Heat is inevitably generated in the semiconductors during operation. Cooling in an electronic device, and in its main part – printed circuit board (PCB), microprocessor, capacitors, etc. It is crucial, allowing the proper functioning without overheating, malfunctioning, and damage. In order to estimate the temperature as a function of time, it is important to solve the differential equations describing the heat flow and to understand how it depends on the physical properties of the system. This project aims to answer these questions by considering a simplified model of the LRU+ heat sink. A simple model is presented to estimate the temperature of the printed circuit board (PCB) based on the power consumption and time. The problem is analyzed and solved using two concepts: heat capacity and heat current or flow. For simplicity the analyzed model consists of the PCB and the heat sink only. For a given heat pulse, two situations are considered: when heat is added to the system (power on), and when the system is cooling (power off).

**Keywords:** Computational fluid dynamics, electronics, heat transfer, line replaceable unit, thermal analysis.

I. INTRODUCTION

Thermal design of PCBs in electronic systems is critical to maintain device operating temperatures below specified limits. Although the predictions from full-field CFD simulations are accurate, the computational cost and model generation time could be fairly high. Thus, it is preferable to use a quick estimation tool to design a preliminary layout of LRU with different heat–dissipating components. As mentioned, thermal management of the electronics device is an important aspect in the LRU design. Keeping the temperature within operational limits is needed to maintain performance and preservation of the electronics device itself. Therefore, it can be extremely useful to have a model that can estimate the behavior of these systems. Heat transfer is a complicated process; here we attempt to provide a simple and phenomenological description of an LRU thermal behavior. As the number of components with different materials and geometries in the LRU structure make the thermal analysis complicated. The analysis of more complex models of thermal management in an LRU could be considerably simplified if equivalent electrical circuits are designed and correlations between the thermal and electrical quantities are found. A line-replaceable unit (LRU) or line-replaceable item (LRI) is a modular component of an airplane, ship or spacecraft (or any other manufactured device) that is designed to be replaced quickly at an operating location. The different lines (distances) are essential for logistics planning and operation. An LRU is usually a sealed unit such as a radio or other auxiliary equipment. LRUs are typically assigned logistics control numbers (LCNs) or work unit codes (WUCs) to manage logistics operations. LRUs can improve maintenance operations, because they can be stocked and replaced quickly from distributed nearby on-site inventories (sometimes mobile storage), restoring the mobile systems to service, while the failed (unserviceable) LRU is undergoing complicated repair and overhaul actions in other support locations (lines). Because of their modularity, LRUs also can contribute reducing system costs and increase quality, by centralizing development across different models of vehicles. LRUs are designed to specifications to assure that they can be interchanged, especially if they are from different manufacturers. Usually a class of LRUs will have coordinated environmental specifications (i.e. temperature, condensation, etc.). However, each particular LRU will also have detailed specifications describing its function, tray size, tray connectors, attachment points, weight ranges, etc. It is common for LRU trays to have standardized connections for rapid mounting, cooling air, power, and grounding. The mounting hardware is often manually removable standard-screw-dent detent quick-release fittings. Front-mounted electrical connectors are often jacks for ring-locked cannon plugs that can be removed and replaced (R&R) without tools. Specifications also define the supporting tools necessary to remove and replace the unit. Many require no tools, or a standard-sized Frearson screwdriver. Frearson is specified for some vehicles and many marine systems because Frearson screws keep their mating screwdriver from camming out, and the same screwdriver can be used on many sizes of screws. Most LRUs also have handles, and specific requirements for their bulk and weight. LRUs typically need to be "transportable" and fit through a door or hatchway. There are also requirements for flammability, unwanted radio emissions, resistance to damage from fungus, static electricity, heat, pressure, humidity, condensation drips, vibration, radiation, and other environmental measurements.

II. CONDUCTION

The process by which heat is directly transmitted through the material of a substance when there is difference of temperature between adjoining region without movement of material

**FOURIERS LAW OF CONDUCTION**

It states that time rate of heat transfer through a material is proportional to the negative gradient in temperature and to arc at right angle to the gradient through which the heat flows:

\[
Q = -kA \frac{dT}{dx}
\]

Where:

- \( Q \) is the heat transfer rate in watts
- \( k \) is the thermal conductivity of the material
- \( A \) is the cross-sectional area of the material
- \( T \) is the temperature
- \( x \) is the distance along the direction of heat flow

The process by which heat is directly transmitted through the material of a substance when there is difference of temperature between adjoining region without movement of material.
K= conductivity of material
dT/dx = difference in temperature along length x

**III. CONVECTION**

The transfer of heat from a solid body to a fluid or from a fluid to a solid body is known as convection.

**GOVERNING LAW OF CONVECTION**

The rate of heat loss of a body is directly proportional to the difference in the temperature between the body and its surrounding provide the temperature difference Small and natural radiating surface remain same.

\[ Q \alpha A (T-t) \]
\[ Q = hA (T-t) \]

Q= heat transfer rate
A= surface area exposed to heat transfer
T= fluid temperature
h= heat transfer coefficient

**IV. RADIATION**

Radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium.

**GOVERNING LAW OF RADIATION**

It states that which governs the intensity of radiation emitted by unit surface area into a fixed direction from the black body as a function of wavelength for a fixed temperature

\[ Q \alpha \sigma A T^4 \]

T= surface temperature from which heat is emitted
A= surface area
\( \sigma \) = Stefan Boltzmann constant
\( \approx 5.67 \times 10^{-8} \) (W/m²K)

**V. EXPERIMENTATION**

The project aims to deal with increasing the dissipation of heat from the line replaceable unit. We are tasked with the remodelling of an existing model of LRU which has undergone some internal upgradations leading to higher heat being emitted from its components. To counter the higher heat being dissipated we had to come up with a solution which deals with some design and structural upgradation, this will lead to the increase in heat dissipation levels without changing the dimensions or material of the LRU From different literature survey’s, references & research papers it is understood that increasing the surface area increases the heat dissipation & this is achieved by adding some heat sinks around the high heat emitting devices/units in the PCB & adding on additional fins in the surface of the LRU and increasing the size of existing ventilations which would promote additional air flow. Initially the revised design of the LRU will be modelled in SOLIDWORKS and the thermal analysis will be performed using FLOEFD simulation software’s to simulate the different temperature gradients on each surface of the body and components, the internal fluid temperature gradients, the convective currents and flow trajectories.

**VI. RESULTS**

From the upcoming diagrams and graph for the component tested at ambient temperatures -40°C, 25°C and 55°C with PCB’s generating a heat of 4.5w, 6.5w and 6.5w and transducers generating 1.3w of heat we were able to simulate the conditions such as convection currents, surface temperatures, fluid temperatures.
VII. CONCLUSION

<table>
<thead>
<tr>
<th></th>
<th>ambient</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-40</td>
<td>-6.5</td>
<td>3.34</td>
<td>2.32</td>
<td>-24.97</td>
<td>-24.96</td>
<td>-24.98</td>
<td>-25.04</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>53.64</td>
<td>62.02</td>
<td>60.51</td>
<td>36.62</td>
<td>36.65</td>
<td>36.63</td>
<td>36.55</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>81.33</td>
<td>88.82</td>
<td>87.11</td>
<td>65.19</td>
<td>65.22</td>
<td>65.19</td>
<td>65.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>ambient</th>
<th>motherboard</th>
<th>front cover</th>
<th>Motherboard casing</th>
<th>PCB enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-40</td>
<td>-11.55</td>
<td>-23.07</td>
<td>-25.07</td>
<td>-24.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-24.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-23.83</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>48.52</td>
<td>37.8</td>
<td>36.53</td>
<td>37.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37.63</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>76.11</td>
<td>66.29</td>
<td>65.04</td>
<td>65.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66.15</td>
</tr>
</tbody>
</table>

Thermal analysis of the final design of Line replaceable unit is executed and the results obtained under 3 ambient conditions are well below its operational limit. We were able to come to the conclusion using the above results and through analyzing the flow trajectories by which we were able to determine the conventional current which were carrying the heat away from the heat away from the body. By comparing both initial and final model we came to the conclusion that heat dissipation from the final design is higher due to its increase in surface area, which was possible by designing fins on to the original model.

VIII. REFERENCES

[1]. SIXTH EDITION Fundamentals of Heat and Mass Transfer FRANK P. INCROPERA College of Engineering University of Notre Dame DAVID P. DEWITT School of Mechanical Engineering Purdue University THEODORE L. BERGMAN Department of Mechanical Engineering University of Connecticut ADRIENNE S. LAVINE Mechanical and Aerospace Engineering Department University of California, Los Angeles


[3]. A REVIEW ON HEAT EXCHANGER Shambhu Kumar Rai1, Parmeshwar Dubey2, Vol-3 Issue-1 2017, IJARIIE-ISSN(O)-2395-4396