ANALYSIS ON ELECTRONICS CHIP USING SURFACE TO SURFACE RADIATION

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As day by day the size of the electronic instruments decreases drastically and simultaneously the number of functions per chip increases hugely. So it's a great challenge to packaging engineers to remove the heat generated by the chip efficiently. Many researches are going on in this direction for the past few decades. In the last decade or so CFD simulations have become more and more widely used in studies of electronic cooling. Validation of these simulations has been considered to be very important.

Compact packaging is also in progress in desktops and in server computers, driven by the needs to reduce the box dimensions and cut wiring distances between electronic devices. In a growing number of applications computer failure results in a major disruption of vital services and can even have life-threatening consequences. As a result, efforts to improve the reliability of electronic computers or electronics chips are as important as efforts to improve their speed and storage capacity.

In this study we are analyzing the cooling effects of the chip by modeling the geometry numerically. We have considered a single chip module. The modeling is carried out by solving the governing equations for a flow through a channel via obstruction. The case we have considered is transient laminar flow. The method we have used here to discretize the governing equations, namely the continuity equation, the momentum equation and the energy equation is Finite Difference Method (FDM). To solve the problem the algorithm we have used is Marker and Cell method, and to discretize the convective term we have used the weighted second upwind and space centered difference. The diffusive terms are discretized by central difference scheme.

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 worksbestinallsituations.Goodthermal

Conduction

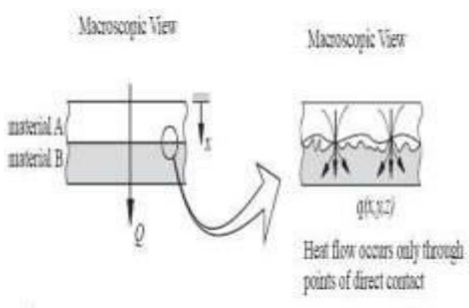


Fig:1Conduction

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. HEATTRANSFERTHEORY

Threebasicnaturallawsofphysics:

a. Heat will always be transferred from a hot medium to a cold medium, until equilibrium is reached.
b. Theremustbeatemperaturedifference
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.

ModesofHeatTransfer

¬ Conduction
¬ Convection
¬ Radiation

TABLE1
ThermalConductivityofvariousmaterials

Material	W/mK
Aluminum(Pure)	216
AluminumNitride	230
Alumina	25
Copper	398
Diamond	2300
Epoxy(No fill)	0.2
Epoxy(Highfill)	2.1
Epoxyglass	0.3
Gold	296
Lead	32.5
Silicon	144
SiliconCarbide	270
SiliconGrease	0.2
Solder	49.3

Convection

One of the mechanism ofheat transferoccurring because of bulk motion (observable movement) of fluids.Heatis the entity of interest being adverted (carried), and diffused (dispersed). This can be contrasted withconductiveheat transfer, which is the transferofenergybyvibrationsatamolecularlevel through a solid or fluid, and radioactive, the transfer of energy through electromagnetic waves.

Convectionmode

Therearetwomajormodeofconvection,

- NaturalConvectionorfreeconvection
- ForcedConvection

Naturalconvection

Natural convection, orfree 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 (lessdense) componentsrise, 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.

Forcedconvection

Inforced convection, also calledheat advection, fluidmovementresultsfromexternal surface forcessuch as a fan or pump. Forced convection is typically used to increase the rate of heat exchange. Many types ofmixingalso 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 oraerodynamic heating. Fluid radiator systems, and also heating and cooling of parts of the body byblood circulation, are other familiar examples of forced convection.

Radiation

Thermalradiationisenergyemittedbymatter aselectromagnetic wavesdue to the pool ofthermal energythat all matter possesses that has atemperature aboveabsolute zero. Thermal radiation propagates without the presence of matter throughthe vacuum of space.

Thermalradiationisadirectresultofthe random movements of atoms and molecules in matter. Since these atoms and molecules are composed of charged particles(protonsandelectrons),theirmovement results in the emission ofelectromagnetic radiation, which carries energy away from the surface.

III. TYPESOFFLOW

- LAMINARFLOW
- TURBULANTFLOW

Laminarflow

It is also called asstreamlineflow, which is occurs,whenafluidflowsinparallellayerswithno disruption between the layers. There are no cross currentsperpendiculartothedirectionofflow,noreddieso r swirls of fluids. In laminar flow the motion of the particles of fluid is very orderly withall particles moving in straight lines parallel to the pipe walls.Influid dynamics, laminar flow is a flow regime characterized by high momentum diffusion and low momentum convection.

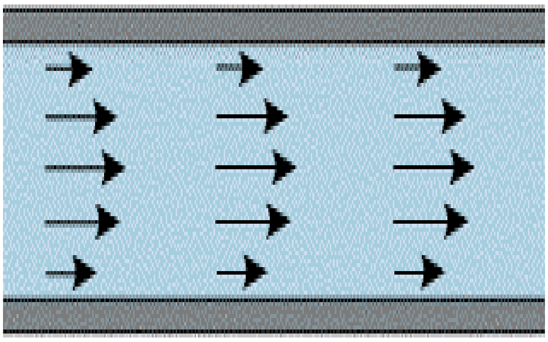


Fig:2LaminarFlow

Turbulence or Turbulent flow

Isaflowregimecharacterisedbychaotic andstochasticpropertychanges.Thisincludes lowmomentum diffusion, high momentum Convection and rapid variation ofpressureand velocityin space and time. Nobel LaureateRichard Feynmandescribedturbulenceas"themostimportant unsolvedproblemofclassicalphysics" Flowinwhich thekinetic energydies out due to the action of fluid molecular viscosityiscalled laminarflow.While thereisnotheoremrelatingthenon-dimensionalReynoldsnumber(Re)toturbulence flows at Reynolds numbers larger than 100000 are typically(butnotnecessarily)turbulentwhilethoseat low Reynolds numbers usually remain laminar.

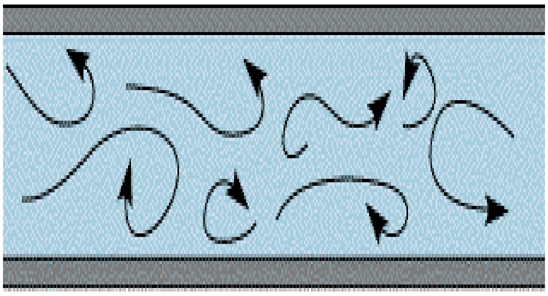


Fig:3TurbulentFlow

IV. PRINTEDCIRCUITBOARD

A printed circuit board (PCB), is used to mechanically support and electrically connect electronic components usingconductive pathways, tracksorsignaltraces etchedfromcoppersheets laminated onto a non-conductivesubstrate. It is also referredtoasprintedwiringboard(PWB)oretched wiring board. Printed circuit boards are used in virtually all but the simplest commercially produced electronic devices.

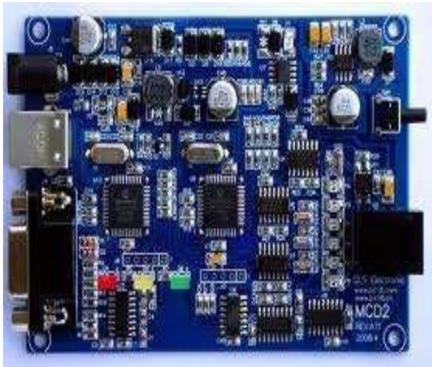


Fig:4 PrintedCircuitBoard

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

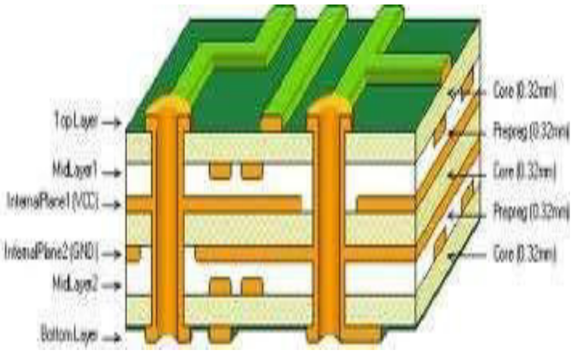


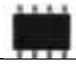
Fig:5 CrossSectionofPrintedCircuitBoard

MaterialCore:Coppersheet
Prepreg: It is a non conductive material to separate two copper sheets.

V. ELECTRONICCOMPONENTS

Anelectroniccomponent isabasic indivisibleelectronicelement that is available in a discrete form. Electronic components are discrete devicesordiscretecomponents,mostlyindustrial products and not to be confounded with electrical elements which are conceptual abstractions representing idealized electronic components. Electroniccomponentshavetwoormoreelectricaltermin als(orleads).Theseleadsconnect, usuallysolderedtoaprintedcircuitboardtocreate anelectroniccircuit(adiscretecircuit)witha particular function (for example anamplifier,radio receiver oroscillator). Basic electronic components may be packaged discretely as arrays or networks of like components or integrated inside of packagessuchassemiconductorintegratedcircuits,hybri d integrated circuits or thick film devices.

TABLE2COMPONENTS HISTORY

COMPONENTTYPE	IMAGE
DIP	
QFP	
SOIC	
QFN	
BGA	
SON	

ConstructionofComponent

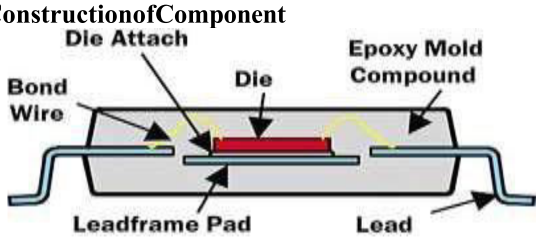


Fig:6ConstructionofcomponentMaterials

VI. AIMANDSCOPE

Reducing the operating temperature and increase theproductlife,Anoperatingtemperatureis thetemperatureat which an electrical or mechanical device operates. The device will operate effectively within a specifiedtemperature range which varies based on the device function and application context andrangesfromthe minimumoperating temperature to the maximum operating temperature(orpeak operating temperature). Outside this range ofsafe operating temperaturesthe 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.

Atelevated temperaturesasilicondevicecanfail 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. Mostdevices 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.

Thelifeofanelectronicdeviceisdirectlyrelated 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 coolaspossible(withinanacceptablenoiselevel)for maximum reliability, longevity and return on investment.

VII. DEFINITIONS

Thetermsusedforthermalanalysisvary 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-Junctiontemperature,oftenassumedtobeconstant across the die surface (°c)

T_C -Package temperature at the interface between thepackageandits 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-Heattransfer per unittime(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 referencepoints―A‖and―B‖ orRTHAB(°c)

R_{QJMA}-Junctiontomovingairambientthermal resistance (°c/w)

R_{QJC} - Junction to case thermal resistance of a packagedcomponent fromthesurfaceofitssiliconto its thermal tab or R_{THJC} (°c/w)

R_{QJA}-Junctiontoambient thermal resistance orR_{THJA}

C_{QAB}ThermalCapacitancebetweenreferencepoints ―A‖and―B‖orC_{THAB}(°c/w)

Z_{QAB} -Transient thermal impedance between referencepoints―A‖and―B‖orZTHAB

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

wecaneasilyderivetheoftenusedequationfor estimating junction temperature:

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

Forexample,let'sassumethat:

$R_{\Theta JA}$=30°C/W P_D = 2.0W

T_A=75.C

Then,bysubstitution:

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

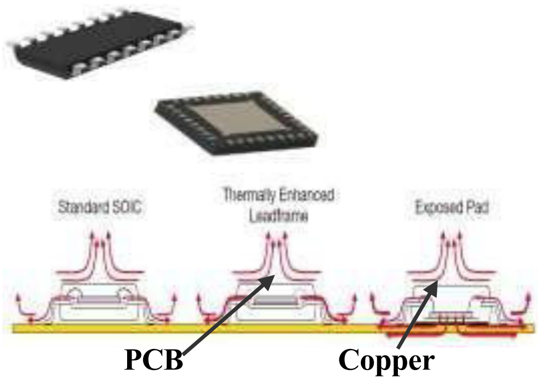
T_J=75°C+(2.0W*30°C/W) T_J = 75°C + 60°C

T_J= 135°C

A cautionary note is in order here. The thermal conductivities of some materials vary significantly with temperature. Silicon's conductivity, forexample, falls by about half over the min-max operatingtemperaturerangeofsemiconductor devices. Ifthe die'sthermal resistance isa significant portion of the thermal stack-up, then this temperature dependency needs to be included in the analysis.

VIII. JUNCTIONTEMPERATURE

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 andIGBTs.Usingtheconcept―junctiontemperature‖ 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 safeto assume that the power is generated at the die's surface.



IX. THERMALMODEL

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.

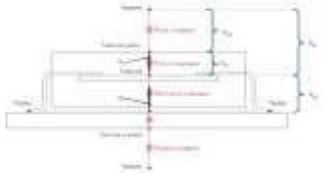


Fig:7 ThermalModel

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 totheir universal adoptionremain. The JEDECindustry standards committee is engaged in standardizingsome of these methodologies.

X. COMPACTTHERMALMODEL

A Compact Thermal Model is a behavioralmodel 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 computationaleffort.Acompactthermalmodelisnot 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.

TWORESISTORMODEL

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.

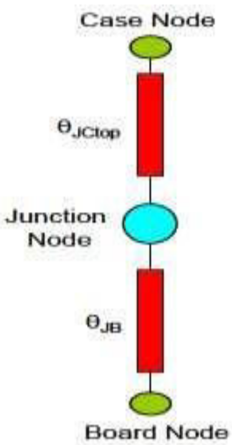


Fig:8 Tworesistormode

Junction-to-boardthermalresistance(θ_{JB})

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

Themetricisdefinedas:

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

Where

θ_{JB}=thermalresistancefromjunction-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 thelongest sideofthepackagenomorethan 1mm from the edge of the package body (ºC)

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

Junction-to-casethermalresistance(θ_{JC}top)

Themetricismeasuredinatopcoldplatefixture and is defined as:

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

Where

θ_{JCtop}=Thermalresistancefromjunction-to-case (ºC/W)

T_J=Junctiontemperaturewhenthedevicehasachieved steady-state after application of P_H

(ºC)T_{Ctop}=Casetemperature,measuredatcenterofthe 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 forelectronics thermal management.

IcepakObjects

ANSYS Icepak software contains many productivity-enhancement features that enable quick creationandsimulationofelectronicscooling 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 smartobjectscapturegeometricinformation,material properties, meshing parameters and boundary conditions — all of which can be parametric for performing sensitivity studies and optimizingdesigns.

ECAD/MCADInterfaces

To accelerate model development, ANSYS IcepakimportsbothelectronicCAD(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 productsenableANSYSIcepaktoimportECADdata 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 Modellersoftware allows ANSYS Icepak to import geometry from all major mechanical CAD packages through the ANSYSWorkbenchgeometryinterfaces. Geometry imported from ECAD and MCAD can be combined into smart objects to efficiently create models of electronic assemblies.

FlexibleAutomaticMeshing

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,whichenableautomaticgenerationofbody-fitted meshes with minimal user intervention. The meshdensity canbe localized through nonconformal interfaces, which allows inclusion of a variety of componentscaleswithinthesameelectronicscooling model.

While fully automated, ANSYS Icepak contains many mesh controls that allow customization of the meshing parameters to refine the mesh and optimize thetrade-offbetweencomputationalcostandsolution 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 FLUENTCFD 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 meshflexibilityand allowssolutionofeven the most complex electronic assemblies using unstructured meshes — providing robust and extremely fast solution times.

RobustNumericalSolution

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XII. PRODUCTSELECTEDFOR 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.

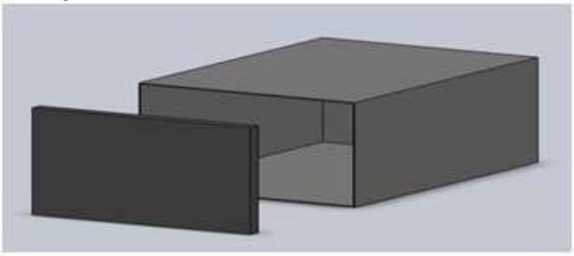


Fig:9Enclosure

HARDDISK

Inthisproduct,therearetwo Harddisks.

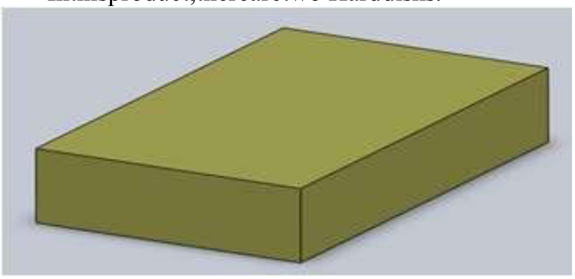


Fig:10Harddisk

XIII. PRINTEDCIRCUITBOARD(PCB)

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

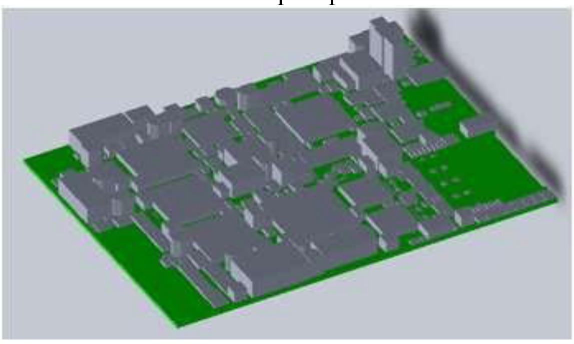


Fig:11PrintedCircuit Board

XIV. ASSEMBLYOFPARTS

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

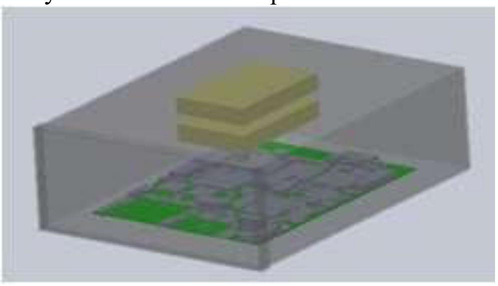


Fig:12Assemblyofparts

XV. COMPONENTSCONSIDERED 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:13ComponentsList

XVI. POWERDISSIPATIONAND 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.

TABLE3
POWERANDTEMPERATURELIMIT 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. THERMALRESISTANCEVALUES

TABLE4
Thermalresistancevalues

Sl.No	Components	Power in W	Rjc in °C/W	Rjbin °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. THERMALSIMULATION

PCB Level thermal simulation in natural convection

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

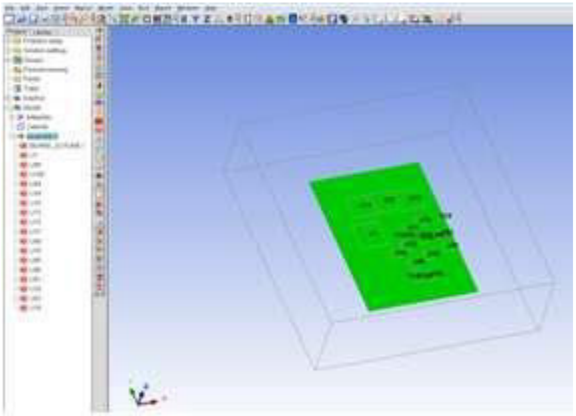
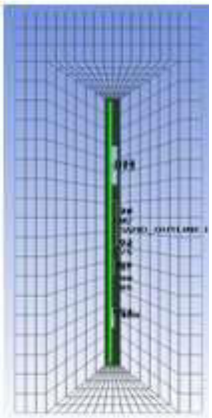


Fig:14PCBThermalmodel



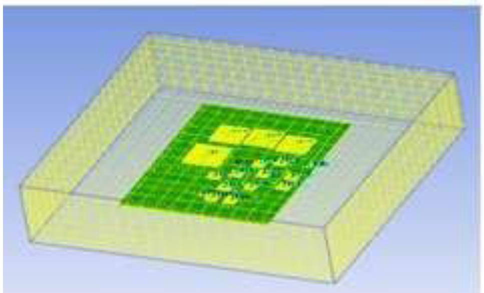


Fig:15ThermalModelwithMeshing

TABLE5
PCBLEVELTHERMALSIMULATIONRESULT

Sl. No	Components	Simulated Temperature in °C	TemperatureLimitin°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

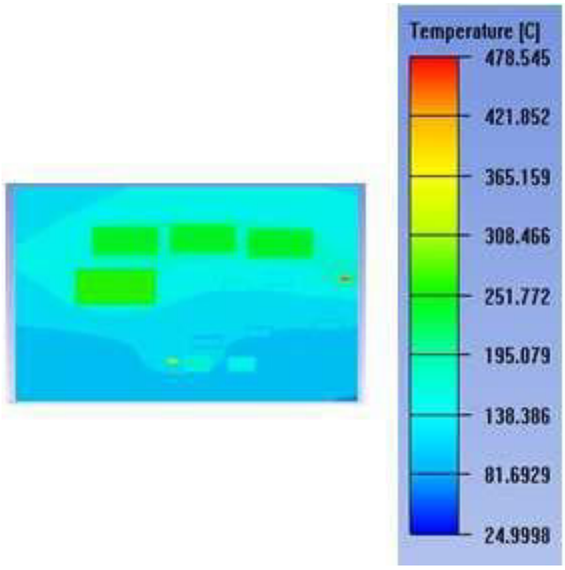


Fig:16ContoursofPCBLevelsimulationResult
NOTE

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

System Level thermal simulation in natural convection

ThePCBandthe harddisksareplacedinside the enclosure and done the system level thermal simulation in natural convection.

TABLE6
RESULTSOFSYSTEMLEVELTHERMALSIMULATIONIN NATURAL CONVECTION

Sl. No	Components	Simulated Temperature in °C	TemperatureLimitin °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. PRODUCTENHANCEMENT

Iteration1

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.

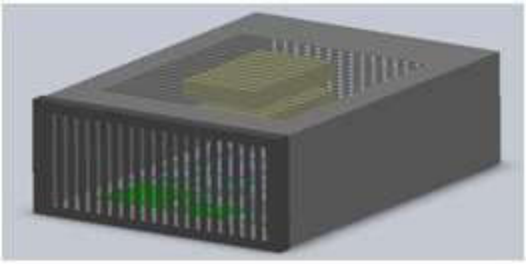


Fig:17ThermalSimulationinNatural Convection

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

TABLE7
RESULTWITHVENTHOLESSETUPINNATURALCONVECTION

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	Harddisk1	168.542	
20	Harddisk2	171.47	

NOTE

According to first iteration, some of the components worked outand manyofthecomponents got failed.

InputsforFanSelection

Fig:18ModelwithfanTable

TABLE 8
Resultsonthermalsimulationwithforced convection

Sl. No	Components	Simulated Temperature in °C	TemperatureLimitin °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

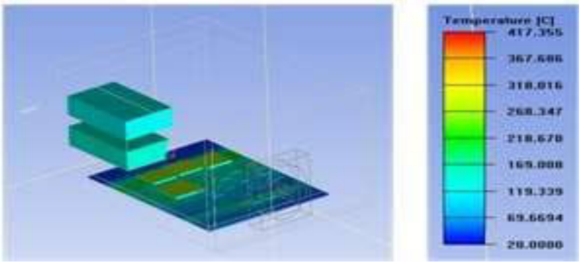


Fig:19Contoursforcedconvectionsimulation result

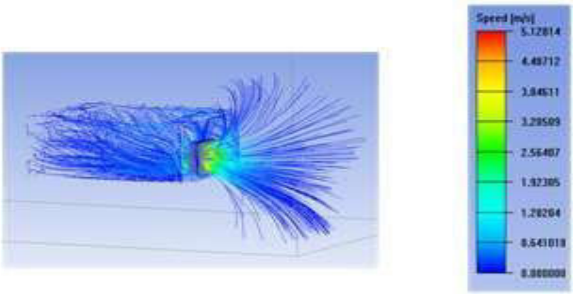


Fig:20Airflow

NOTE

Accordingtotheforcedconvectionresults,all the components failed.

Iteration2

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 themajority 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.

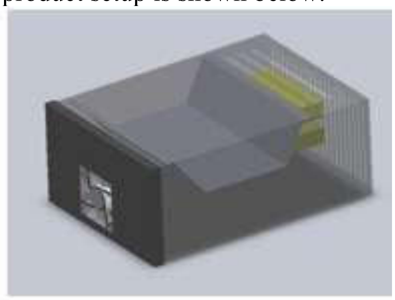


Fig:21Baffleplate attached

TABLE9
Simulationresultonforcedconvectionwithbaffle 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	

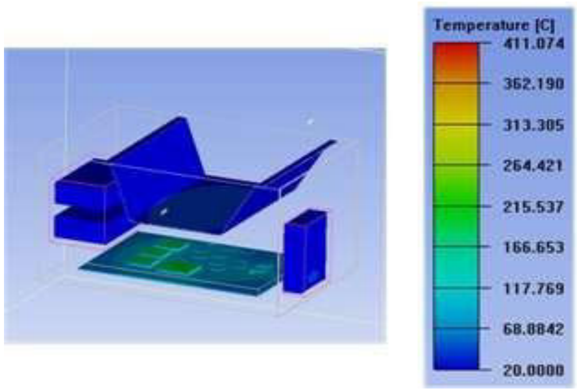


Fig:22Simulationresultforforcedconvection

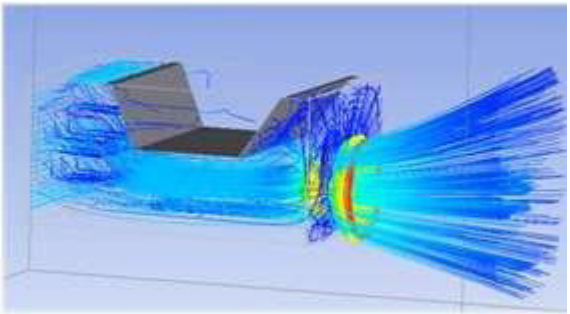


Fig:23Airflowthroughexhaustfan NOTE

AccordingtoIteration2some ofthecomponents worked out and all other components are very closeto maximum limits.

Iteration3

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 decidedas per below process.

InputsforHeatSinkSelection

- Powerdissipationofthechipset/processor (P_{max})
- Maximumallowablejunctiontemperature(T_J)or Case Temperature
- Thermalresistances,R_{JC},$R_{CA}$and R_{JB}
- LocalambientTemperature(T_A)
- Formfactorofthesystem
- Spaceavailability
- Flowavailability
- Chiporprocessormechanicalrequirements (weight and mounting arrangement)

SelectionProcedure

CalculationofThermalResistance:

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

$R_{SA}=(T_J-T_A)/P_{max}-R_{JC}-R_{TIM}$(Here R_{TIM}=ThermalInterfacematerialresistance)

TABLE10

SIMULATIONRESULTS

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	

TABLE11

COMPARISONBETWEENPREENHANCEMENTANDPOST ENHANCEMENT

Sl. No	Components	Initial Design Results Temperature in °C	Enhanced Design Results Temperaturein°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	

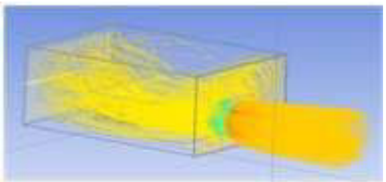


Fig:24AirflowthroughExhaustFan

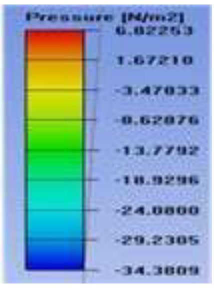


Fig:25Pressureinsidetheproduct

NOTE

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

XX. CONCLUSION

The postenhancement result works wellthanthe 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 reliabilityof 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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