Evaluation of Temperature for an Electronic Enclosure

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***Abstract-*—The evaluation of temperature for a typical electronic package used in the spacecraft industry has been verified using a lumped modeling methodology including radiation exchange calculation. Electronic enclosure packages constitute various heat dissipating elements mounted on the layered circuit board. The protection of components from thermal damages requires, that can be done by the careful selection of layouts, the dissipation levels which affects the circuit board and various used thermal control methods. ITAS refers to the integrated thermal analysis simulation available in the ISAC for calculation of radiation exchange factor internally, uses Gebhart technique and Monte Carlo Simulation technique. Package level simulation has been done to evaluate the temperature of electronic enclosure and results validated. Results of these thermal analysis are compared with the results given by thermovac tests conducted at ISAC. Under typical operating environmental condition and considerations of conduction and radiation heat transfer modes, temperature levels of the PCB and Components were improved. Based on this thermal analysis variance results suggestions have given to improve the thermal performance of the electronic enclosure packages.**

Keywords—Enclosure, Power card, Control card,ITAS, NISA HEAT/FEAP,Electroflo, Contact Conductance, Area Conductance.

I. INTRODUCTION

The thermal design of electronic packages ensures the reliability of the packages, getting such a thermal design an iterative task. For ex. consider a case of designing an electronic package with PCB with somecomponents on each. Before manufacturing such an electronic packagesthermally feasible layout of all components on the each PCB is required. This is necessary because, when all components aretraced at random and connected properly circuits function well. But when all components placed over specified area PCB, it may not work longer time. This is because, when all electronics components are working hot- spots generated on the PCB due to different power capacities of the chips. When temperature of the hot spots goes beyond the tolerable temperature of the electronic component, the component may fail. Then it is suggested that the chips are to be relocated such that the maximum temperature of the chips arelower. This process is to be repeated until the final temperature of the component lie within the reliable temperatures.

For better thermal analysis it is necessary to know how the electronic packages are fabricated. Packaging details design of the electronic components to the final assembly stages. The different stages involved in the package design are listed below.

1. Selection of components.
2. PC board selection.
3. Interaction between boards.
4. Casing (Enclosure) for the electronic package.

First stage is the selection of the basic components like ICs, resistors, Capacitors etc. Each with unique application.

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II.ELETRONIC ENCLOSURE PACKAGE DETAILS

The Electronic enclosure package is having a PCB along with the various components which is having a different level of heat dissipations. The components of PCB with enclosure is coupled with conductive and radioactive heat transfer mechanisms. The main objective of this work is to evaluate the steady state temperature of this electronic enclosure package. Various effects by the different thermal parameters of the components are also accounted and analyzed.

The enclosure, PCB along with components properties and mounting detail is required to evaluate and analyzed this problem.

A. CONFIGURATION

The package consists of two typical PCB cards mounted on Aluminium housing as shown in fig. PCB houses power card and control card. Power card is mounted first on the turret of the housing and the control card is mounting above the power card separated by the spacers.

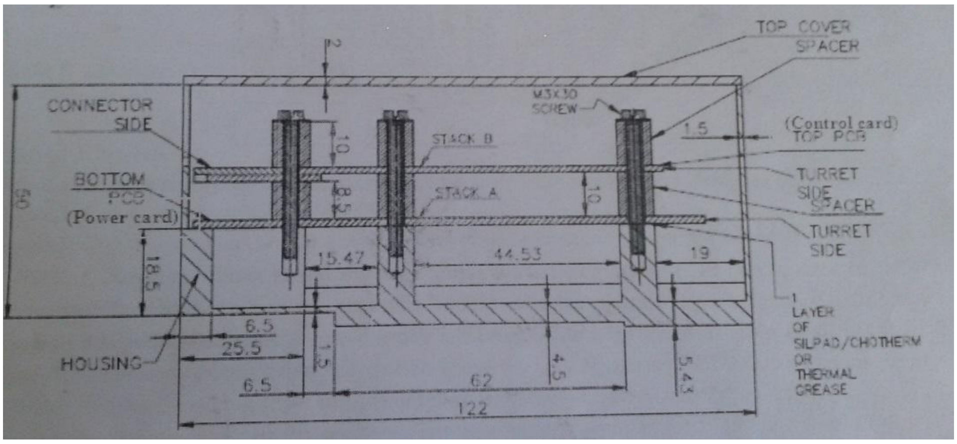

Fig.1. Construction details of Electronic Package

B.POWERCARD

The dimensions of the power card are 114 mm X 44 mm with the card thickness of 1.7 mm. The layer configuration of the card consists of high TG FR4 (prepeg) in between two 105 µm thick copper planes on either side of the prepeg. Components are mounted on one side of the card towards the anodized housing (turret interface). The card is mounted on turret with five no's of M3 screws with silpad as interface material. There are totally eight resisters and 6 mosfets are mounted on the power card. The footprints of all the components is as shown in fig. below.

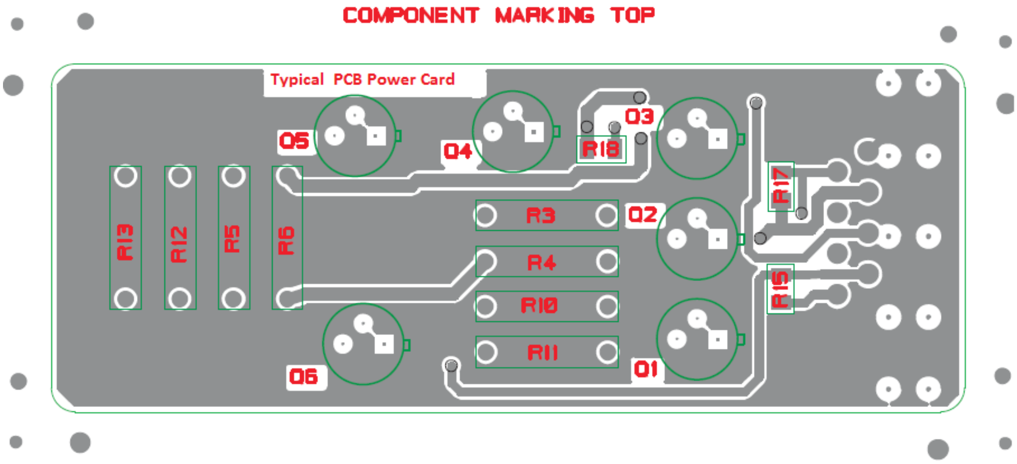

Fig. 2 Typical PCB power Card

C. CONTROL CARD

The dimensions of the control card are 100 mm X 44 mm with a total card thickness of 1.7 mm, and made up of TG FR4 prepeg. Control card is connected to the power card at 5 locations with M3 screws and spacers. Dissipation in control card is negligible.

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D THERMAL ANALYSIS

The main thermal inputs required for the thermal analysis are the thermal dissipation (constant or varying), PCB card mounting and size, and the temperature specification limits for the components. The component dissipations in various scenarios are accounted and tabulated as:

Table.1 Dissipation value of Component

Case	Total (W)	Q1	Q2	Q3	Q4	Q5	Q6
1	8.3	0.75	0.75	0.63	0.75	0.75	0.63
R1	R2	R3	R4	R5	R6	R7	R8
0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51

The main objective of the thermal analysis is to estimate the steady state temperatures of dissipating components and temperature distributions in a typical package. Further feasible thermal suggestions are given as per the requirement.

E THERMAL SPECIFICATIONS

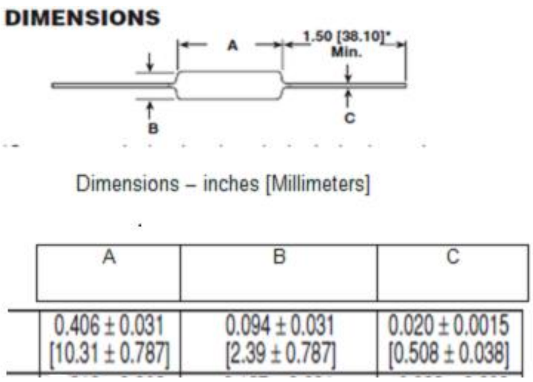
The de-rated temperature specification of the two components in the package is tabulated as:

Table.2: De-rated temperature specification of the package components

Sl. No.	Component	Maximum Dissipation, (W)	Mass (g)	No. Of pins	Type of mounting	Derated value, (°C)
01	MOSFET	0.75	1	3	Flush	110
02	RESISTOR	0.51	0.34	2	Sty cast	115

F. THERMAL PROPERTIES

The effective in-plane thermal conductivity (calculated) of Power PCB card is 25 W/m K due to the two copper planes. The leads of the resistor are considered to be Kovar with thermal conductivity of 17.3 W/m K. The PCB and the components coated with conformal coating is considered in the analysis ($\mathcal{E}_{IR}$=0.72). The emissivity of 0.56 is considered in the analysis. The thermo-physical property of other materials is given in the table below. The in-plane thermal conductivity of the control PCB is enhance further by adding addition copper planes later.



A	B	C
0.406 ± 0.031 [10.31 ± 0.787]	0.094 ± 0.031 [2.39 ± 0.787]	0.020 ± 0.0015 [0.508 ± 0.038]

Fig.3 Constructional Details of Resistors

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Table.3 Thermo-physical properties of materials used in the package

Material	Thermal Conductivity (W/m K)
Silpad 2000 (<0.3mm)	3.5
Sty cast	1.0
High TG FR4	0.5
Copper	390.0
Aluminium	168.0

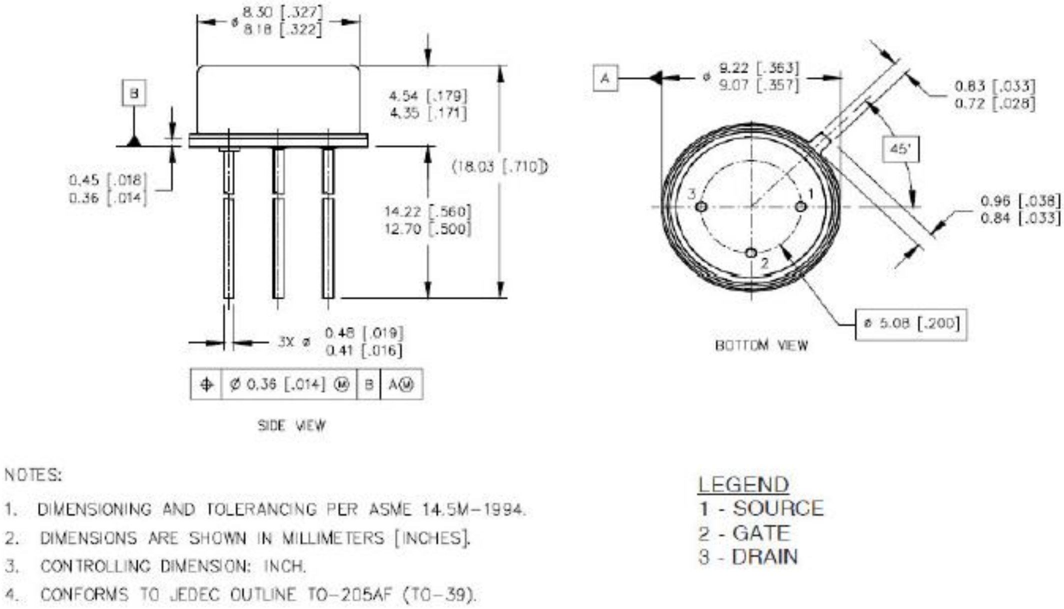

Fig.4 Constructional Details of Mosfet

G. BOARD PROPERTIES

Name: A Typical Power card

Type: PCB

Material: FR4

Thermal conductivity: 0.5 W/m^{0}C

Board emissivity: 0.72

Total Power: 8.3 W

Length: 114 mm

Width: 44 mm

Thickness: 1.7 mm Initial temperature: 30^{0}C.

H. ENCLOSURE PROPERTIES

Type: Hollow Box type.

Total Power: 0W

Dimensions: 122(X) mm X 50(Y) mm X 50(Z) mm

Temperature: 30^{0}C

Thermal conductivity: 168.0 W/m^0 C

Wall thickness: 1.0 mm.

Emissivity: 0.56

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I. COMPONENT DETAILS

Table.4 Component Details

Source	Power (W)	X- Pos (mm)	Y-Pos (mm)	Length (mm) or Dia.(For Mosfet)	Width (mm)	Height (mm)	Component Type
1	0.75	7.901	8.364	10.36	-	-	Mosfet(Q1)
2	0.75	79.901	20.817	10.36	-	-	Mosfet(Q2)
3	0.63	79.482	33.271	10.36	-	-	Mosfet(Q3)
4	0.75	56.983	34.213	10.36	-	-	Mosfet(Q4)
5	0.75	37.203	33.69	10.36	-	-	Mosfet(Q5)
6	0.63	38.041	7.841	10.36	-	-	Mosfet(Q6)
7	-	89.073	12.286	2.377	5.271	2.0	Resistor(R01)
8	-	89.163	18.463	2.616	5.535	2.0	Resistor(R02)
9	0.51	51.802	22.544	18.523	2.5	2.0	Resistor(03)
10	0.51	52.325	16.893	17.791	2.5	2.0	Resistor(04)
11	0.51	20.721	11.765	2.5	18.314	2.0	Resistor(05)
12	0.51	27.21	11.87	2.5	18.419	2.0	Resistor(06)
13	-	89.267	24.951	2.093	5.024	2.0	Resistor(07)
14	-	65.302	80.812	5.337	2.512	2.0	Resistor(08)
15	-	43.849	35.102	5.233	2.302	2.0	Resistor(09)
16	0.51	51.593	11.032	18.628	2.5	2.0	Resistor(10)
17	0.51	52.64	5.695	17.581	2.5	2.0	Resistor(11)
18	0.51	13.919	11.556	2.5	18.733	2.0	Resistor(12)
19	0.51	7.326	11.869	2.5	18.419	2.0	Resistor(13)
20	-	45.105	6.533	5.233	2.512	2.0	Resistor(14)
21	-	89.267	12.393	2.198	4.709	2.0	Resistor(15)
22	-	62.267	20.242	2.616	5.128	2.0	Resistor(16)
23	-	89.372	24.847	2.093	4.814	2.0	Resistor(17)
24	-	65.362	30.782	5.023	2.407	2.0	Resistor(18)

III. RESULTS AND DISCUSSION

A. RESULTS

Any thermal design has to ensure appropriate heat flow path between heat dissipating zone (Resisters and Mosfets) and the Sink. This is ensure by the use of thermal interface material between components and PCB. In this package the components are mounted on the PCB with sty-cast and silpad and the card is mounted on the package box with silpad.

The Results are as follows.

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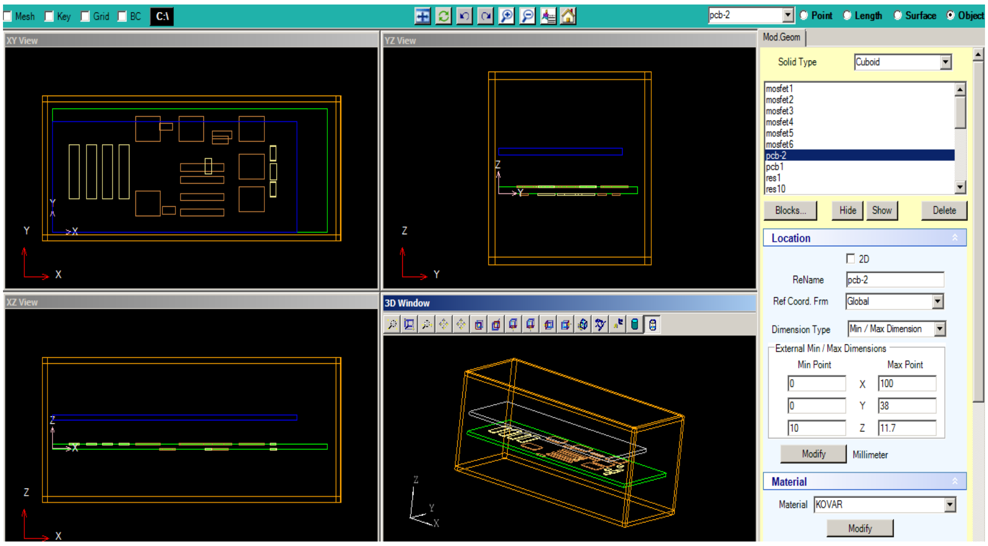

Fig.5 Schematic showing power card, control card and enclosure

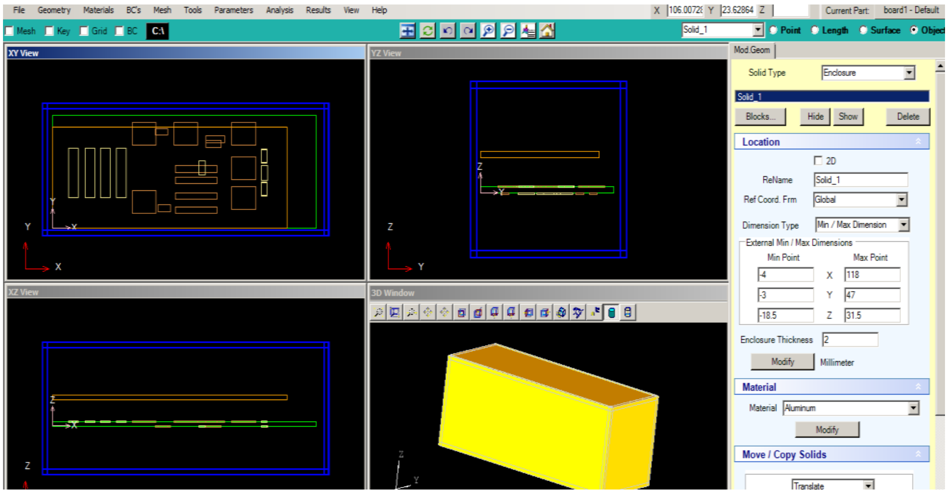

Fig.6 Schematic showing Components Locations and Properties

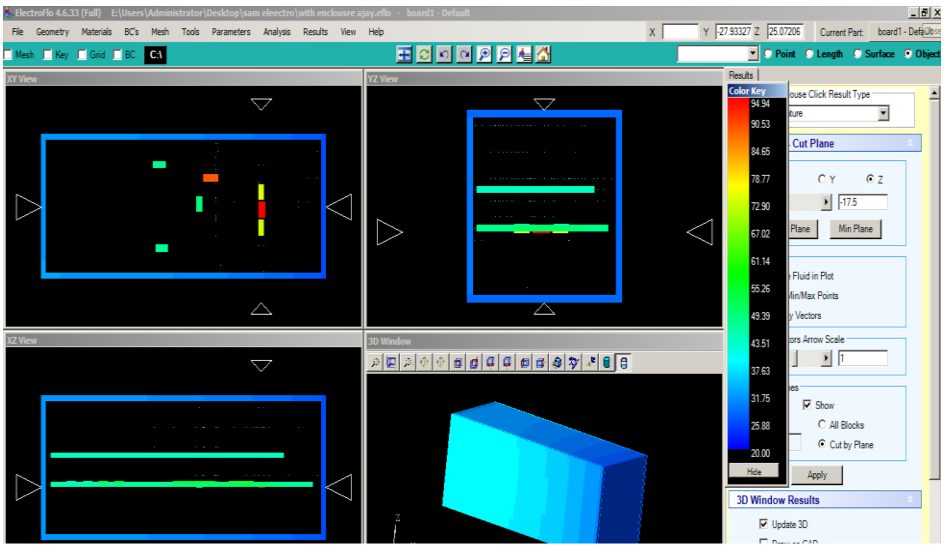

Fig.7 Schematic showing the temperature of Enclosure

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Table 5. Results table (Temperature)

Component	Analysis Results by Electroflo	Analysis results by ITAS
Mosfet		
Q1	88.3	83.8
Q2	88.8	84.1
Q3	93.2	89.1
Q4	90.3	88.1
Q5	85.8	83.6
Q6	94.3	91.8
Resistors		
R1	82	69.4
R2	83.1	69.7
R3	74.3	65.7
R4	73.8	62.6
R5	83.8	70.3
R6	83.3	69.5
R7	71.7	59.4
R8	70.2	58.2
PCB	51	49.9

Fig.8 Result Comparison Graph

B. DISCUSSIONS

A steady state thermal analysis for a PCB inside an enclosure has been carried out. The PCB was assigned with appropriate material, elements and boundary conditions. Appropriate assignment of thermal material properties for conduction and radiation of the above PCB in an enclosure was made based upon standard values. Isotropic thermal conductivity values for chip, PCB and enclosure are taken for this analysis. The results are within the acceptable level verified by ISAC.

ACKNOWLEDGMENT

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