ISSN: 2248-9622, Vol. 5, Issue 11, (Part - 1) November 2015, pp.57-68

RESEARCH ARTICLE OPEN ACCESS

Thermal Simulations of an Electronic System using Ansys Icepak

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ABSTRACT
Present electronics industry component sizes are efficiently reducing to meet the product requirement with compact size with greater performance in compact size products resulting in different problems from thermal prospective to bring product better performance electrically and mechanically.
In this paper we will study how to overcome the thermal problem for a product which includes components reliability and PCB performance by using CFD thermal simulation tool (Ansys Icepak).

I. INTRODUCTION

Designing a cost competitive power electronics system requires careful consideration of the thermal domain as well as the electrical domain. Over designing the system adds unnecessary cost and weight; under designing the system may lead to overheating and even system failure. Finding an optimized solution requires a good understanding of how to predict the operating temperatures of the system's power components and how the heat generated by those components affects neighboring devices, such as capacitors and microcontrollers.

No single thermal analysis tool or technique works best in all situations. Good thermal assessments require a combination of analytical calculations using thermal specifications, empirical analysis and thermal modeling. The art of thermal analysis involves using all available tools to support each other and validate their conclusions. Power devices and low lead count packages are the primary focus, but the concepts herein are general and can be applied to lower power components and higher lead count devices such as microcontrollers.

II. HEAT TRANSFER THEORY

Three basic natural laws of physics:

a. Heat will always be transferred from a hot medium to a cold medium, until equilibrium is reached.
b. There must be a temperature difference
c. The heat lost by the hot medium is equal to the amount of heat gained by the cold medium, except for losses to the surroundings.

Modes of Heat Transfer

¬ Conduction
¬ Convection
¬ Radiation

Conduction

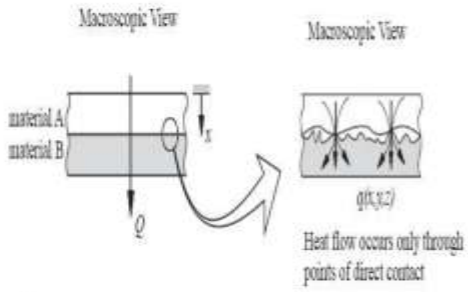


Fig:1 Conduction

TABLE 1
Thermal Conductivity of various materials

Material	W/mK
Aluminum (Pure)	216
Aluminum Nitride	230
Alumina	25
Copper	398
Diamond	2300
Epoxy (No fill)	0.2
Epoxy (High fill)	2.1
Epoxy glass	0.3
Gold	296
Lead	32.5
Silicon	144
Silicon Carbide	270
Silicon Grease	0.2
Solder	49.3

Convection

One of the mechanism of heat transfer occurring because of bulk motion (observable movement) of fluids. Heat is the entity of interest being adverted (carried), and diffused (dispersed). This can be contrasted with conductive heat transfer, which is the transfer of energy by vibrations at a molecular level through a solid or fluid, and radioactive, the transfer of energy through electromagnetic waves.

Convection mode

There are two major mode of convection,

- ¬ Natural Convection or free convection
- ¬ Forced Convection

Natural convection

Natural convection, or free convection, occurs due to temperature differences which affect the density, and thus relative buoyancy, of the fluid. Heavier (more dense) components will fall, while lighter (less dense) components rise, leading to bulk fluid movement. Natural convection can only occur, therefore, in a gravitational field. A common example of natural convection is the rise of smoke from a fire. it can be seen in a pot of boiling water in which the hot and less-dense water on the bottom layer moves upwards in plumes, and the cool and more dense water near the top of the pot likewise sinks.

Forced convection

In forced convection, also called heat advection, fluid movement results from external surface forces such as a fan or pump. Forced convection is typically used to increase the rate of heat exchange. Many types of mixing also utilize forced convection to distribute one substance within another. Forced convection also occurs as a by-product to other processes, such as the action of a propeller in a fluid or aerodynamic heating. Fluid radiator systems, and also heating and cooling of parts of the body by blood circulation, are other familiar examples of forced convection.

Radiation

Thermal radiation is energy emitted by matter as electromagnetic waves due to the pool of thermal energy that all matter possesses that has a temperature above absolute zero. Thermal radiation propagates without the presence of matter through the vacuum of space.

Thermal radiation is a direct result of the random movements of atoms and molecules in matter. Since these atoms and molecules are composed of charged particles (protons and electrons), their movement results in the emission of electromagnetic radiation, which carries energy away from the surface.

III. TYPES OF FLOW

- ¬ LAMINAR FLOW
- ¬ TURBULANT FLOW

Laminar flow

It is also called as streamline flow, which is occurs, when a fluid flows in parallel layers with no disruption between the layers. There are no cross currents perpendicular to the direction of flow, nor eddies or swirls of fluids. In laminar flow the motion of the particles of fluid is very orderly with all particles moving in straight lines parallel to the pipe walls. In fluid dynamics, laminar flow is a flow regime characterized by high momentum diffusion and low momentum convection.

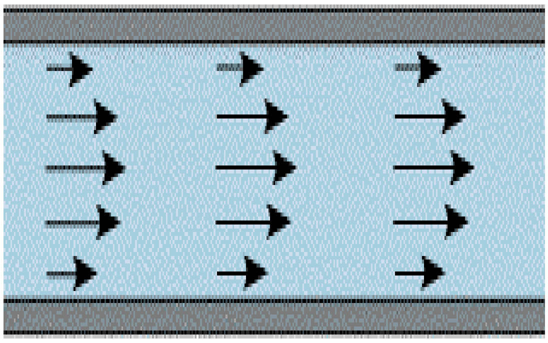


Fig: 2 Laminar Flow

Turbulence or Turbulent flow

Is a flow regime characterised by chaotic and stochastic property changes. This includes low momentum diffusion, high momentum Convection and rapid variation of pressure and velocity in space and time. Nobel Laureate Richard Feynman described turbulence as "the most important unsolved problem of classical physics" Flow in which the kinetic energy dies out due to the action of fluid molecular viscosity is called laminar flow. While there is no theorem relating the non-dimensional Reynolds number (Re) to turbulence flows at Reynolds numbers larger than 100000 are typically (but not necessarily) turbulent while those at low Reynolds numbers usually remain laminar.

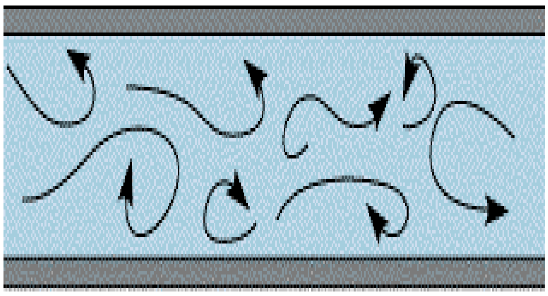


Fig: 3 Turbulent Flow

IV. PRINTED CIRCUIT BOARD

A printed circuit board (PCB), is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or signal traces etched from copper sheets laminated onto a non-conductive substrate. It is also referred to as printed wiring board (PWB) or etched wiring board. Printed circuit boards are used in virtually all but the simplest commercially produced electronic devices.

Fig: 4 Printed Circuit Board

A PCB populated with electronic components is called a printed circuit assembly (PCA), printed circuit board assembly or PCB Assembly (PCBA). In informal use the term "PCB" is used both for bare and assembled boards, the context clarifying the meaning.

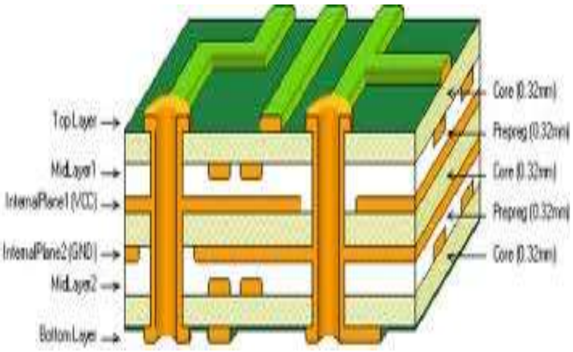


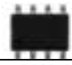
Fig: 5 Cross Section of Printed Circuit Board

Material Core: Copper sheet
Prepreg: It is a non conductive material to separate two copper sheets.

V. ELECTRONIC COMPONENTS

An electronic component is a basic indivisible electronic element that is available in a discrete form. Electronic components are discrete devices or discrete components, mostly industrial products and not to be confounded with electrical elements which are conceptual abstractions representing idealized electronic components. Electronic components have two or more electrical terminals (or leads). These leads connect, usually soldered to a printed circuit board to create an electronic circuit (a discrete circuit) with a particular function (for example an amplifier, radio receiver or oscillator). Basic electronic components may be packaged discretely as arrays or networks of like components or integrated inside of packages such as semiconductor integrated circuits, hybrid integrated circuits or thick film devices.

TABLE 2
COMPONENTS HISTORY

COMPONENT TYPE	IMAGE
DIP	
QFP	
SOIC	
QFN	
BGA	
SON	

Construction of Component

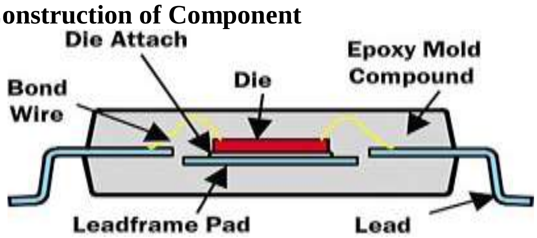


Fig: 6 Construction of component Materials

VI. AIM AND SCOPE

Reducing the operating temperature and increase the product life, An operating temperature is the temperature at which an electrical or mechanical device operates. The device will operate effectively within a specified temperature range which varies based on the device function and application context and ranges from the minimum operating temperature to the maximum operating temperature (or peak operating temperature). Outside this range of safe operating temperatures the device may fail. Aerospace and military-grade devices generally operate over a broader temperature range than industrial devices commercial-grade devices generally have the lowest operating temperature range.

At elevated temperatures a silicon device can fail catastrophically, but even if it doesn't its electrical characteristics frequently undergo intermittent or permanent changes. Manufacturers of processors and other computer components specify a maximum operating temperature for their products. Most devices are not certified to function properly beyond 50°C-80°C (122°F-176°F). However, in a loaded PC with standard cooling, operating temperatures can easily exceed the limits. The result can be memory errors, hard disk read-write errors, faulty video and other problems not commonly recognized as heat related.

The life of an electronic device is directly related to its operating temperature. Each 10°C (18°F) temperature rise reduces component life by 50%. Conversely, each 10°C (18°F) temperature reduction increases component life by 100%. Therefore, it is recommended that computer components be kept as cool as possible (within an acceptable noise level) for maximum reliability, longevity and return on investment.

VII. DEFINITIONS

The terms used for thermal analysis vary somewhat throughout the industry. Some of the most commonly used thermal definitions and notations are

T_A-Temperature at reference point "A" (°c)

T_J Junction temperature, often assumed to be constant across the die surface (°c)

T_C - Package temperature at the interface between the package and its heat sink should be the hottest spot on the package surface and in the dominant thermal path (°c)

ΔT_{AB}- Temperature difference between reference points "A" and "B" (°c)

q - Heat transfer per unit time (W)

P_D -Power dissipation, source of heat flux (Watts)

H- Heat flux, rate of heat flow across a unit area (J·m- 2·s-1) (°c)

R_{QAB} - Thermal resistance between reference points "A" and "B" or RTHAB (°c)

R_{QJMA} - Junction to moving air ambient thermal resistance (°c/w)

R_{QJC} - Junction to case thermal resistance of a packaged component from the surface of its silicon to its thermal tab or R_{THJC} (°c/w)

R_{QJA} -Junction to ambient thermal resistance or R_{THJA}

C_{QAB} Thermal Capacitance between reference points "A" and "B" or C_{THAB} (°c/w)

Z_{QAB} -Transient thermal impedance between reference points "A" and "B" or ZTHAB

$\Delta T_{JA} = (T_J - T_A) = P_D R_{\Theta JA}$

we can easily derive the often used equation for estimating junction temperature:

$T_J = T_A + (P_D R_{\Theta JA})$

For example, let's assume that:

$R_{\Theta JA} = 30°C/W$

$P_D = 2.0W$

$T_A = 75.C$

Then, by substitution:

$T_J = T_A + (P_D R_{\Theta JA})$

$T_J = 75°C + (2.0W * 30°C/W)$

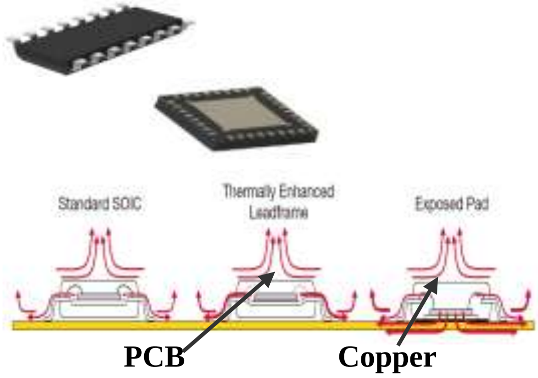
$T_J = 75°C + 60°C$

$T_J = 135°C$

A cautionary note is in order here. The thermal conductivities of some materials vary significantly with temperature. Silicon's conductivity, for example, falls by about half over the min-max operating temperature range of semiconductor devices. If the die's thermal resistance is a significant portion of the thermal stack-up, then this temperature dependency needs to be included in the analysis.

VIII. JUNCTION TEMPERATURE

The term junction temperature became commonplace in the early days of semiconductor thermal analysis when bipolar transistors and rectifiers were the prominent power technologies. Presently the term is reused for all power devices, including gate isolated devices like power MOSFETs and IGBTs. Using the concept "junction temperature" assumes that the die's temperature is uniform across its top surface. This simplification ignores the fact that x-axis and y-axis thermal gradients always exist and can be large during high power conditions or when a single die has multiple heat sources. Analyzing gradients at the die level almost always requires modeling tools or very special empirical techniques. Most of the die's thickness is to provide mechanical support for the very thin layer of active components on its surface. For most thermal analysis purposes, the electrical components on the die reside at the chip's surface. Except for pulse widths in the range of hundreds of microseconds or less, it is safe to assume that the power is generated at the die's surface.



IX. THERMAL MODEL

The challenge of accurately predicting junction temperatures of IC components in system-level CFD simulations has engaged the engineering community for a number of years. The primary challenge has been that near-exact physical models of such components (known as detailed thermal models, or DTMs) are difficult to implement directly in system designs due to the wide disparity in length scales involved, which results in large computational inefficiencies. A compact thermal model (CTM) attempts to solve this problem by taking a detailed model and extracting an abstracted, far less grid-intensive representation that is still able to preserve accuracy in predicting the temperatures at key points in the package, such as the junction.

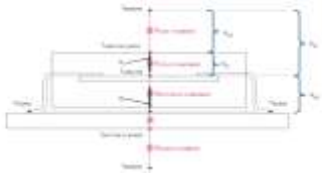


Fig: 7 Thermal Model

Thermal modeling is now an integral part of the electronics design process. In recent years, new thermal modeling methods have been proposed that seek to predict temperatures and fluxes of packages with varying degrees of accuracy and computational efficiency. These methods are being widely used in the industry, although some important barriers to their universal adoption remain. The JEDEC industry standards committee is engaged in standardizing some of these methodologies.

X. COMPACT THERMAL MODEL

A Compact Thermal Model is a behavioral model that aims to accurately predict the temperature of the package only at a few critical points e.g., junction, case, and leads; but does so using far less computational effort. A compact thermal model is not constructed by trying to mimic the geometry and material properties of the actual component. It is rather an abstraction of the response of a component to the environment it is placed in. Most compact thermal model approaches use a thermal resistor network to construct the model, analogous to an electrical network that follows Ohm's law. The most popular types of compact thermal model in use today are two-resistor and DELPHI.

TWO RESISTOR MODEL

The JEDEC two-resistor model consists of three nodes as shown in Fig:. These are connected together by two thermal resistors which are the measured values of the junction-to-board (θ_{JB}, JEDECStandard JESD51-8) and junction-to-case (θ_{JCtop}, discussed in JEDEC Guideline JESD51-12) thermal resistances described above.

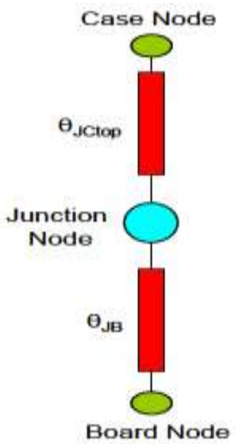


Fig: 8 Two resistor mode

Junction-to-board thermal resistance(θ_{JB})

This parameter is measured in a ring cold plate fixture (see JESD51-8). This test fixture is designed to ensure that all the heat generated in the package is conducted to the cold plate via the board.

The metric is defined as:

$\theta_{JB} = (T_J - T_B)/P_H$

Where

θ_{JB} = thermal resistance from junction-to-board ºC/W)

T_J = junction temperature when the device has achieved steady-state after application of P_H (ºC)

T_B = board temperature, measured at the midpoint of the longest side of the package no more than 1mm from the edge of the package body (ºC)

P_H= heating power which produced the change in junction temperature (W)

Junction-to-case thermal resistance (θ_{JC} top)

The metric is measured in a top cold plate fixture and is defined as:

$\theta_{JCtop} = (T_J - T_{ctop}) / P_H$

Where

θ_{JCtop} = Thermal resistance from junction-to-case (ºC/W)

T_J = Junction temperature when the device has achieved steady-state after application of P_H (ºC)

T_{Ctop} = Case temperature, measured at center of the package top surface (ºC)

P_H = Heating power in the junction that causes the difference between The junction temperature T_J and the case temperature T_{Ctop} this is Equal to the power passing through the cold plate (W)

XI. TOOL DESCRIPTION

ANSYS Icepak software provides robust and powerful computational fluid dynamics for electronics thermal management.

Icepak Objects

ANSYS Icepak software contains many productivity-enhancement features that enable quick creation and simulation of electronics cooling models of integrated circuit (IC) packages, printed circuit boards and complete electronic systems. Models are created by simply dragging and dropping icons of predefined objects — including cabinets, fans, packages, circuit boards, vents and heat sinks — to create models of complete electronic systems. These smart objects capture geometric information, material properties, meshing parameters and boundary conditions — all of which can be parametric for performing sensitivity studies and optimizing designs.

ECAD/MCAD Interfaces

To accelerate model development, ANSYS Icepak imports both electronic CAD (ECAD) and mechanical CAD (MCAD) data from a variety of sources. ANSYS Icepak software directly supports IDF, MCM, BRD and TCB files that were created using EDA software such as Cadence® Allegro® or Cadence Allegro Package Designer. Additional products enable ANSYS Icepak to import ECAD data from a number EDA packages from Cadence, Zuken®, Sigrity®, Synopsys® and Mentor Graphics®.

ANSYS Icepak directly supports the import of mechanical CAD data from neutral file formats including STEP and IGES files. ANSYS Design Modeller _ software allows ANSYS Icepak to import geometry from all major mechanical CAD packages through the ANSYS Workbench geometry interfaces. Geometry imported from ECAD and MCAD can be combined into smart objects to efficiently create models of electronic assemblies.

Flexible Automatic Meshing

ANSYS Icepak software contains advanced meshing algorithms to automatically generate high-quality meshes that represent the true shape of electronic components. Options include hex-dominant, unstructured hexahedral and Cartesian meshing, which enable automatic generation of body-fitted meshes with minimal user intervention. The mesh density can be localized through nonconformal interfaces, which allows inclusion of a variety of component scales within the same electronics cooling model.

While fully automated, ANSYS Icepak contains many mesh controls that allow customization of the meshing parameters to refine the mesh and optimize the trade-off between computational cost and solution accuracy. This meshing flexibility results in the fastest solution times possible without compromising accuracy.

ANSYS Icepak software uses state-of-the-art technology available in the ANSYS FLUENT CFD solver for thermal and fluid flow calculations. The ANSYS Icepak solver solves for fluid flow and includes all modes of heat transfer — conduction, convection and radiation — for both steady-state and transient thermal flow simulations. The solver uses a multigrid scheme to accelerate solution convergence for conjugate heat transfer problems. It provides complete mesh flexibility and allows solution of even the most complex electronic assemblies using unstructured meshes — providing robust and extremely fast solution times.

Robust Numerical Solution

ANSYS Icepak software uses state-of-the-art technology available in the ANSYS FLUENT CFD solver for thermal and fluid flow calculations. The ANSYS Icepak solver solves for fluid flow and includes all modes of heat transfer — conduction, convection and radiation — for both steady-state and transient thermal flow simulations. The solver uses a multigrid scheme to accelerate solution convergence for conjugate heat transfer problems. It provides complete mesh flexibility and allows solution of even the most complex electronic assemblies using unstructured meshes — providing robust and extremely fast solution times.

XII. PRODUCT SELECTED FOR THERMAL SIMULATION

The below shown product has been selected for thermal simulation. The components which are used in this product are shown below.

ENCLOSURE

The enclosure has two parts, front cover & back cover. In enclosure, there are circuit board and hard disks placed.

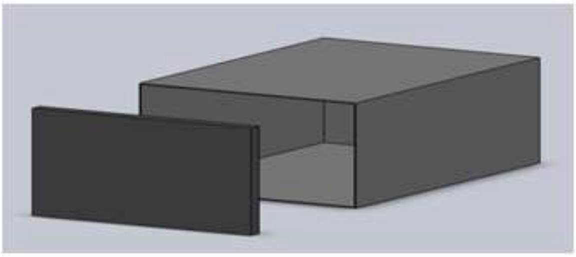


Fig: 9 Enclosure

HARD DISK

In this product, there are two Hard disks.

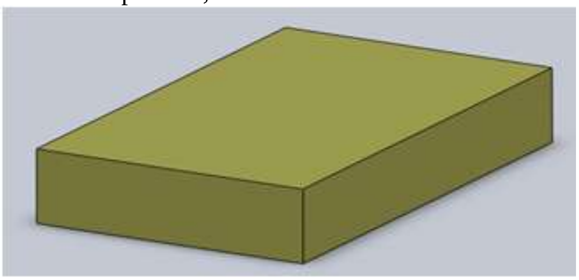


Fig: 10 Hard disk

XIII. PRINTED CIRCUIT BOARD (PCB)

The PCB is the main heat source in this product, because the semiconductor components which are used in the PCB will dissipate power.

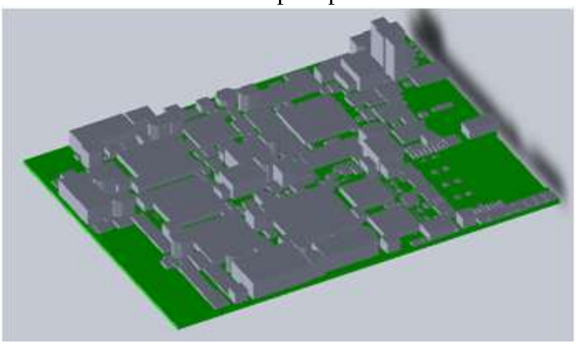


Fig: 11 Printed Circuit Board

XIV. ASSEMBLY OF PARTS

The parts are assembled inside the enclosure, the assembly is made like actual product.

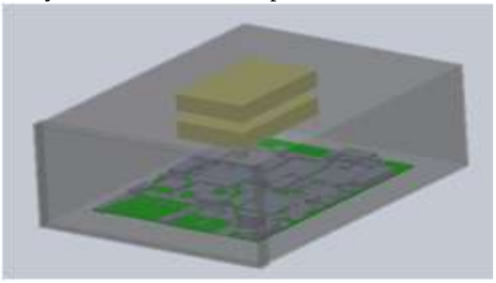


Fig: 12 Assembly of parts

XV. COMPONENTS CONSIDERED FOR SIMULATION

In the PCB there are many components. But some components will generate heat because it will consume more power. The selected components are mentioned below.

Fig: 13 Components List

XVI. POWER DISSIPATION AND TEMPERATURE LIMITS

The power dissipation values are taken from the datasheets of individual components and listed in the below table. The maximum junction temperature of the components which can withstand when operating is listed in the table. If the component exceeds the prescribed junction temperature, then the particular device will get fail.

TABLE 3
POWER AND TEMPERATURE LIMIT CHART

Sl. No	Components	Power in W	Temperature Limit in °C
1	U1	49.2	125
2	U72	27.76	125
3	U73	27.76	125
4	U74	27.76	125
5	U99	2.5	125
6	U100	2.5	125
7	U85	0.435	85
8	U86	0.435	85
9	U75	0.435	85
10	U77	0.435	85
11	U90	0.435	85
12	U76	0.435	85
13	U78	0.435	85
14	U91	0.435	85
15	U93	0.435	85
16	U94	14.25	125
17	U34	17	125

XVII. THERMAL RESISTANCE VALUES

TABLE 4
Thermal resistance values

Sl.No	Components	Power in W	Rjc in °C/W	Rjb in °C/W
1	U1	49.2	0.1	3.5
2	U72	27.76	0.1	3.5
3	U73	27.76	0.1	3.5
4	U74	27.76	0.1	3.5
5	U99	2.5	10.1	31.19
6	U100	2.5	10.1	31.19
7	U85	0.435	4.4	10.44
8	U86	0.435	4.4	10.44
9	U75	0.435	4.4	10.44
10	U77	0.435	4.4	10.44
11	U90	0.435	4.4	10.44
12	U76	0.435	4.4	10.44
13	U78	0.435	4.4	10.44
14	U91	0.435	4.4	10.44
15	U93	0.435	4.4	10.44
16	U94	14.25	64.8	14.4
17	U34	17	64.8	14.4

XVIII. THERMAL SIMULATION

PCB Level thermal simulation in natural convection

In this simulation, the PCB is kept in open environment. The simulation is done in natural convection mode. The calculated power dissipation & resistance values are fed into the individual model. The Total PCB thermal model is done in Ansys IcePak tool as shown below.

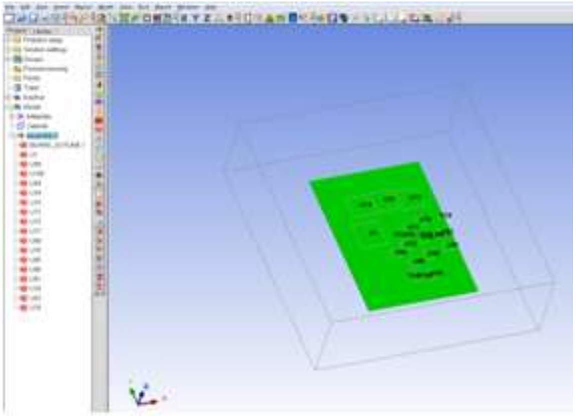
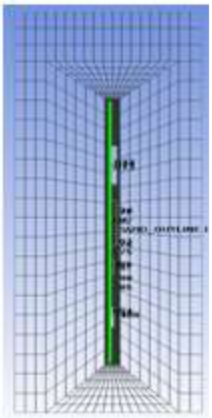


Fig: 14 PCB Thermal model



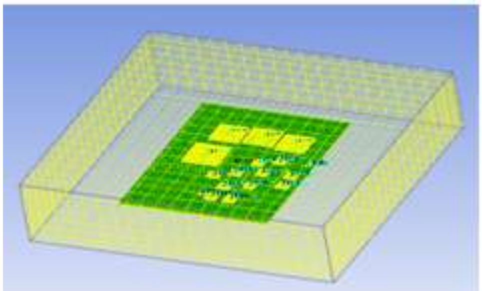


Fig: 15 Thermal Model with Meshing

TABLE 5
PCB LEVEL THERMAL SIMULATION RESULT

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	138.456	
2	U1	213.634	125
3	U72	141.428	125
4	U73	314.383	125
5	U74	212.15	125
6	U99	208.221	125
7	U100	209.885	85
8	U85	130.16	85
9	U86	129.921	85
10	U75	141.301	85
11	U77	147.715	85
12	U90	119.734	85
13	U76	128.535	85
14	U78	116.812	85
15	U91	118.567	85
16	U93	134.426	85
17	U94	237.051	125
18	U34	132.931	125

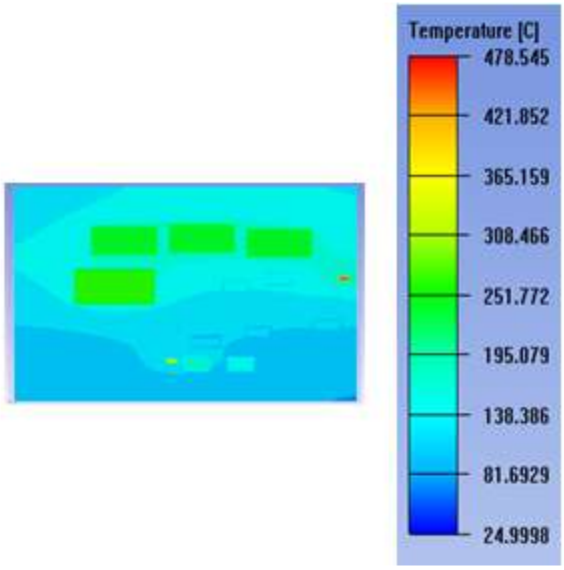


Fig: 16 Contours of PCB Level simulation Result

NOTE

According to the simulation result, all the components exceeded maximum Junction temperature limit. So the product failed.

System Level thermal simulation in natural convection

The PCB and the hard disks are placed inside the enclosure and done the system level thermal simulation in natural convection.

TABLE 6
RESULTS OF SYSTEM LEVEL THERMAL SIMULATION IN NATURAL CONVECTION

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	144.85	
2	U1	226.206	125
3	U72	196.979	125
4	U73	469.124	125
5	U74	257.366	125

6	U99	248.233	125
7	U100	250.11	85
8	U85	113.508	85
9	U86	122.17	85
10	U75	162.645	85
11	U77	212.444	85
12	U90	109.589	85
13	U76	107.837	85
14	U78	107.564	85
15	U91	107.577	85
16	U93	121.133	85
17	U94	340.369	125
18	U34	179.358	125

NOTE

According to the system level Simulation result, all the components are exceeded maximum Junction temperature limit. So the product failed.

XIX. PRODUCT ENHANCEMENT

Iteration 1

Since there is no air circulation inside the enclosure, the product got failed in previous simulation. So we modified the enclosure to have better air for better convection heat transfer. The modified model is shown below.

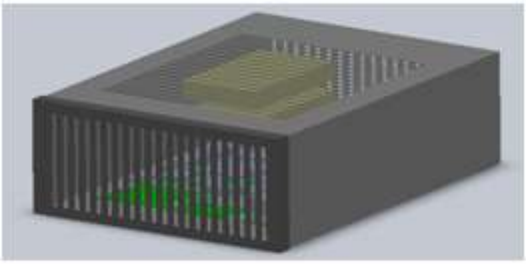


Fig: 17 Thermal Simulation in Natural Convection

In the above shown model, vent holes are provided on front and back cover of the product.

TABLE 7
RESULT WITH VENT HOLES SETUP IN NATURAL CONVECTION

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	124.565	
2	U1	231.989	125
3	U72	159.369	125
4	U73	409.913	125
5	U74	261.046	125
6	U99	253.023	125
7	U100	255.344	85
8	U85	97.5216	85
9	U86	108.352	85
10	U75	169.31	85
11	U77	208.172	85
12	U90	72.4817	85
13	U76	75.417	85
14	U78	69.5815	85
15	U91	71.2659	85
16	U93	104.618	85
17	U94	267.461	125
18	U34	144.834	125
19	Hard disk1	168.542	
20	Hard disk2	171.47	

NOTE

According to first iteration, some of the components worked out and many of the components got failed.

Inputs for Fan Selection

Fig: 18 Model with fan Table

TABLE 8
Results on thermal simulation with forced convection

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	122.873	
2	U1	226.304	125
3	U72	157.685	125
4	U73	275.192	125
5	U74	248.631	125
6	U99	243.018	125
7	U100	239.553	85
8	U85	115.799	85
9	U86	121.94	85
10	U75	155.888	85
11	U77	166.916	85
12	U90	85.6956	85
13	U76	103.237	85
14	U78	87.9969	85
15	U91	89.5494	85
16	U93	115.029	85
17	U94	284.436	125
18	U34	137.849	125

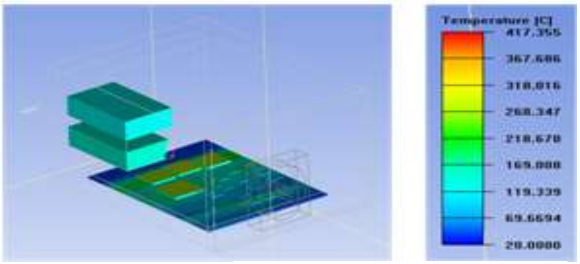


Fig: 19 Contours forced convection simulation result

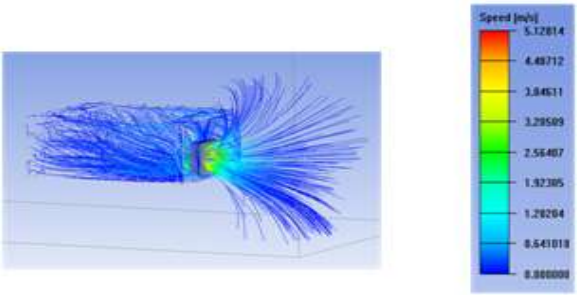


Fig: 20 Air flow

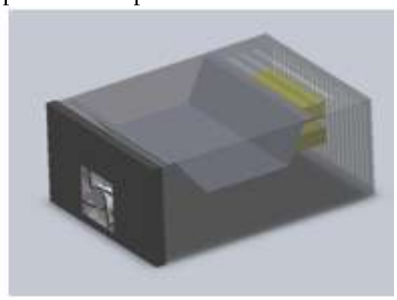
NOTE

According to the forced convection results, all the components failed.

Iteration 2

Since the area of contact is more inside the product, the sucked air is not passing through the components.

In this iteration we are planning to reduce the area of the enclosure near to the PCB, because the majority of air circulated above the PCB which was not required. So we decided to redirect the air flow towards the PCB by introducing a Baffle Plate and modifying the vent holes on top surface of the enclosure. The hard disk location also got changed due to space constrain to place the Baffle Plate. The modified product setup is shown below.



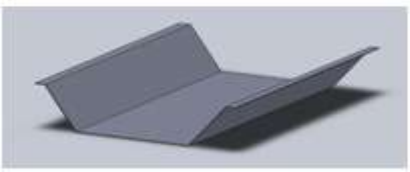


Fig: 21 Baffle plate attached

TABLE 9
Simulation result on forced convection with baffle plate

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	87.6197	
2	U1	161.578	125
3	U72	104.616	125
4	U73	155.081	125
5	U74	140.965	125
6	U99	137.714	125
7	U100	140.712	85
8	U85	90.6301	85
9	U86	86.8725	85
10	U75	93.5949	85
11	U77	93.2014	85
12	U90	87.0362	85
13	U76	92.7542	85
14	U78	81.1759	85
15	U91	78.7009	85
16	U93	85.2573	85
17	U94	219.218	125
18	U34	97.7462	125
19	Hard disk1	30.506	
20	Hard disk2	26.3746	

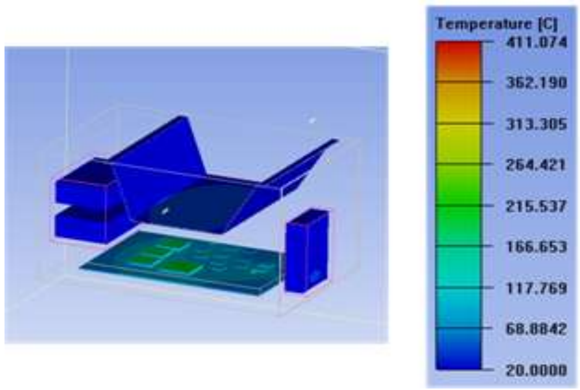


Fig: 22 Simulation result for forced convection

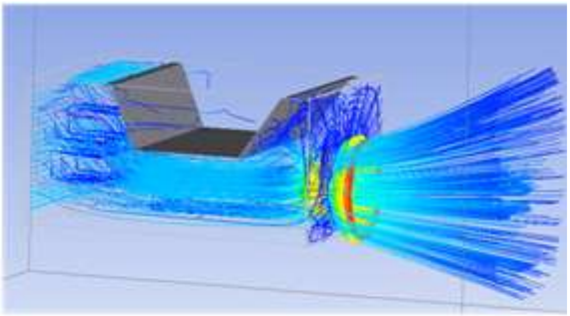


Fig: 23 Air flow through exhaust fan

NOTE

According to Iteration 2 some of the components worked out and all other components are very close to maximum limits.

Iteration 3

In the previous iteration majority of the components were close to the pass region. Due to the high power dissipation components, the other components are in failure region. So heat sinks with fins are fixed to dissipate heat through conduction from hot components. The heat sink can be decided as per below process.

Inputs for Heat Sink Selection

¬ Power dissipation of the chip set / processor (P_{max})
¬ Maximum allowable junction temperature (T_J) or Case Temperature
¬ Thermal resistances, R_{JC}, R_{CA} and R_{JB}
¬ Local ambient Temperature (T_A)
¬ Form factor of the system
¬ Space availability
¬ Flow availability
¬ Chip or processor mechanical requirements (weight and mounting arrangement)

Selection Procedure
Calculation of Thermal Resistance:

Thermal resistance of the heat sink (Heat sink to Ambient) will be calculated as follows

$\mathbf{R_{SA} = (T_J - T_A) / P_{max} - R_{JC} - R_{TIM}}$ (Here R_{TIM}=Thermal Interface material resistance)

TABLE 10
SIMULATION RESULTS

Sl. No	Components	Simulated Temperature in °C	Temperature Limit in °C
1	BOARD	53.3359	
2	U1	77.9133	125
3	U72	78.1164	125
4	U73	112.373	125
5	U74	71.8405	125
6	U99	68.2758	125
7	U100	71.5518	85
8	U85	59.1115	85
9	U86	56.9832	85
10	U75	60.0849	85
11	U77	59.5009	85
12	U90	58.9298	85
13	U76	59.843	85
14	U78	54.5763	85
15	U91	51.8815	85
16	U93	55.5079	85
17	U94	124.691	125
18	U34	72.4292	125
19	Hard disk1	22.4728	
20	Hard disk2	21.1395	

TABLE 11
COMPARISON BETWEEN PRE ENHANCEMENT AND POST ENHANCEMENT

Sl. No	Components	Initial Design Results Temperature in °C	Enhanced Design Results Temperature in °C	Temperature Limit in °C
1	BOARD	144.85	53.3359	
2	U1	226.206	77.9133	125
3	U72	196.979	78.1164	125
4	U73	469.124	112.373	125
5	U74	257.366	71.8405	125
6	U99	248.233	68.2758	125
7	U100	250.11	71.5518	85
8	U85	113.508	59.1115	85
9	U86	122.17	56.9832	85
10	U75	162.645	60.0849	85
11	U77	212.444	59.5009	85
12	U90	109.589	58.9298	85
13	U76	107.837	59.843	85
14	U78	107.564	54.5763	85
15	U91	107.577	51.8815	85
16	U93	121.133	55.5079	85
17	U94	340.369	124.691	125
18	U34	179.358	72.4292	125
19	Hard disk1	186.076	22.4728	
20	Hard disk2	180.79	21.1395	

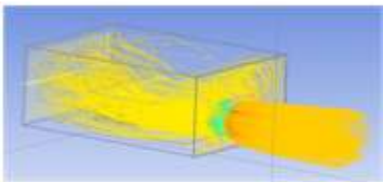


Fig: 24 Air flow through Exhaust Fan

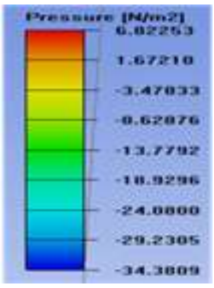


Fig: 25 Pressure inside the product

NOTE

According to Iteration 3, all the components operating temperature are within the maximum limit.

XX. CONCLUSION

The post enhancement result works well than the pre enhancement result. The operating temperature values are within the maximum limit in iteration 3, hence the life of product much improved. The rate of failure on components is very less, so the reliability of the product improved and cost on service also reduced.

The same process can be followed to any electronic product for better thermal performance.

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