

Design and Thermal Analysis of Power Supply Module

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ABSTRACT: In modern defence technology, naval combat ships play an important role in maintaining order and control in international waters. It is one of the most feared combat machinery used in international waters due to its advancement in electronic equipments. Powering all the electronic equipments is power module which supplies electricity to the electronic equipment. This study outlines the effectiveness of the design and efficiency of the newly designed power supply module under naval conditions. The design and analysis is carried out using SOLIDWORKS. Design of the power supply module plays a significant role as the naval ships are constraints of space. The present power supply modules occupy more space and if all the electronic components are connected in series to the same power supply, failure of one power supply may lead to malfunctioning of multiple electronic components. The new power supply design is more compact by about 30% compared to previous design. Since the design is more compact the problem of heat dissipation plays a vital role in effective working of all the components in the power supply module as humidity is an important factor in naval conditions. The power supply has been designed using extrusions and stress distributing brackets to absorb continuous vibrations. To overcome the heat dissipation issue, the heat generating components are mounted on the rear facia of the power supply module to improve heat dissipation through conduction. Further analysis is carried out on the design to verify the working under naval conditions using SOLIDWORKS (2017).

KEYWORDS: power supply modules, SOLIDWORKS, heat dissipation.

I. INTRODUCTION

A power supply module is defined as an enclosure of multiple sensitive electronic circuits and components used to power electrical devices. The enclosures are so designed to withstand continuous vibrations and stress experienced in navy environment.

II. EXISTING SYSTEM

The existing system uses lot of space and all the devices are connected to a single power supply module due to which , failure of a single power supply results in the failure of multiple electronic devices. Since failure of electronic components is not a option in naval conditions , by dividing the loads on the single power supply we can achieve much more reliable system.

III. DESIGN AND METHODOLOGY

The efficient manufacturing and maintenance of the power supply module consists of the following steps:

- Design.
- Analysis.
- Product simulation based on practical navy conditions.
- Software used – Solidworks v2014 (Dassault systems)

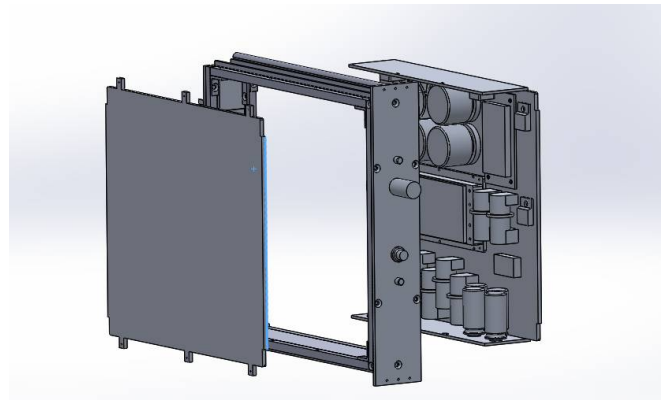
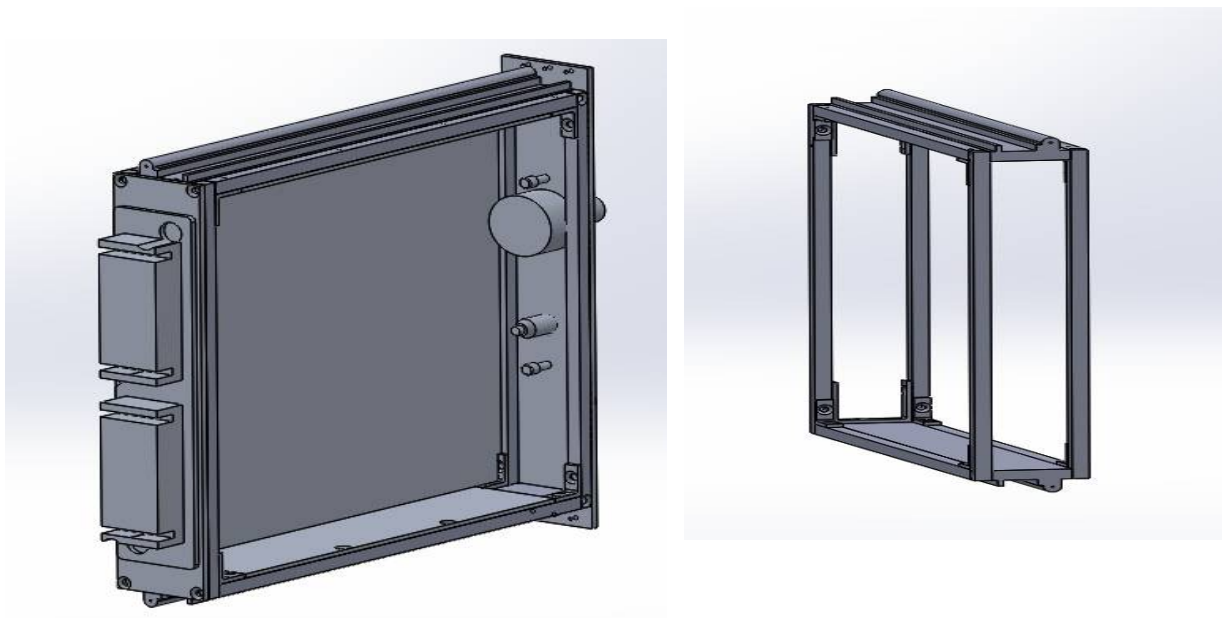


Fig. 1. Block Diagram

The design has been carried out in 3 sections where main frame with stress distributing brackets integrated with guide rails are designed. In the second section the front and rear fascia of the power supply unit are mounted. In the third section the electronic components are mounted on the C-frame which also serves as a side panel and helps improve heat dissipation.



IV. POWER RATINGS

The power rating of each component was calculated using amount of current it uses and its efficiency. We can calculate the amount of heat dissipated as:

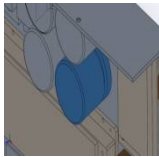
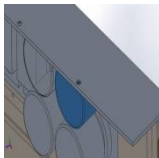
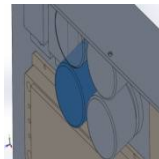

$$P = I * (1 - \text{efficiency of the component})$$

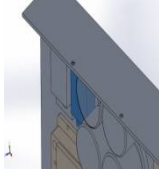

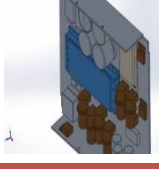
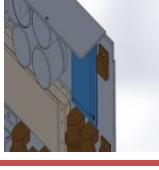

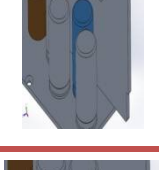
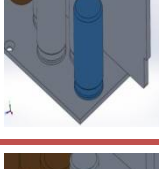
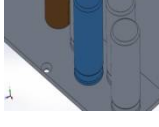
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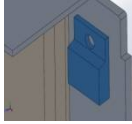

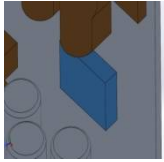
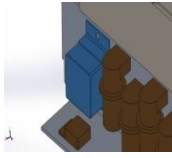

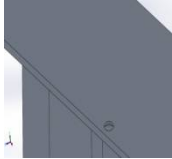
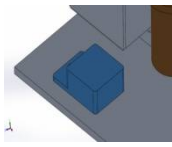
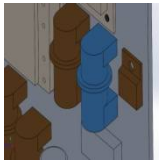
| | |
|---------------|-----------------------|
| Study name | Thermal 1 |
| Analysis type | Thermal(Steady state) |
| Mesh type | Solid Mesh |
| Solver type | FFEPlus |
| Solution type | Steady state |

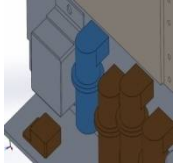
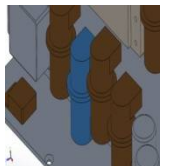
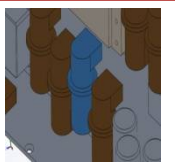
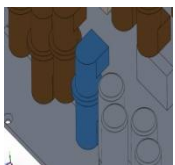



Units

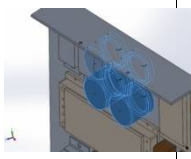
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|---------------------|------------------|
| Unit system: | SI (MKS) |
| Length/Displacement | mm |
| Temperature | Kelvin |
| Angular velocity | Rad/sec |
| Pressure/Stress | N/m ² |

| Load name | Load Image | Load Details |
|--------------|---|---|
| Heat Power-1 |  | Entities: 1 component (s) Heat Power Value: 50 W |
| Heat Power-2 |  | Entities: 1 component (s) Heat Power Value: 50 W |
| Heat Power-3 |  | Entities: 1 component (s) Heat Power Value: 50 W |
| Heat Power-4 |  | Entities: 1 component (s) Heat Power Value: 50 W |

| Load name | Load Image | Load Details |
|---------------|---|--|
| Heat Power-5 |  | Entities: 1 component(s) Heat Power Value: 25 W |
| Heat Power-6 |  | Entities: 1 component(s) Heat Power Value: 25 W |
| Heat Power-7 |  | Entities: 1 component(s) Heat Power Value: 68 W |
| Heat Power-8 |  | Entities: 1 component(s) Heat Power Value: 28 W |
| Heat Power-9 |  | Entities: 1 component(s) Heat Power Value: 14 W |
| Heat Power-10 |  | Entities: 1 component(s) Heat Power Value: 14 W |
| Heat Power-11 |  | Entities: 1 component(s) Heat Power Value: 14 W |
| Heat Power-12 |  | Entities: 1 component(s) Heat Power Value: 14 W |

| Load name | Load Image | Load Details |
|---------------|---|---|
| Heat Power-13 |  | Entities: 1 component (s) Heat Power Value: 10 W |
| Heat Power-14 |  | Entities: 1 component (s) Heat Power Value: 10 W |
| Heat Power-15 |  | Entities: 1 component (s) Heat Power Value: 25.6 W |
| Heat Power-16 |  | Entities: 1 component (s) Heat Power Value: 16 W |
| Heat Power-17 |  | Entities: 1 component (s) Heat Power Value: 20 W |
| Heat Power-18 |  | Entities: 1 component (s) Heat Power Value: 20 W |
| Heat Power-19 |  | Entities: 1 component (s) Heat Power Value: 20 W |
| Heat Power-20 |  | Entities: 1 component (s) Heat Power Value: 23 W |

| Load name | Load Image | Load Details |
|---------------|---|--|
| Heat Power-21 |  | Entities: 1 component(s) Heat Power Value: 23 W |
| Heat Power-22 |  | Entities: 1 component(s) Heat Power Value: 23 W |
| Heat Power-23 |  | Entities: 1 component(s) Heat Power Value: 23 W |
| Heat Power-24 |  | Entities: 1 component(s) Heat Power Value: 23 W |
| Convection-1 |  | Entities: 29 face(s) Convection Coefficient: 240 W/(m ² .K) Bulk Ambient Temperature: 300 Kelvin |
| Convection-2 |  | Entities: 243 face(s) Convection Coefficient: 150 W/(m ² .K) Bulk Ambient Temperature: 300 Kelvin |
| Convection-3 |  | Entities: 42 face(s) Convection Coefficient: 240 W/(m ² .K) Time variation: Off Temperature variation: Off Bulk Ambient Temperature: 300 Kelvin |

| Load name | Load Image | Load Details |
|------------------|---|--|
| Convec tion-4 |  | <p>Entities: 32 face(s) Convection: 210 Coefficient: $W/(m^2.K)$ Bulk Ambient Temperature: 300 Kelvin</p> |

V. MATERIAL PROPERTIES

| |
|--|
| <p>Name: 1060 Alloy Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Thermal conductivity: 200 W/(m.K) Specific heat: 900 J/(kg.K) Mass density: 2700 kg/m³</p> |
| <p>Name: 1350 Alloy Model type: Linear Elastic Isotropic Thermal conductivity: 230 W/(m.K) Specific heat: 1000 J/(kg.K) Mass density: 2700 kg/m³</p> |
| <p>Name: Aluminum Bronze Model type: Linear Elastic Isotropic Thermal conductivity: 56 W/(m.K) Specific heat: 380 J/(kg.K) Mass density: 7400 kg/m³</p> |
| <p>Name: Copper Model type: Linear Elastic Isotropic Thermal conductivity: 390 W/(m.K) Specific heat: 390 J/(kg.K) Mass density: 8900 kg/m³</p> |
| <p>Name: Rubber Model type: Linear Elastic Isotropic Thermal conductivity: 0.14 W/(m.K) Mass density: 1000 kg/m³</p> |
| <p>Name: 6063-O Model type: Linear Elastic Isotropic Thermal conductivity: 218 W/(m.K) Specific heat: 900 J/(kg.K) Mass density: 2700 kg/m³</p> |

| | |
|-----------------------|---------------------------------|
| Name: | 7075-T6, Plate (SS) |
| Model type: | Linear Elastic Isotropic |
| Thermal conductivity: | 130 W/(m.K) |
| Specific heat: | 960 J/(kg.K) |
| Mass density: | 2810m³ |

VI. MESH INFORMATION

| | |
|--|---------------|
| Mesh type | Solid Mesh |
| Mesher Used: | Standard mesh |
| Automatic Transition: | Off |
| Include Mesh Auto Loops: | Off |
| Jacobian points | 4 Points |
| Element Size | 4.46933 mm |
| Tolerance | 0.223467 mm |
| Mesh Quality Plot | High |
| Remesh failed parts with incompatible mesh | Off |

Mesh information - Details

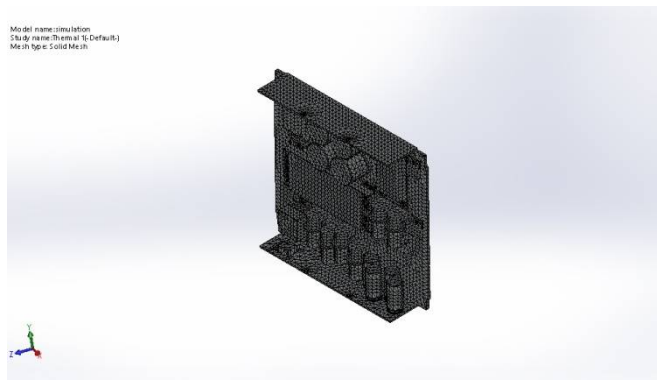
| | |
|--------------------------------------|-------|
| Total Nodes | 94416 |
| Total Elements | 54475 |
| Maximum Aspect Ratio | 32.65 |
| % of elements with Aspect Ratio < 3 | 89.6 |
| % of elements with Aspect Ratio > 10 | 0.224 |

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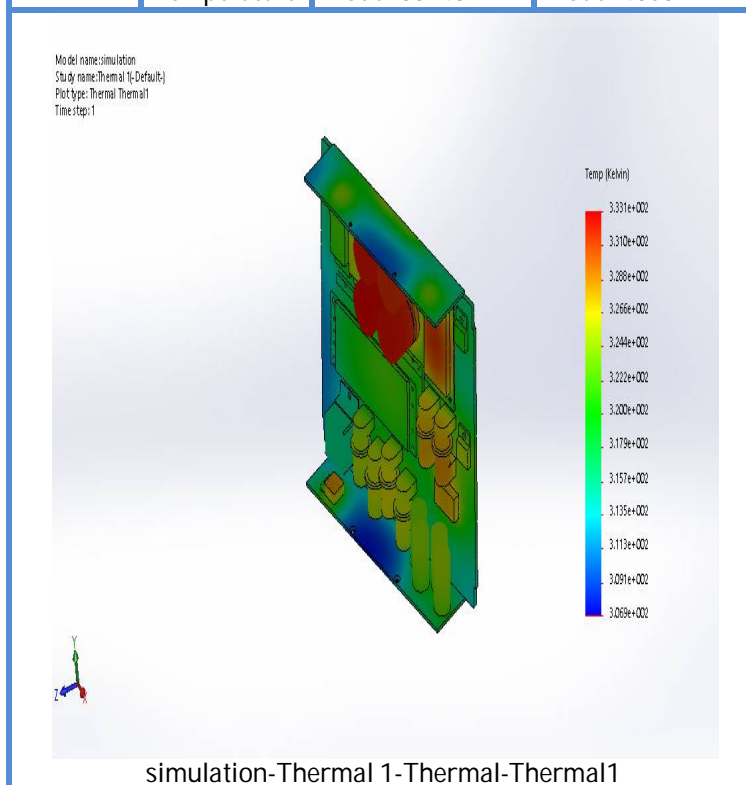
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VII. STUDY RESULTS

| Name | Type | Min | Max |
|----------|----------------------|---------------------------------|---------------------------------|
| Thermal1 | TEMP: Temperature | 3.069e+002Kelvin Node: 33243 | 3.331e+002Kelvin Node: 43539 |

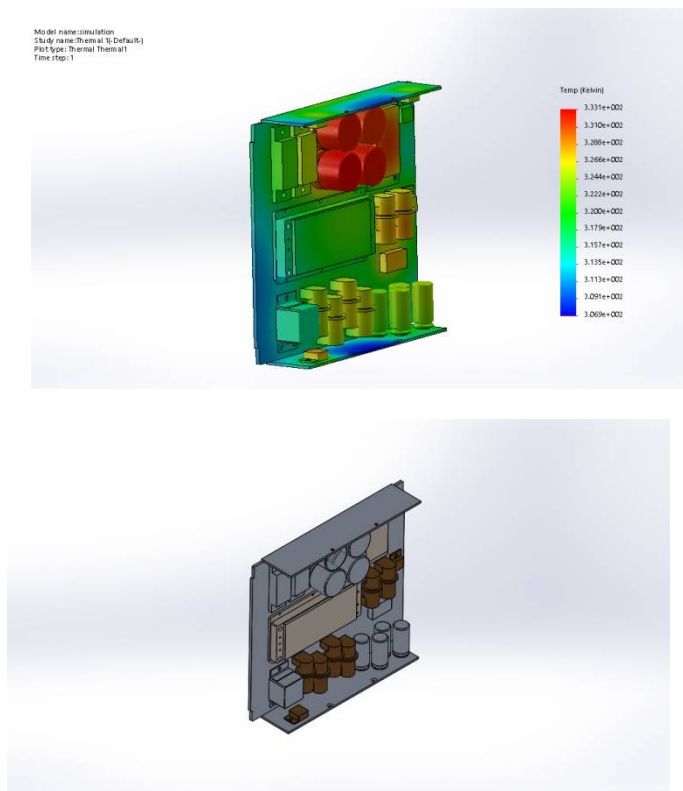


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VIII. CONCLUSION

The product analysis reveals that the maximum working temperature is 333k and the minimum working temperature is 306k. Further study would be to improve ventilation and time testing and practical situation testing of the designed product for testing in naval environment.

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