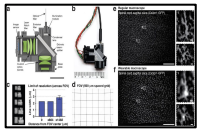
TEAM #13

ADVANCED IMAGE SENSOR MODULES FOR WEARABLE MINIATURE MICROSCOPES

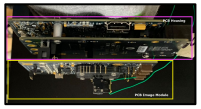
Team Members: Jami Pryde, Gilbert Mayengbam, Ava Romero, Georgia Hahn, Thomas Smith, and Weidong Moscato-Goodpaster
Mentors: Dr. Milton Aguirre, Dr. Axel Nimmerjahn

CUSTOMER BACKGROUND

The third generation of the Salk Institute's wearable microscope has six primary components, "the custom optics barrels (including eight microlenses), fluorescence filters, main body, image sensor module, illumination module, and base plate" [2].



[2]



The testing stand Team 13 inherited from the previous capstone group consists of two main subsystems: the PCB housing and the PCB image module.

PROBLEM STATEMENT / SCOPE OF WORK

Developing a new heat sink computationally by using ANSYS software and experimentally testing the new version against previous designs using our self-made lab setup. Testing an AR0331 ISM with DevWareX to allow for higher resolution, increased frame rate, increased sensitivity, as well as a dynamic range using monochrome, and color CMOS sensor technology.

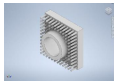


Figure Heat sink V1

Figure Heat sink V2

Figure Heat sink V3

Figure ISM Testing Stand

REQUIREMENTS

Req #	Design Requirements	Design Targets	Rational	Validation
1	ISM Weight	Final ISM shall be < 2 grams (including image sensor, PCB, and heat sink)	Requirment stated directly in Senior Capstone Project Catalog	Test weight by placing the final ISM on a scale.
2	ISM Length	Final ISM shall have 12 -15 mm side length and final heat sink should be 16.60 mm x 15.70 mm	Requirment stated directly in Senior Capstone Project Catalog	Test length by using a micrometer to measure the final ISM.
3	Heat Dissipation Temperature	The heat sink shall dispate enough heat so that the PCB does not exceed 80 degrees Celcius	Requirment stated directly in Senior Capstone Project Catalog	Monitor the temperature of the ISM using thermocouples.
4	Thermocouple Placement	The thermocouples measuring ambient and junction air temperatures shall be between 1 and 3 inches away from the surface of the heat sink	The distance is an industry standard for temperature measuring locations.	Verify by using a micrometer to measure distance during testing set up.
5	Testing Enviorment Size	The heat sink testing enviorment shall be 10.75 in x 10.75 in by 8 in.	These dimensions are used by Salk during their testing.	Test length by using a ruler to measure the final testing enviroment.
6	ISM Specifications	The image sensor shall output a minimum of 45 fps, be capable of processing images at 720p resolution, have a dynamic range of at least 82dB, provide at least 5.6V/lux-sec, not have a pixle size exceeding 3.7h um, and capture greyscale and color images.	Requirement stated in the datasheet of the image sensor used for all three microscope generations	Verify by analysing an input image in DevWare.

[1]"Heat Sink Testing Methods and Common Oversights (Part 1 of 3) | Advanced Thermal Solutions." https://www.qats.com/cms/2011/03/17/heat-sink-testing-methods-and-common-oversights-part-1-of-3/ (accessed Sep. 12, 2022).
[2] "Thermal Resistance - an overview | ScienceDirect Topics." https://www.sciencedirect.com/topics/engineering/thermal-resistance (accessed Jan. 31, 2023).

EXPERIMENTATION / CONCEPTS EXPLORED

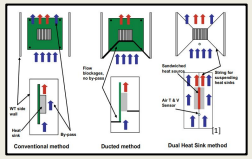


Figure Heat Sink Testing Methods [1]

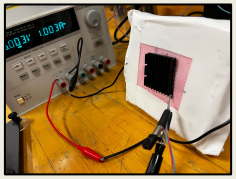


Figure Alpha Novatech heatsink

Figure DevWareX Data

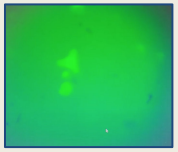


Figure DevWareX Image

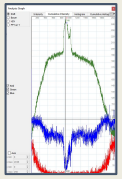


Figure DevWareX Results

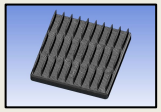


Figure Benchmark Heatsink Mesh

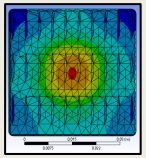


Figure Benchmark Steady-state

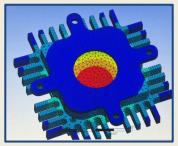


Figure SALK V3 Steady-state

FINAL DESIGN

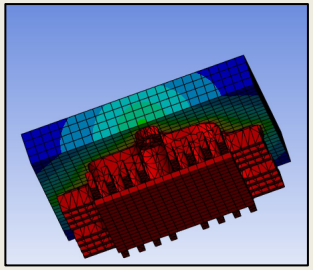


Figure Isometric View of Final SALK V3 Heatsink

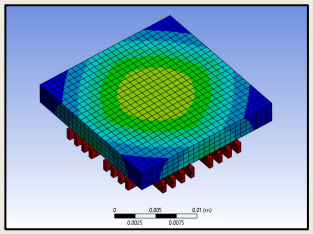


Figure Isometric View of Final ANSYS Simulation

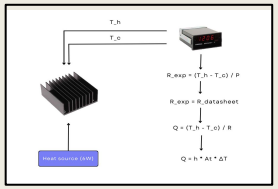


Figure Benchmark heatsink testing procedure

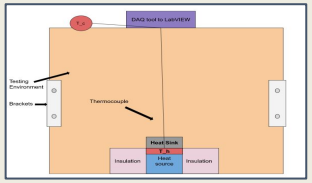


Figure Testing environment setup

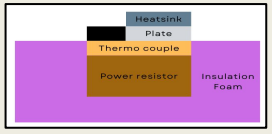


Figure Heat source diagram

FMEA

FMEA - Failure Modes and Effective Analysis

Key Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Action Taken
Benchmark Heatsink Testing									
Heat source fixture	Unresponsive cartidge heater	Unfunctional system for heatsink testing	8	Unavailable equipment for high AC supply	3	Have 2 other types of heaters as backup	9	216	Have a backup power resistor to match power dissipation
Heatsink base measurement	Inaccurate and unstable temperature values	Improper connection between T_h and base	8	Thermocouple tip not interfacing with base	2	Use solidifying thermal adhesive	7	112	Possibly acquire flat surface thermocouple
Heat adapter	Experimental setup failure	Heatsink fall off during testing	7	Depth of aluminum adapter too thin	4	Tie heatsink to heatsource with string	9	252	Use additional aluminum block and thermal adhesive for connection
Insulation foam failure	Inaccurate temperature values	Higher T_h values	4	Air gaps in the insulation	4	Insulate around the power resistor tightly	9	144	Insulation spray between insulation foam
Salk Heatsink Testing									
Heat Transfer	Inaccurate T_h values	Improper connection between adapter plate and heatsink	5	Micro-heatsink movement	3	Calibration of heatsink mount before testing procedure	3	45	Heatsink mounting is verified before every test run
Thermal resistance calculation	Varying ambient temperature	Air conditioner setting	2	Current temperature setting of the lab, heatsource convection	2	Check AC controls before starting testing	7	28	Move thermocouple T_c away from any heatsource
Unecessary convection	Exposed heatsink surface causing convection	Cooler heatsink and T_h temperature values	7	Improper insulation	4	Foam insulation tape around the heatsource	9	252	Extra foam on top of heatsink surface

TESTING RESULTS

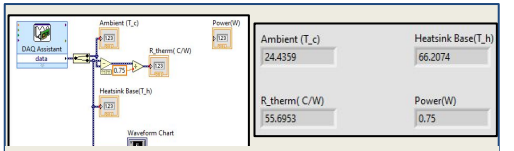


Figure LabVIEW Block Diagram and Front panel view

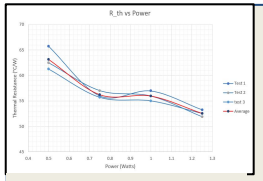


Figure Thermal Resistance vs Power

Our experimentation has revealed that the Salk heatsink performs best with power dissipation levels between 1-1.25W. By utilizing our testing method, we were able to determine the heat sink thermal resistance for various power levels, providing valuable insights into its performance. These results offer the opportunity for future optimization of the heatsink use in a variety of applications.

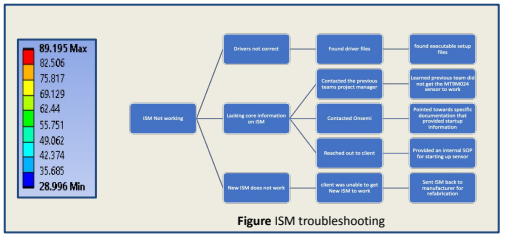


Figure ISM troubleshooting