0.029 79 m
Fin parameter, m	27.901/m
Fin efficiency, η_f	0.8195
Overall surface efficiency, η_o	0.8079
Penalized total area	0.042 68 m^2
Base resistance	0.0023 °C/W
Convection resistance	0.4462 °C/W
Total resistance without added TIM/contact penalty	0.4485 °C/W
Predicted chip temperature	69.85 °C
Estimated heat-sink mass	54.6 g
Margin to 85 °C	15.15 °C
Margin to 70 °C	0.15 °C
Official 85 °C requirement	Pass
Derated 70 °C target	Pass, but marginal

B. TIM and Contact Resistance Sensitivity

The 0.4485 °C/W result is reported without an added TIM/contact penalty. Since the margin to the 70 °C target is only 0.15 °C, contact resistance is important. Table 6 shows the effect of adding contact/TIM resistance.

Table 6 TIM / Contact Resistance Sensitivity

$R_{TIM/contact}$ (°C/W)	R_{total} (°C/W)	T_{chip} (°C)
0.00000	0.4485	69.85
0.00155	0.4500	70.00
0.00310	0.4516	70.16
0.01140	0.4599	70.99
0.05000	0.4985	74.85

The sensitivity results show that the final design is robust relative to the official 85 °C limit but sensitive relative to the 70 °C derated target. If the real installed interface resistance is higher than the ideal pad resistance, the final design may exceed the derated target while still satisfying the official requirement.

C. 15-Fin Final Design vs. 17-Fin Ideal Baseline

Table 7 Final 15-Fin Design vs. 17-Fin Ideal Baseline

Design	Fins	Spacing (mm)	R_{total} (°C/W)	T_{MATLAB} (°C)	T_{Fusion} (°C)	Mass (g)
Final 15-fin DFMA	15	2.557	0.4485	69.85	69.775	54.6
17-fin ideal baseline	17	2.1125	0.3529	60.29	61.487	75.3

The 17-fin baseline is thermally better. The 15-fin design is selected because it improves spacing, lower mass, tool access, airflow practicality, and manufacturability.

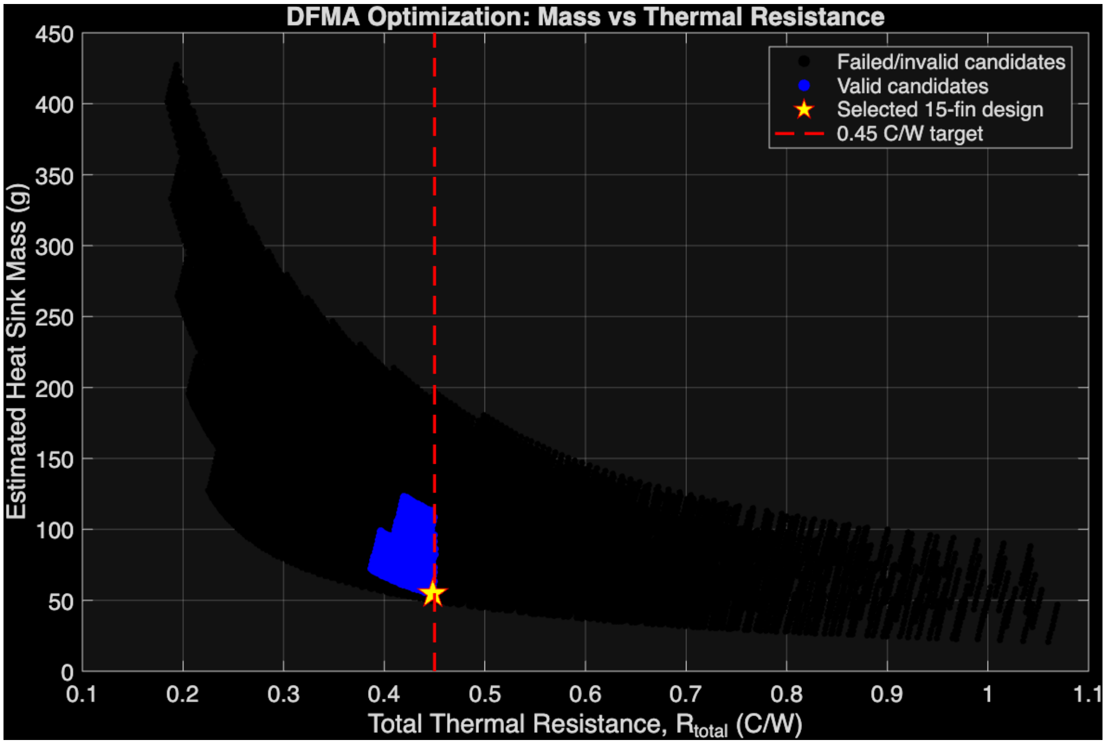


Fig. 2 Mass vs. thermal resistance from MATLAB parametric analysis. The selected 15-fin design balances thermal resistance with reduced mass and manufacturability.

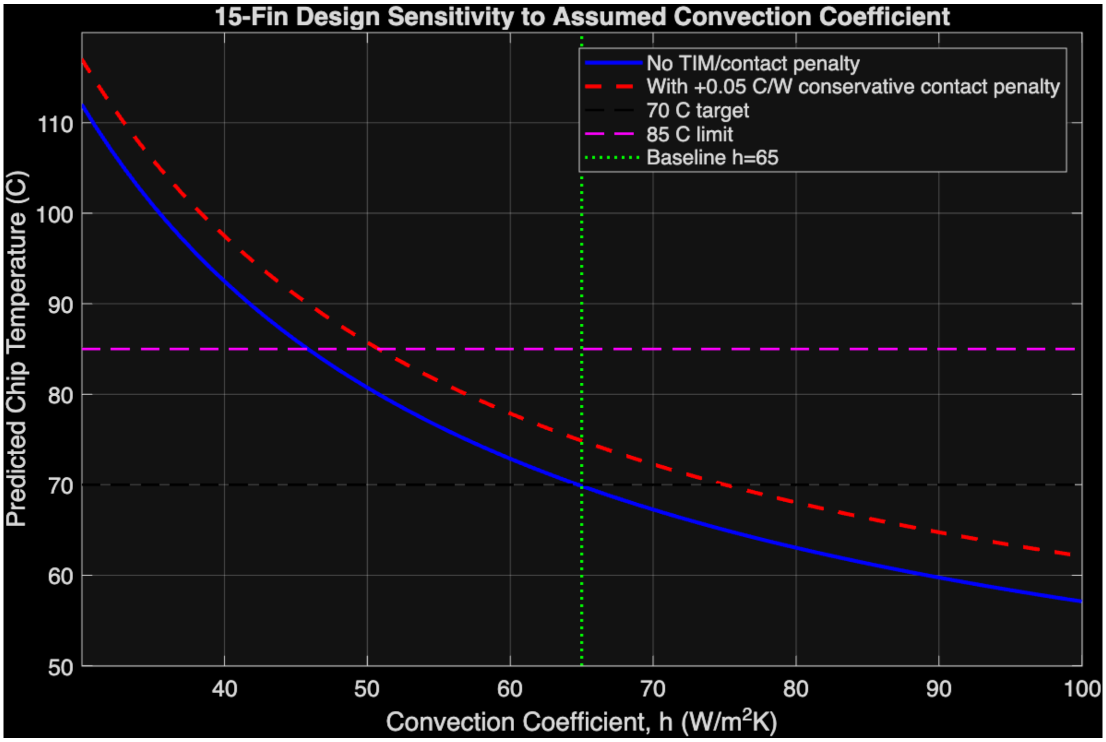


Fig. 3 Predicted chip temperature as a function of assumed convection coefficient. This plot shows why the assumed convection coefficient is a critical design input.

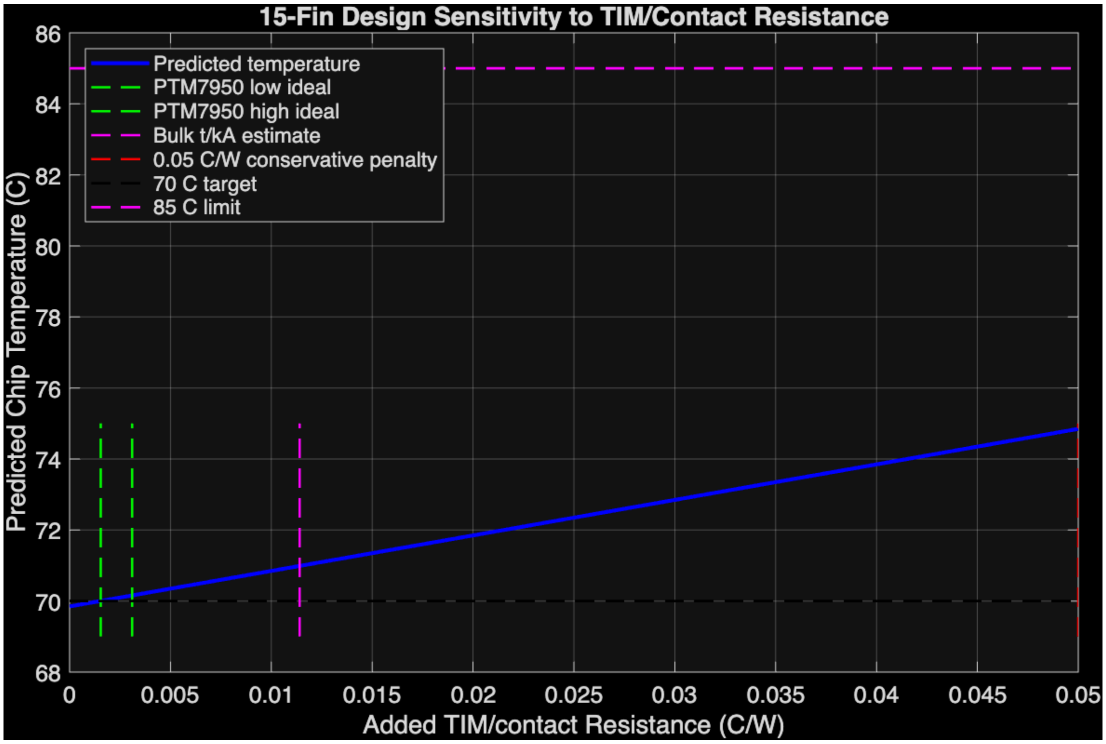


Fig. 4 Predicted chip temperature as a function of added TIM/contact resistance. The official 85 °C limit remains satisfied, but the 70 °C derated target is sensitive to interface resistance.

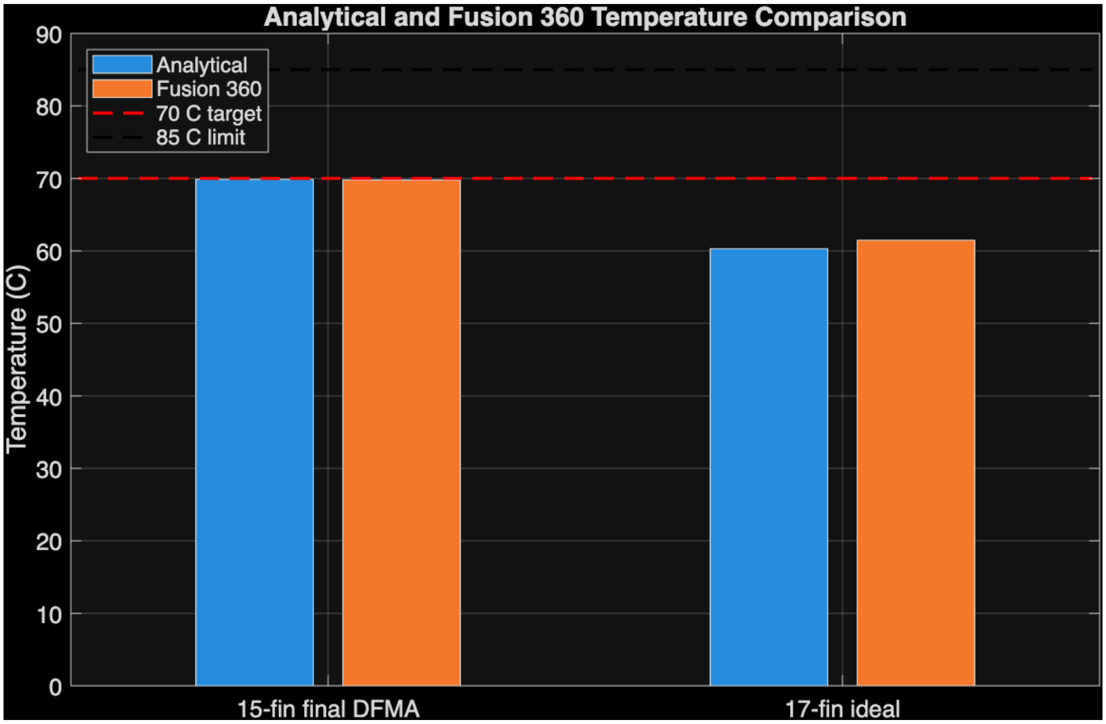


Fig. 5 Analytical and Fusion 360 temperature comparison for the final 15-fin DFMA design and the 17-fin ideal baseline.

VI. Fusion 360 Thermal Simulation

Fusion 360 was used to compare the ideal 17-fin baseline and final 15-fin DFMA model. The simulations are treated as simplified predictions under modeled boundary conditions rather than full validation.

Table 8 Fusion 360 Thermal Simulation Comparison

Model	Fins	Max Temp. (°C)	Meets 85 °C?	Engineering Interpretation
Final 15-fin DFMA	15	69.775	Yes	Selected final design; marginal relative to 70 °C target
17-fin ideal baseline	17	61.487	Yes	Thermally better, but less practical for spacing/tool access

Fusion 360 predicts that the final 15-fin model reaches a maximum temperature of 69.775 °C. This supports the selected design as a promising solution, but it does not prove real-world fan performance. The simulation result depends on the heat load, ambient temperature, material model, convection coefficient, convection-applied surfaces, mesh settings, and contact/TIM assumptions.

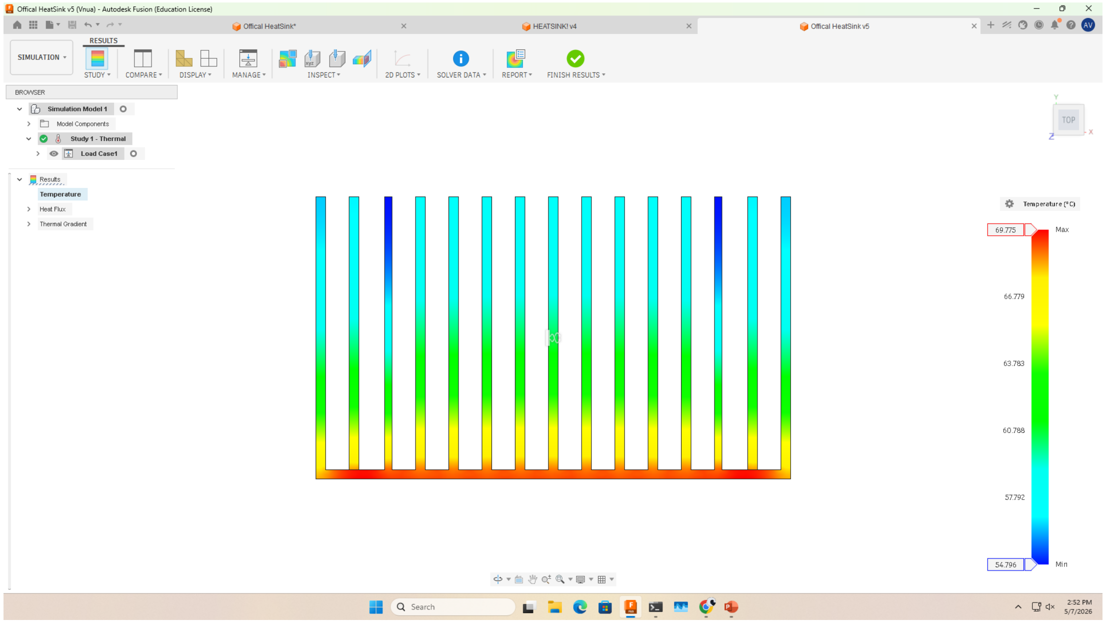


Fig. 6 Fusion 360 temperature result for the final 15-fin DFMA heat sink. Maximum modeled temperature is 69.775 °C.

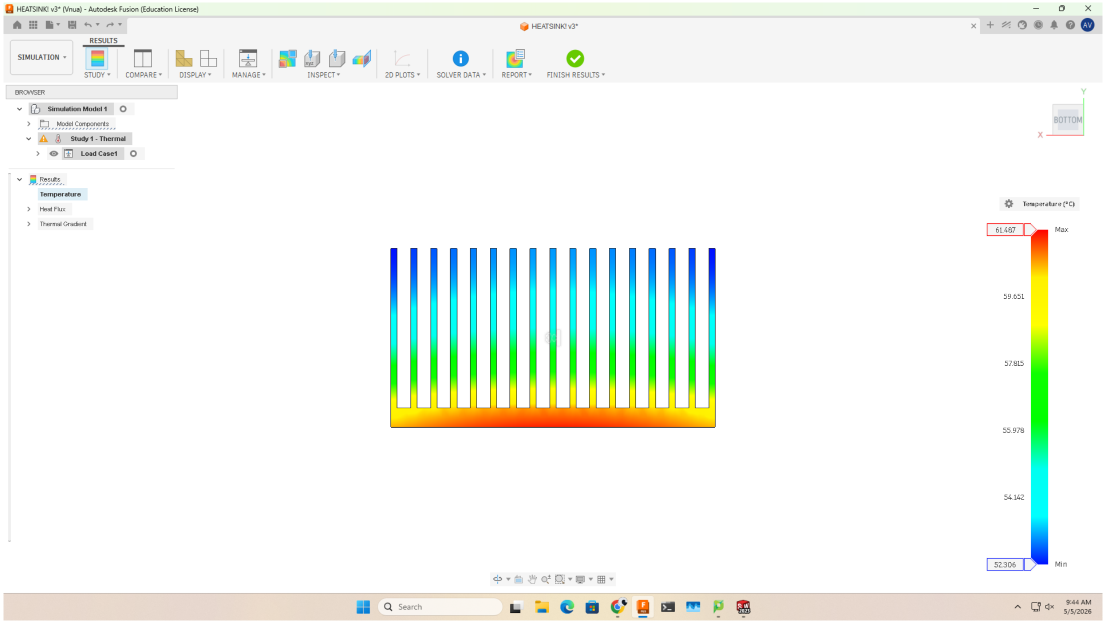


Fig. 7 Fusion 360 temperature result for the 17-fin ideal baseline. Maximum modeled temperature is 61.487 °C.

VII. Drawing Package

The drawing package defines the physical bounds of the manufactured heat sink. This is important because the MATLAB and Fusion 360 results only apply if the physical part matches the final modeled geometry. The final drawing package must be sufficient for fabrication and inspection of the selected 15-fin DFMA heat sink. The 17-fin drawing is included as the ideal thermal baseline, while the final 15-fin drawing is the selected design package.

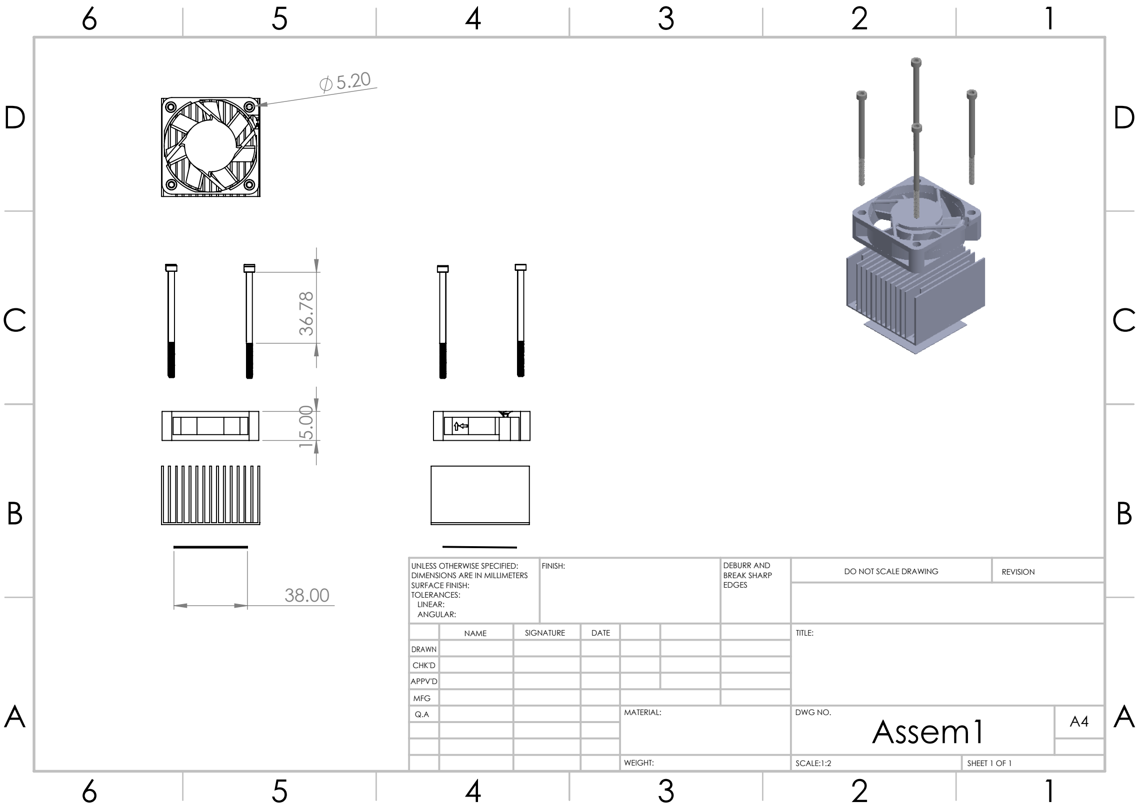


Fig. 8 Final SolidWorks drawing package for the selected 15-fin DFMA heat sink. This drawing defines the final build geometry used for manufacturing review and comparison with the analytical and Fusion 360 models.

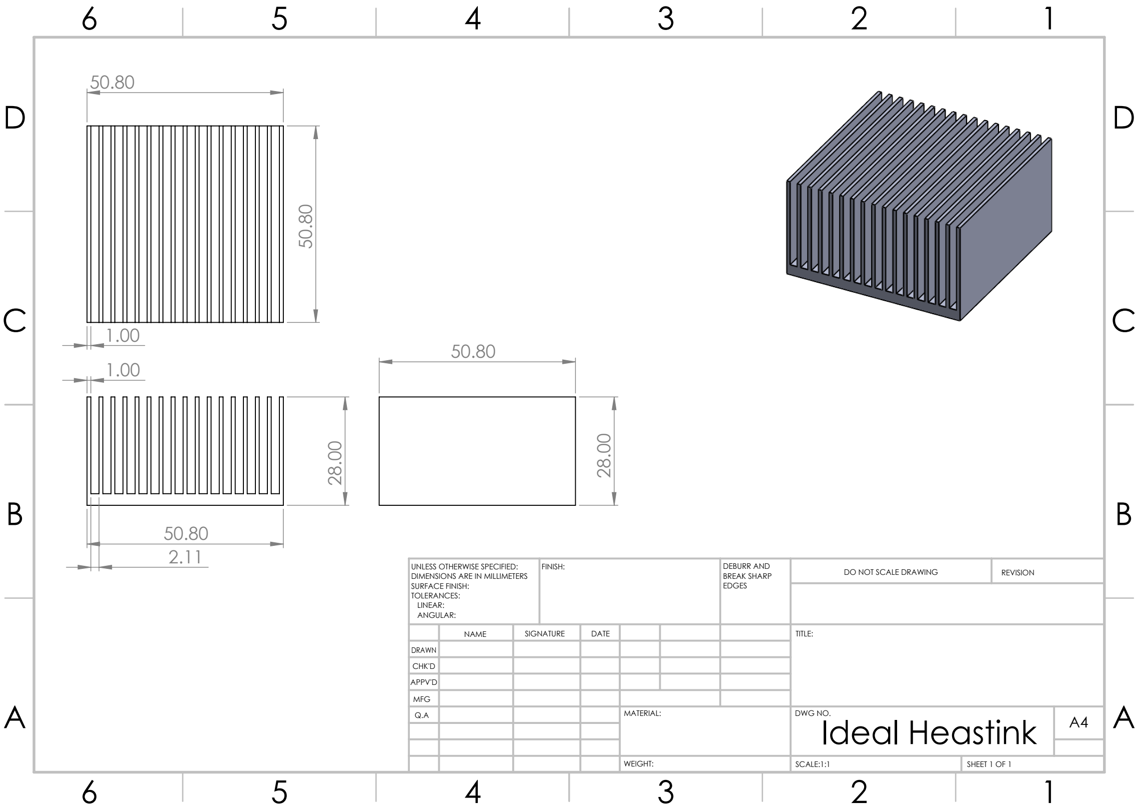


Fig. 9 Ideal 17-fin SolidWorks drawing package used as the thermal baseline. This model is cooler in simulation, but it is retained as a baseline rather than the selected final design because the final 15-fin DFMA design improves spacing, tool access, lower mass, and manufacturability.

The drawing package is the main evidence that the final design is buildable. If the final SolidWorks mass properties differ from the MATLAB mass estimate of 54.6 g, the CAD mass should replace the MATLAB estimate in the final report.

VIII. Bill of Materials

The bill of materials is separated into two groups: the final product BOM and the prototype/test BOM. The final product BOM contains the parts needed for the actual heat-sink assembly. The prototype/test BOM contains the equipment needed to experimentally verify whether the design satisfies the official 85 °C requirement at 100 W and approximately 25 °C ambient. This separation is important because the final cooling product and the validation equipment serve different purposes.

A. Final Product BOM

Table 9 Final Product Bill of Materials

Item	Vendor / Contact	Part No.	Description	Qty	Unit Cost	Ext. Cost	Justification
Heat sink body	McMaster-Carr / mcmaster.com	9146T84	Al-6061 stock	1	$38.61	$38.61	Raw material for the machined final 15-fin Al-6061 heat-sink body.
50 mm fan	Digi-Key / digikey.com	AFB0512HHB or AFB0512HHB-F00	12 V, 50 mm DC axial fan	1	$12.80	$12.80	Provides forced convection through the plate-fin channels.
Thermal pad / TIM	McMaster-Carr / mcmaster.com	1272N29	Thermal interface pad	1	$16.90	$16.90	Reduces contact resistance between the CPU simulator and heat-sink base.
M3 standoffs	McMaster-Carr / mcmaster.com	95947A030	M3 standoff hardware	4	$0.47	$1.88	Interfaces the heat-sink/fan assembly with existing mounting hardware.
M3 screws	McMaster-Carr / mcmaster.com	91292A110	M3 × 0.5 socket-head screw, 5 mm long	1 pack	$5.19	$5.19	Secures the heat sink, fan, standoffs, or mounting bracket.
M3 washers	McMaster-Carr / mcmaster.com	93475A210	18-8 stainless washer, 3.2 mm ID × 7 mm OD	4	$0.02	$0.08	Distributes fastener load and supports M3 mounting hardware.
Fan guard	Coolerguys / coolerguys.com	840556001294	50 mm wire fan guard	1	$0.89	$0.89	Reduces finger-contact risk with the 50 mm fan blades.
					Final Product Grand Total	$76.35	

Final product BOM note: The final product BOM includes only the parts needed for the cooling assembly itself: the Al-6061 heat-sink body, fan, TIM, fasteners, standoffs, washers, and fan guard. Prices are budgeting values and should be checked against current supplier pricing before purchase.

B. Prototype and Test BOM

Table 10 Prototype and Test Bill of Materials

Item	Vendor / Contact	Part No.	Description	Qty	Unit Cost	Ext. Cost	Justification
CPU simulator / heater	Rapid Industrial Supply or equivalent	Not commercially available through McMaster-Carr; included as a prototype concept.	100 W, 120 V cartridge heater, 1/4 in diameter × 1 in long	1	$17.43	$17.43	Provides the controlled 100 W heat load required to simulate the CPU.
Heater power supply	MicrosolderingSupply or equivalent	Korad KA3005D	Adjustable DC bench supply, 0–30 V, 0–5 A	1	$129.99	$129.99	Controls electrical input during heater or fan testing.
Power measurement	Lab stock	Lab multimeter	Digital multimeter / power meter	1	Lab stock	$0.00	Measures voltage and current so heater power can be verified.
Thermocouple wire	SteinAir or equivalent	Type-K FEP wire	20 AWG Type-K thermocouple wire with FEP insulation	5 ft	$2.50/ft	$12.50	Used to measure interface, base, fin, inlet air, and outlet air temperatures.
Data logger / DAQ	Omega or lab stock	OM-EL-USB-TC-LCD or equivalent	USB thermocouple data logger	1	$175.00	$175.00	Records temperature versus time until steady state.
Fan power supply	General electronics supplier	12 V DC adapter	Regulated 12 V DC adapter, ≥ 2 A	1	$12.00	$12.00	Runs the 50 mm fan at controlled voltage.
Test fixture / insulation	McMaster-Carr or lab stock	Not commercially available through McMaster-Carr; included as a prototype concept.	Vertical fixture and calcium-silicate insulation board	1	$30.00	$30.00	Holds the assembly vertically and reduces uncontrolled heat loss.
Safety equipment	Lab stock	Lab PPE	Heat-resistant gloves, eye protection, warning labels	As needed	Lab stock	$0.00	Protects against burn, electrical, and fan-contact hazards.
					Prototype/Test Grand Total	$376.92	

Prototype/test BOM note: The prototype/test BOM is not part of the final product cost. It lists the equipment needed to validate the design experimentally. Lab-stock items are listed at $0.00 for project purchasing purposes because they are assumed to be available through the university laboratory. If any item must be purchased instead of borrowed from lab stock, the total should be updated with the current vendor quote.

BOM summary: The final product assembly cost is estimated as $76.35. The prototype/test equipment cost is estimated as $376.92 if purchased new, or less if laboratory equipment is used. The report separates these totals because the final heat-sink assembly and the experimental validation setup are different deliverables.

IX. Prototype Validation Plan

A. Test Objective

The objective of the prototype test is to determine whether the final 15-fin heat sink can keep the chip temperature at or below 85 °C when dissipating 100 W in 25 °C ambient air. A secondary objective is to determine whether the design can meet or approach the 70 °C derated target.

B. Test Setup

A heater block with a 50.8 mm by 50.8 mm contact surface will simulate the CPU. The heat sink will be mounted vertically to match the project condition. The TIM will be installed between the heater block and heat-sink base. A 50 mm fan will drive air through the fin array.

C. Instrumentation

Table 11 Prototype Instrumentation Plan

Quantity	Instrument	Purpose
Heater power	Power meter or voltage/current measurement	Confirms 100 W input
Interface temperature	Thermocouple	Estimates chip/contact temperature
Base temperature	Thermocouple	Measures heat-sink base temperature
Fin temperature	Thermocouple	Checks fin temperature gradient
Ambient inlet temperature	Thermocouple	Confirms 25 °C ambient condition
Outlet air temperature	Thermocouple	Measures air heating across sink
Fan voltage/current	Multimeter or power supply readout	Confirms fan operating condition
Airflow or RPM	Anemometer or tachometer if available	Evaluates fan performance

D. Procedure

1) Assemble the heater block, TIM, heat sink, fan, and mounting hardware.
2) Install thermocouples at the interface, base, fin, inlet air, and outlet air locations.
3) Set ambient air temperature to approximately 25 °C.
4) Power the fan at its rated voltage.
5) Apply 100 W to the heater block.
6) Record temperatures, heater power, and fan operating condition over time.

7) Continue until steady state is reached. Steady state is defined as temperature change less than 0.5 °C over 5 minutes.
8) Repeat the test at least three times.
9) Compute total thermal resistance using Eq. (10).

$$R_{total,test} = \frac{T_{chip,test} - T_{\infty,test}}{Q} \tag{10}$$

E. Pass/Fail Criteria

Table 12 Prototype Pass/Fail Criteria

Criterion	Requirement
Official pass criterion	$T_{chip,test} \leq 85\,^\circ\text{C}$ at 100 W
Derated target criterion	$T_{chip,test} \leq 70\,^\circ\text{C}$ at 100 W
Steady-state condition	Temperature change < 0.5 °C over 5 minutes
Repeatability	At least three trials with similar results
Model comparison	Compare measured resistance to MATLAB and Fusion 360 predictions

X. Safety, Manufacturing, and Environmental Considerations

The heat sink and heater block may reach temperatures near or above 70 °C; therefore, burn hazard warnings and handling precautions are required during testing. The fan should include a guard to reduce finger-contact risk. The heater power supply and wiring should be arranged to avoid electrical hazards.

Manufacturing concerns include fin spacing, tool access, notch geometry, base flatness, and mounting hole alignment. The 15-fin design improves manufacturability compared with the 17-fin ideal baseline because it increases the clear spacing to 2.557 mm and includes 7 mm access notches. Base flatness and TIM compression are important because interface resistance strongly affects the derated 70 °C target.

Al-6061 or Al-6061-T6 is selected because it offers a practical balance of conductivity, density, machinability, availability, corrosion resistance, and cost. Aluminum is recyclable and commonly recovered in scrap streams. This report avoids claiming “100 percent recyclability” because actual recycling depends on collection and processing.

XI. Discussion

The final 15-fin heat sink is predicted to satisfy the official project requirement. The analytical result gives a chip temperature of 69.85 °C, and the Fusion 360 result gives 69.775 °C under modeled boundary conditions. Both are below the official 85 °C limit. The design also narrowly meets the 70 °C derated target in the current analytical and Fusion 360 models.

The 17-fin model is thermally superior, with Fusion 360 predicting 61.487 °C. However, the 17-fin design is less practical because its tighter spacing reduces tool access, increases assembly difficulty, and may increase pressure drop. The final 15-fin DFMA design is a better final product choice because it balances thermal performance with spacing, lower mass, tool access, airflow practicality, and manufacturability.

The major uncertainty is the convection coefficient. The model assumes $h = 65\,\mathrm{W/(m^2\,K)}$, but a real fan may not provide this effective heat transfer coefficient after installation. Pressure drop, fan P-Q curve behavior, flow maldistribution, and local stagnation can all affect performance. Therefore, this coefficient should be treated as an assumed model input rather than proven fan performance.

A second uncertainty is TIM/contact resistance. The analytical result has only a 0.15 °C margin to the derated target, so real interface behavior may determine whether the prototype remains below 70 °C. However, even conservative contact penalties leave the design well below the official 85 °C limit.

XII. Rubric Completion Checklist

Table 13 summarizes how the final report addresses the ENGG 114 design report rubric.

Table 13 Final Rubric Completion Checklist

Rubric Category	Points	Evidence Included in Report
Problem Definition	20	Official chip size, vertical mounting, 100 W heat load, 25 °C ambient, 85 °C limit, and derived thermal resistance targets.
Design Concepts	120	Three concepts are described and evaluated: copper pin-fin natural convection, aluminum folded-fin/heat-pipe concept, and Al-6061 forced-convection plate-fin concept.
Concept Development	160	MATLAB thermal resistance model, sensitivity plots, 15-fin vs. 17-fin comparison, Fusion 360 results, complete final-product BOM, separate prototype/test BOM, and prototype validation plan.
Drawing Package	80	Final and ideal SolidWorks drawing PDFs are included; the final drawing verifies dimensions needed for manufacturing and inspection.
Technical Writing	20	Report uses equations, tables, figures, conservative wording, and separates analytical prediction, simulation, physical demonstration models, and prototype validation.

XIII. Conclusions

The final selected design is a 15-fin Al-6061 forced-convection plate-fin heat sink. It was developed from an ideal 17-fin thermal baseline and refined into a manufacturable DFMA design. The 17-fin baseline is thermally better, with Fusion 360 predicting a maximum temperature of 61.487 °C, but it is less practical because of narrower spacing and worse tool access. The final 15-fin design improves spacing to 2.557 mm, reduces estimated mass to 54.6 g, and provides better assembly practicality.

MATLAB predicts a total thermal resistance of 0.4485 °C/W and a chip temperature of 69.85 °C for the final 15-fin design without added TIM/contact penalty. Fusion 360 predicts a maximum temperature of 69.775 °C under modeled boundary conditions. These results indicate that the final design satisfies the official 85 °C requirement and narrowly meets the 70 °C derated target in simplified modeling.

Prototype validation is still required before making real-world performance claims. The most important next steps are to complete the SolidWorks drawing package, document Fusion 360 boundary conditions, finalize BOM costs, verify CAD mass properties, and test the prototype at 100 W and 25 °C ambient.

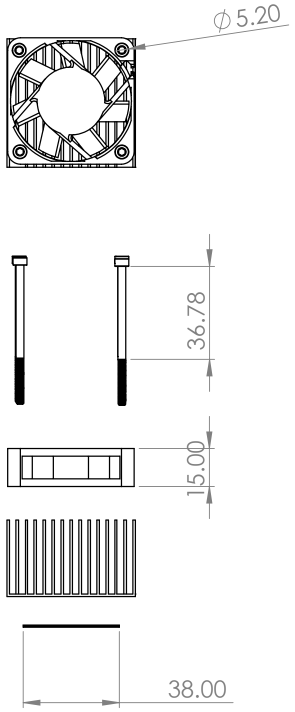
Acknowledgments

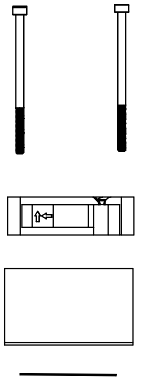
The author acknowledges Professor Nicholas DiZinno for instruction and guidance in ENGG 114 Heat Transfer during the Spring 2026 semester.

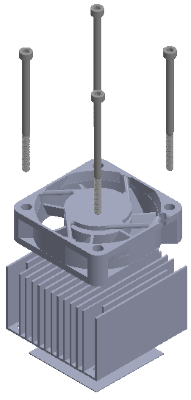
Appendix A: SolidWorks Drawing Packages

The full SolidWorks drawing packages are included for design review, fabrication, and inspection reference.

Final 15-Fin DFMA Drawing







UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

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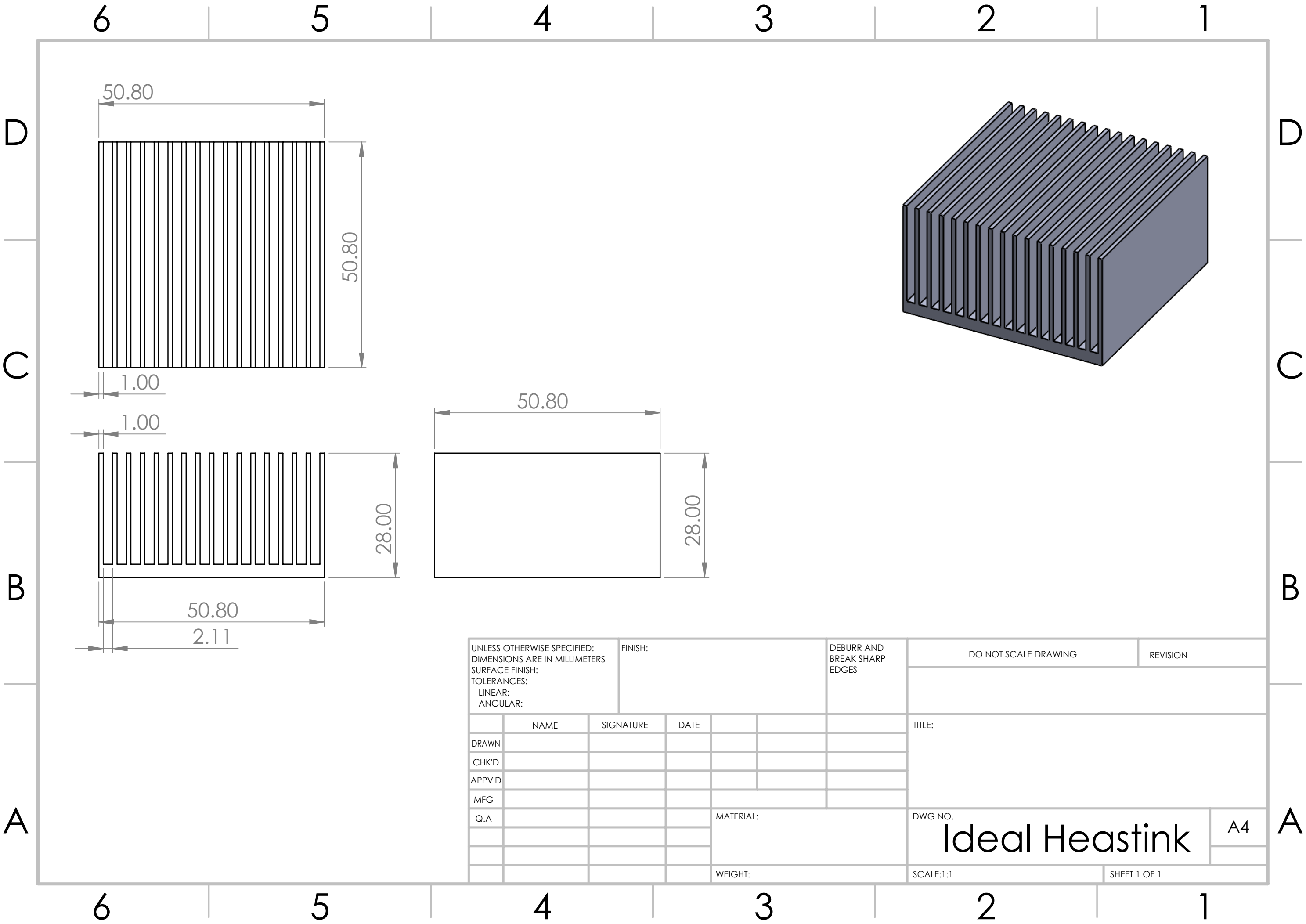
SHEET 1 OF 1

Ideal 17-Fin Baseline Drawing



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