

**SELECTION AND EXECUTION OF A SERIES
MEASUREMENTS TO INVESTIGATE THERMAL
CONDUCTIVE MATERIALS USE FOR COOLING
ELECTRONIC COMPONENTS IN IP65/67 POWER SUPPLY
UNIT CONSIDERING THE ASSEMBLY AND COSTS**

By

Mikola Francesco
11901038

BACHELOR'S DEGREE
in

MECHANICAL ENGINEERING – MECHATRONICS CONCENTRATION
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY



SWISS GERMAN UNIVERSITY
The Prominence Tower
Jalan Jalur Sutera Barat No. 15, Alam Sutera
Tangerang, Banten 15143 - Indonesia

Revision after the Thesis Defense on 10th July 2023

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Mikola Francesco

Student

18.07.2023

Date

Approved by:

Dr. Yunita Umniyati, S.Si., M.Sc.

Thesis Advisor

18.07.2023

Date

Christian Wolfförster, B.Eng.

Thesis Co-Advisor

18.07.2023

Date

Dr. Maulahikmah Galinium, S.Kom., M.S

Dean

24.07.2023

Date

Mikola Francesco

ABSTRACT

Investigating Thermal Conductive Materials for Cooling Electronic Components in IP65/67 Power Supply Unit

By

Mikola Francesco

Dr. Yunita Umniyati, S.Si., M.Sc., Advisor
Mr. Chrisian Wolfförster, B. Eng., Co-Advisor

SWISS GERMAN UNIVERSITY

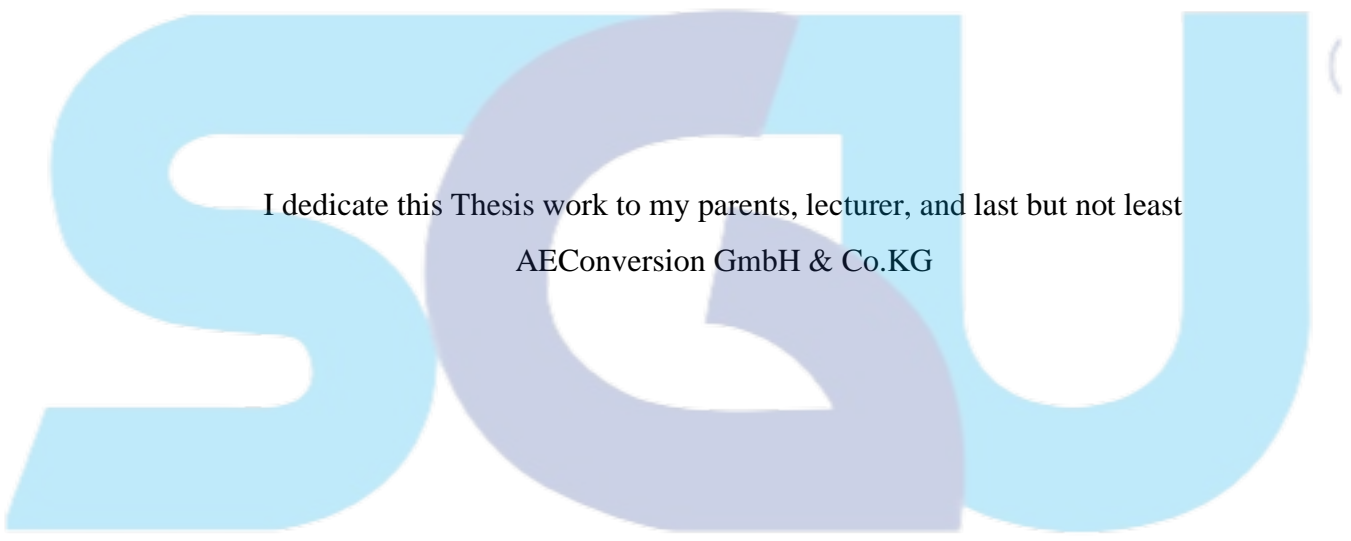
Cooling components inside Power Supply Unit (PSU) is vital to prevent the device from overheating. In the IP65/67 Power Supply Unit, there is another important problem to be solved as the power supply is working underwater and isolated from outer environment. This means there will be no air circulation and the heat are accumulated inside the power supply.

The purpose of this thesis work is to design and assemble the cooling system that suits the IP65/67 Power Supply Unit (PSU). The PSU currently experiencing over temperature in a several components inside. By applying heat transfer theory and method, conductive heat transfer method must be applied. The cooling components must be designed to reduce the heat and temperature inside the power supply. The components and materials can be defined through calculation and research. Several materials can be used as thermal conductive materials to help absorb heat and reduce temperature inside the power supply while the device is running. After the calculation and design has finished, the cooling system must be assembled and tested inside the PSU. After obtaining the result, the final components and material must be assembled so the IP65/67 Power Supply Unit (PSU) can run smoothly and will not experience any overheating issues. It is recommended to use the material with a high thermal conductivity and high dielectric strength for safety reasons and better heat conduction.

Keywords: IP65/67 PSU, Thermal Conductive Materials, Heat transfer, Overheating, Phase change Materials



DEDICATION



I dedicate this Thesis work to my parents, lecturer, and last but not least
AEConversion GmbH & Co.KG

ACKNOWLEDGEMENTS

I am very thankful for the people that has support me in the making of this thesis work. The right guidance and gentle direction have been most appreciated. Dr. Yunita Umniyati, S.Si., M.Sc. was tremendously helpful in teaching me about the thermodynamics and guiding me toward the calculation in heat transfer method. Mr. Christian Wolfförster, B.Eng.'s intelligence and practical experience has taught me more about the IP65/67 Power Supply Unit and how it works. Finally, I would like to give my deepest gratitude to Dr. Theodor Schulte and Dr. Stefan Grösbrink. They gave me the chance to do the thesis work in AEConversion GmbH & Co.KG in Germany. From the beginning, they believed in my ability to complete this IP65/67 Power Supply Unit flawlessly.

Throughout the semester in Swiss German University. I found that all the subject and coursework has been very useful especially thermodynamics subject. The subjects have taught me a lot about what to do and choosing the right method and that helped me in finishing the thesis work.

TABLE OF CONTENTS

	Page
STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	5
ACKNOWLEDGEMENTS.....	6
LIST OF FIGURES.....	9
CHAPTER 1 - INTRODUCTION.....	15
1.1 Background.....	15
1.2 Research problems.....	16
1.3 Research Objectives.....	16
1.3 Significance of Study.....	17
1.4 Research Questions.....	17
1.5 Hypothesis.....	18
CHAPTER 2 - LITERATURE REVIEW.....	19
2.1 Theoretical Perspectives.....	19
2.1.1 Hybrid Heat Pipe based Passive Cooling for Nuclear Fuel Dry Storage Cask... 19	19
2.1.2 Engineering the Storage Battery as an Underwater Power Supply.....	20
2.1.3 Thermoelectric self-cooling for power electronics: Increasing the cooling power	21
2.1.4 IP65/67 Power Supply.....	22
2.1.5 Electrical Insulators.....	24
2.1.6 Thermal Conductors.....	24
2.1.7 Magnetic Components.....	25
2.1.8 Electro Optics Components.....	26
2.2 Theoretical Approach.....	27
CHAPTER 3 – RESEARCH METHODS.....	28
3.1 Theoretical calculation.....	28
3.2 Materials and Equipment.....	30
3.3 Testing Method.....	44
CHAPTER 4 – RESULTS AND DISCUSSIONS.....	54
4.1 Testing result.....	54

4.1.1	Material 1: Ceramic Plate	55
4.1.2	Material 2: Thermal Conductive Silicone Rubber Gap Filler.....	65
4.1.3	Material 3: Hi-Flow (Phase Change Material).....	75
4.2	Validity test	85
4.2.1	Ceramic Plate	86
4.2.2	Thermal Conductive Silicone Rubber Gap Filler	94
4.2.3	Hi Flow (Phase Change Material).....	102
4.3	Data analysis	110
4.3.1	Ceramic Plate	111
4.3.2	Thermal conductive silicone rubber gap filler	113
4.3.3	Hi Flow (Phase Change Materials).....	115
4.4	Efficiency	117
4.4.1	Ceramic Plate.....	117
4.4.2	Thermal Conductive silicone rubber gap filler	118
4.4.3	Hi Flow (Phase Change Material)	119
CHAPTER 5 – CONCLUSIONS AND RECCOMENDATIONS		121
5.1	Conclusions	121
5.2	Recommendations	122
Appendix.....		123
REFERENCES		128
CURRICULUM VITAE		129

LIST OF FIGURES

Figures	Page
Chapter 1	
Figure 1. 1. Phase change of PCM	14
Chapter 2	
Figure 2. 1. Codes and meaning for ingress protection	22
Chapter 3	
Figure 3.2 1. Technical drawing for shape number 1	29
Figure 3.2 2. Technical drawing for shape number 2	30
Figure 3.2 3. Technical drawing for shape number 3	31
Figure 3.2.4. Datasheet of the Ceramic Plate	31
Figure 3.2 5. Datasheet of Thermal Conductive Silicone Rubber Gap Fillers	32
Figure 3.2 6. Datasheet of the Hi Flow	33
Figure 3.2 7. Mounting for the IP65/67 Power Supply	34
Figure 3.2 8. Another view for the mounting of the IP65/67 PSU	35
Figure 3.2 9. Nut and washer for mounting	36
Figure 3.2 10. Temperature measurement device, Thermocouples type K	36
Figure 3.2 11. Thermocouples Type K	37
Figure 3.2 12. Chamber	38
Figure 3.2 13. Thermocouples connected with the receiver	39
Figure 3.2 14. AC input of the IP67/67 PSU	39
Figure 3.2 15. The DC Output of the IP65/67 PSU	40
Figure 3.2 16. The IP65/67 is set for testing	41
Figure 3.2 17. Temperature difference measurement outside the IP65/67 PSU	42

Figure 3.2 18. The IP67 Power Supply Unit	43
Figure 3.3. 1. Heat sink of the IP67 Power Supply	44
Figure 3.3. 2. Thermocouple pin number inside the IP65/67 Power Supply Unit	46
Figure 3.3. 3 Thermocouple pin outside the IP65/67 Power Supply Unit	46
Figure 3.3. 4. Input/output graph for the IP67 Power Supply	47
Figure 3.3. 5. The base of IP67 Power Supply Unit	47
Figure 3.3. 6. The base of IP67 PSU using 3D printed cavity holder for cooling material's precise position	48

Chapter 4

Figure 4.1. 1. Ceramic plate in the IP67 PSU as the Thermal Conductor	53
Figure 4.1. 2 Silicone in the IP67 PSU as the thermal Conductor	63
Figure 4.1. 3. Hi Flow in the IP67 PSU as the thermal conductor	73
Figure 4.2. 1. Ceramic plate after 5 hours of testing	109
Figure 4.2. 2. Thermal conductive silicone rubber gap filler after 5 hours of testing	111
Figure 4.2. 3. The Hi Flow Material after 5 hours of testing	113

Appendix

Figure 1. The IP67 Power Supply Unit	120
Figure 2. The IP67 Power Supply unit with the thermocouples	121
Figure 3. Fan to reduce the temperature in the chamber if the ambient temperature is too high	122
Figure 4. The 3 mm aluminium plate for Hi Flow	122
Figure 5. Voltage source for the fan	123
Figure 6. Voltage input for the IP67 Power Supply Unit	124

LIST OF TABLES

Table Page

Chapter 3

Table 3.3. 1 Maximum temperature for each component inside the IP65/67 PSU 48

Chapter 4

Table 4.1. 1. Pin 1 - 10 temperatures with ceramic plate as the Thermal Conductor 53

Table 4.1. 2. Pin 11 - 20 temperatures with ceramic plate as the Thermal Conductor 54

Table 4.1. 3. Pin 21 - 30 temperatures with ceramic plate as the Thermal Conductor 55

Table 4.1. 4. Pin 31 - 40 temperatures with ceramic plate as the Thermal Conductor 55

Table 4.1. 5. Pin 1 - 10 temperatures with ceramic plate as the Thermal Conductor 56

Table 4.1. 6. Pin 11 - 20 temperatures with ceramic plate as the Thermal Conductor 56

Table 4.1. 7. Pin 21 - 30 temperatures with ceramic plate as the Thermal Conductor 57

Table 4.1. 8. Pin 31 - 40 temperatures with ceramic plate as the Thermal Conductor 57

Table 4.1. 9. Pin 1 - 10 temperatures with ceramic plate as the Thermal Conductor 58

Table 4.1. 10. Pin 11 - 20 temperatures with ceramic plate as the Thermal Conductor
58

Table 4.1. 11. Pin 21 - 30 temperatures with ceramic plate as the Thermal Conductor
59

Table 4.1. 12. Pin 31 - 40 temperatures with ceramic plate as the Thermal Conductor
59

Table 4.1. 13. Pin 1 - 10 temperatures with ceramic plate as the Thermal Conductor 60

Table 4.1. 14. Pin 11 - 20 temperatures with ceramic plate as the Thermal Conductor
60

Table 4.1. 15. Pin 21 - 30 temperatures with ceramic plate as the Thermal Conductor
61

Table 4.1. 16. Pin 31 - 40 temperatures with ceramic plate as the Thermal Conductor
61

Table 4.1. 17. Pin 1 - 10 temperatures with silicone rubber as the Thermal Conductor
63

Table 4.1. 18. Pin 11 - 20 temperatures with silicone rubber as the Thermal Conductor	64
Table 4.1. 19. Pin 21 - 30 temperatures with silicone rubber as the Thermal Conductor	64
Table 4.1. 20. Pin 31 - 40 temperatures with silicone rubber as the Thermal Conductor	65
Table 4.1. 21. Pin 1 - 10 temperatures with silicone rubber as the Thermal Conductor	65
Table 4.1. 22. Pin 11 - 20 temperatures with silicone rubber as the Thermal Conductor	66
Table 4.1. 23. Pin 21 - 30 temperatures with silicone rubber as the Thermal Conductor	66
Table 4.1. 24 . Pin 31 - 40 temperatures with silicone rubber as the Thermal Conductor	67
Table 4.1. 25. Pin 1 - 10 temperatures with silicone rubber as the Thermal Conductor	68
Table 4.1. 26. Pin 11 - 20 temperatures with silicone rubber as the Thermal Conductor	68
Table 4.1. 27. Pin 21 - 30 temperatures with silicone rubber as the Thermal Conductor	69
Table 4.1. 28. Pin 31 - 40 temperatures with silicone rubber as the Thermal Conductor	69
Table 4.1. 29. Pin 1 - 10 temperatures with silicone rubber as the Thermal Conductor	70
Table 4.1. 30. Pin 11 - 20 temperatures with silicone rubber as the Thermal Conductor	70
Table 4.1. 31. Pin 21 - 30 temperatures with silicone rubber as the Thermal Conductor	71
Table 4.1. 32. Pin 31 - 40 temperatures with silicone rubber as the Thermal Conductor	72
Table 4.1. 33. Pin 1 - 10 temperatures with Hi-Flow as the Thermal Conductor	74
Table 4.1. 34. Pin 11 - 20 temperatures with Hi-Flow as the Thermal Conductor	74
Table 4.1. 35. Pin 21 - 30 temperatures with Hi-Flow as the Thermal Conductor	75
Table 4.1. 36. Pin 31 - 40 temperatures with Hi-Flow as the Thermal Conductor	75
Table 4.1. 37. Pin 1 - 10 temperatures with Hi-Flow as the Thermal Conductor	76
Table 4.1. 38. Pin 11 - 20 temperatures with Hi-Flow as the Thermal Conductor	77
Table 4.1. 39. Pin 21 - 30 temperatures with Hi-Flow as the Thermal Conductor	77
Table 4.1. 40. Pin 31 - 40 temperatures with Hi-Flow as the Thermal Conductor	78

Table 4.1. 41. Pin 1 - 10 temperatures with Hi-Flow as the Thermal Conductor	78
Table 4.1. 42. Pin 11 - 20 temperatures with Hi-Flow as the Thermal Conductor	79
Table 4.1. 43. Pin 21 - 30 temperatures with Hi-Flow as the Thermal Conductor	80
Table 4.1. 44. Pin 31 - 40 temperatures with Hi-Flow as the Thermal Conductor	80
Table 4.1. 45. Pin 1 - 10 temperatures with Hi-Flow as the Thermal Conductor	81
Table 4.1. 46. Pin 11 - 20 temperatures with Hi-Flow as the Thermal Conductor	81
Table 4.1. 47. Pin 21 - 30 temperatures with Hi-Flow as the Thermal Conductor	82
Table 4.1. 48. Pin 31 - 40 temperatures with Hi-Flow as the Thermal Conductor	83

Table 4.2. 1. Test 1 and 2 for pin number 3 on Ceramic Plate	84
Table 4.2. 2. Test 3 and 4 for pin number 3 on Ceramic Plate	85
Table 4.2. 3. Test 1 and 2 for pin number 4 on Ceramic Plate	86
Table 4.2. 4. Test 3 and 4 for pin number 4 on Ceramic Plate	87
Table 4.2. 5. Test 1 and 2 for pin number 26 on Ceramic Plate	88
Table 4.2. 6. Test 3 and 4 for pin number 26 on Ceramic Plate	89
Table 4.2. 7. Test 1 and 2 for pin number 27 on Ceramic Plate	90
Table 4.2. 8. Test 3 and 4 for pin number 27 on Ceramic Plate	91
Table 4.2. 9. Test 1 and 2 for pin number 3 on Silicone Rubber	92
Table 4.2. 10. Test 3 and 4 for pin number 3 on silicone rubber	93
Table 4.2. 11. Test 1 and 2 for pin number 4 on Silicone Rubber	94
Table 4.2. 12. Test 3 and 4 for pin number 4 on Silicone Rubber	95
Table 4.2. 13. Test 1 and 2 for pin number 26 on Silicone Rubber	96
Table 4.2. 14. Test 3 and 4 for pin number 26 on Silicone Rubber	97
Table 4.2. 15. Test 1 and 2 for pin number 27 on Silicone Rubber	98
Table 4.2. 16. Test 3 and 4 for pin number 27 on Silicone Rubber	99
Table 4.2. 17. Test 1 and 2 for pin number 3 on Hi Flow	100
Table 4.2. 18. Test 3 and 4 for pin number 3 on Hi Flow	101
Table 4.2. 19. Test 1 and 2 for pin number 4 on Hi Flow	102
Table 4.2. 20. Test 3 and 4 for pin number 4 on Hi Flow	103
Table 4.2. 21. Test 1 and 2 for pin number 26 on Hi Flow	104
Table 4.2. 22. Test 3 and 4 for pin number 26 on Hi Flow	105
Table 4.2. 23. Test 1 and 2 for pin number 27 on Hi Flow	106

