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DESIGN OF ELECTRONIC ENCLOSURE FOR GIVEN THERMAL LOAD

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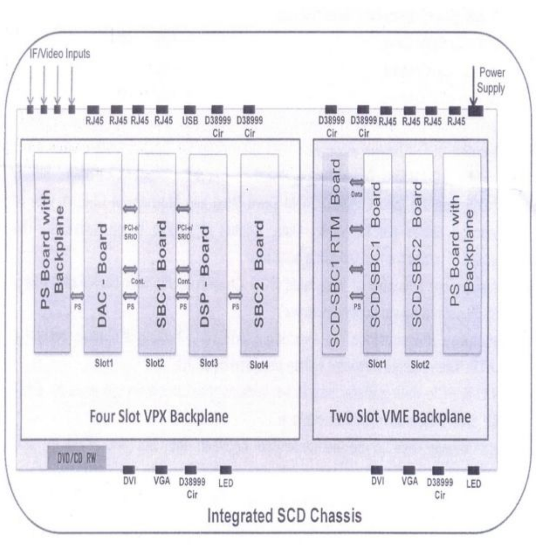
Abstract— In this paper, we will be designing the Chassis according to JSS-55555. The electronic chassis contain many electronic components including Printed Circuit Board (PCB), connectors, etc. Connectors are soldered to the PCB to complete the electronic circuit. This solder joint are weakest link in electronic circuit. Special attention has to be made while designing the circuit and chassis so that the stress level on this solder joints are minimum. Hence for this reason, special attention is done while designing of chassis and mounting of circuit boards so that the natural frequency of chassis does not match with the external natural frequency. By adopting this way, we can avoid the phenomenon of resonance. To ensure that the chassis will sustain such external factors, Ministry of Defense of India has listed Qualification Test (QT) which is released in Joint Service Specification (JSS) manual, which the chassis has to qualify to be used in defense system. Every circuit board emit some heat which increase its temperature. The ICs, connector and other parts of the circuit board have some range of operating temperature beyond which the ICs, connectors and other parts get effected. To ensure that the temperature of the circuit board is well within operating range, thermal management has to be done. We have choose proper fans and there placement for most efficient thermal management.

Index Terms— Electronic chassis, PCB, Vibration, Thermal management.

I. INTRODUCTION

The Integrated SCD Chassis comprises of two sub-assemblies enclosed into one chassis namely VPX backplane for Digital to Analog Converter (DAC) & Digital Signal Processing (DSP) Boards and VME backplane for the boards. The dimension of the chassis is 426 x 452 x 400 mm.



Indian Ministry has release certain test which every equipment whether mechanical or electrical has to qualify for the used in defense system. This test are known as Qualification Test (QT). Qualification test include the test profile and details of the test to be perform on the chassis. Some of the main test and their description are mentioned below.
Table 1

	Test	Specification
1	Vibration test (Sweep)	Sinusoidal, JSS 55555 Reference: N1-28 Sweep test in the x, y, and z-axes. Sweep frequency: 5 - 33 Hz Amplitude:± 0.125 mm for 5-33 Hz constant displacement

II. CARD PLACEMENT

The VME PSU is present near the left plate while VPX PSU is present near the right plate. The VPX and VME backplane are present between this PSU units. RTM card is connected on the VME backplane from the opposite side of the SSB cards. Provision will be provided so the RTM card can be inserted in any slot of VME backplane. The following figure show the placement of Backplane, RTM Card and PSU.

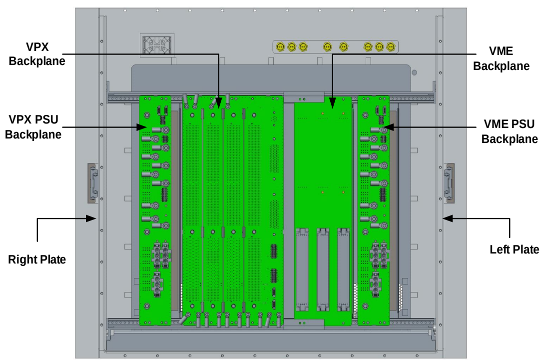


Fig. (a) Card Placement

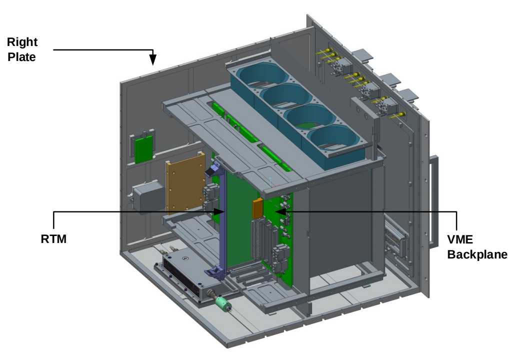


Fig. (b) Card Placement

III. THERMAL ANALYSIS

The power dissipation from each card and its maximum safe operating temperature is given in table below. The values are based on the least maximum safe temperature of the components on cards.

Table 2: Thermal Specification

SCD Chassis Thermal Specifications			
Card Name	Power Dissipation	Maximum Safe Temperature	Design Safe Temperature
DSP Card	55 W	70°C	60°C
DAC Card	45 W	75°C	65°C
SBC	45 W	73°C	63°C
PSU	55 W	70°C	60°C

According to the test condition, the chassis will be subjected at 55°C. So, the inlet air temperature (Tin) will be 55°C. The maximum outlet air temperature should be the less than maximum safe temperature of the cards. Hence, we can say that the cards never reaches the maximum safe temperature. Let us assume, that the temperature difference between the inlet and outlet cannot be more than 35 °C .Hence, T_{out} = 90°C. Let Ts be maximum safe temperature of cards. Hence, the temperature difference between the card surface and air flowing over the card at the ending point of the card will be given by formula:

$\Delta T_{rise}=T_{out}-T_s$ (1)

This temperature difference will be constant throughout the flow over card. From heat Dissipation value, we can calculate the heat flux per unit area from the surface of heat sink of the cards.

$q_{conv}=Q/A_s$ (2)

Where qconv is the convective heat transfer.

Q is heat dissipation rate in Watt

A_s is the surface area of heat sink which is in contact with flow

A_s = Width of the heat sink (W) x Length of the heat sink (L) m^2 (3)

Here, Width is 0.146 m and Length is 0.213 m.

From q_{conv}, we can easily find convective heat transfer co-efficient (h) by below equation:

$q_{conv}=h\Delta_{Trise}$ (4)

$h=q_{conv}/\Delta T_{rise}$(5)

Now, our main objective is find air flow speed which will provide the desired convective heat transfer co-efficient. We will use below equation to find the air flow speed.

$h=\frac{k}{D}Nu$ (6)

Where K=Heat transfer co-efficient of air=0.0287 Wm/K

D=Characteristic length of air flow path

Nu = Nusselt Number

Characteristic length of air passage flow is given by equation:

$D=\frac{4\,A}{p}$ (7)

A = Cross sectional area of air passage flow

p = perimeter of cross sectional area of air passage flow

A = Width of heat sink (W) x Height between Heat sink of card and adjacent card or height of air passage flow (H) (8)

p = 2 x (width of heat sink (W) + Height of air passage flow (H)) (9)

Here, Height between heat sink of card and adjacent is 0.0088 m

Now, we will use Nu number equation in term of Reynold Number (Re) and Prandtl Number (Pr) for turbulent flow or laminar flow based of Reynold Number. Turbulent flow is always preferred for heat transfer since, it result in better heat transfer co-efficient.

Nu = 0.664 Re0.5 Pr1/3 (for laminar flow)(10)

$Pr=\frac{\mu\, C}{K}$ (11)

μ = Dynamic viscosity co-efficient = 1.98e-5 Kg/ms

C = Specific heat co-efficient of air = 1.0077e3 J/Kgk

K = Thermal conductivity of air =0.028 W/mk

$Re=\frac{DV}{\text{Ʊ}}$ (12)

V = velocity of air flow in m/s

Ʊ = Kinematic viscosity co-efficient = 1.84e-5 m^2/s

After calculating the Re value from equation we can get velocity of air flow over each plate. Values of above mention parameter for each card are mentioned in the table below:

Table 3: Parameter Values

	q_s	ΔT	h	Nu	Re	V
DAC	1451.61	25	58.06	34.22	3340.4	3.7
DSP	1774.19	30	59.13	34.86	3465.3	3.8
SBC	1451.61	27	53.76	31.69	2863.8	3.1
PSU	1774.19	30	59.13	34.86	3465.3	3.8

There are 4 fans at the top of card cage. The inlet vent is located on the front door and the exhaust vent is located on the rear panel. Opening are made on the card cage and several air baffles are placed in the cassis for guiding the air flow path. The details the performance curve of the fans are given below:

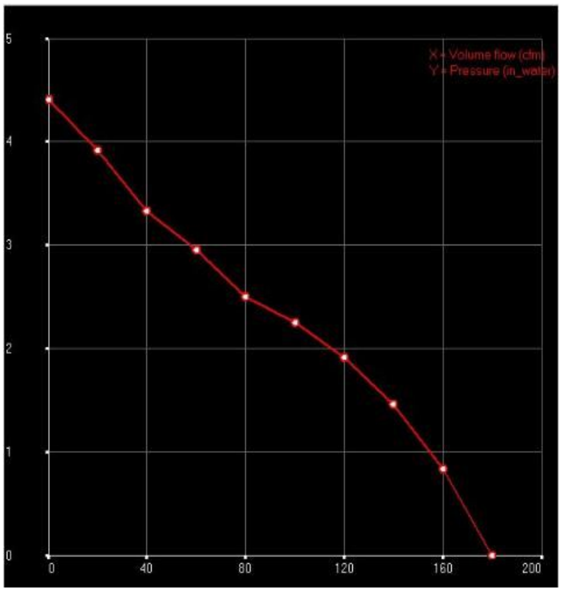


Fig. Fan Performance curve

The fans are place above the card cage near the rear panel. We can place fans either above the card cage or below the card cage. If the fans are placed at the bottom side of the card cage, then for efficient air flow, it is required that there should be space beneath the chassis. This condition cannot be said to be always present. Hence, this condition is generally avoided. To manage the flow direction, we have place air baffles at number of places. These air baffles restrict the air flow in certain direction and only leave a required direction for air flow. Two air baffles are placed in the card cage assembly adjacent to the VME and VPX PSU backplane. We have place fans at the top of card cage just above the card assembly. The opening around the facia are blocked by placing baffles. An air baffles is placed just near the Fan assembly. Opening are provided on the card cage plates. The opening around the facia of RTM is also blocked by air baffles. A small slot cut out is given on the baffles near RTM for harnessing. A small opening is kept open near the VME PSU Heat Sink and RFPS card heat sink on slot 1 of VPX Backplane for better flow of air over the cards.

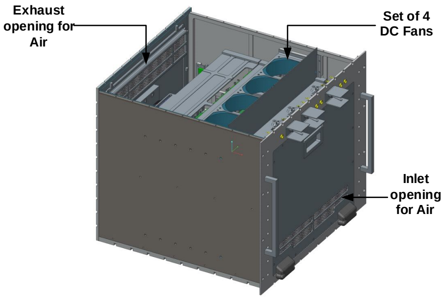


Fig. Fan placement

IV. THERMAL RESULTS

The following tables show the air flow velocity over cards. The flow pattern and velocity may change with a minor quantity depending on the design of Cards.

Table 4: Results

Sr. No.	Component	Slots	Air Velocity (m/s)	Temp. (°C)
1.	DAC	VPX Slot 1	More than 4	64
2.	DSP	VPX Slot 2	More than 4	60
3.	SBC	VPX Slot 3	More than 4	58
4.	SBC	VME Slot 1	More than 4	58
5.	VPX PSU		More than 4	57
6.	VME PSU		More than 4	59

The below shown figures show the air flow pattern and velocity distribution over the cards.

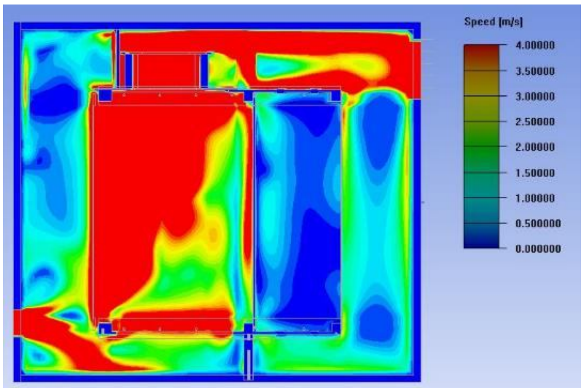
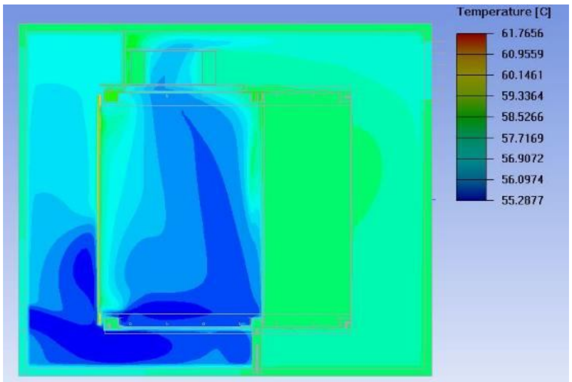


Fig. Velocity Distribution over VME PSU



Temperature Distribution over VME PSU

As we can see in above figures that the average flow over the VME PSU Heat Sink is 4m/s and the maximum temperature reached is 57°C which is less than the maximum safe temperature. As the air flow upward, its temperature increase and hence temperature of the heat sink also increases upward.

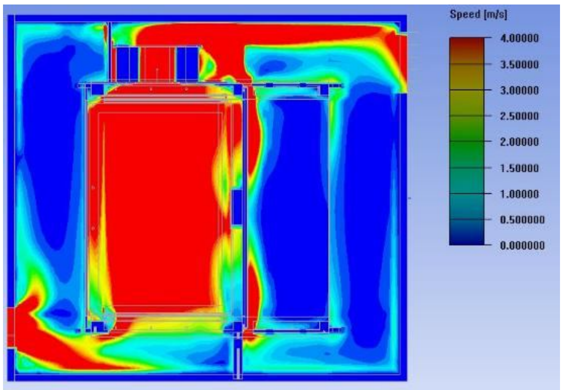


Fig. Velocity Distribution over SBC (VME Slot 1)

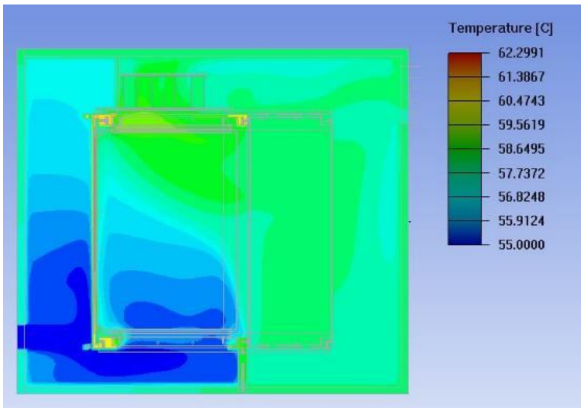


Fig. Temp. Distribution over SBC (VME Slot 1)

As we can see in above figures that the flow over the SBC (VME Slot 1) Heat Sink is 4m/s and the maximum temperature reached is 58°C which is less than the maximum safe temperature

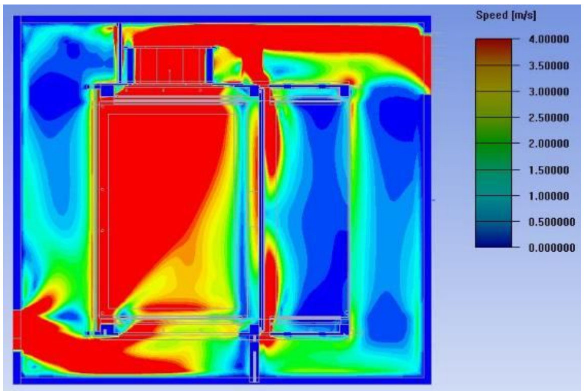


Fig. Velocity Distribution over SBC (VPX Slot 3)

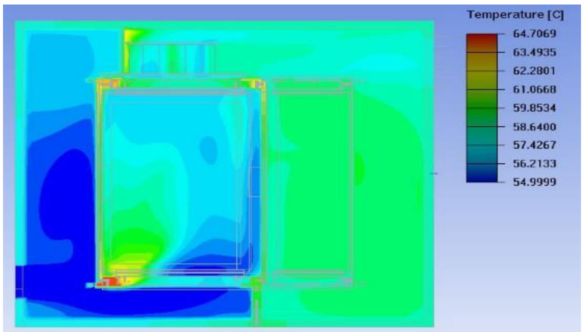


Fig. Temp. Distribution over SBC (VPX Slot 3)

As we can see in above figures that the average flow over the SBC (VPX Slot 3) Heat Sink is 4m/s and the maximum temperature reached is 59°C which is less than the maximum safe temperature

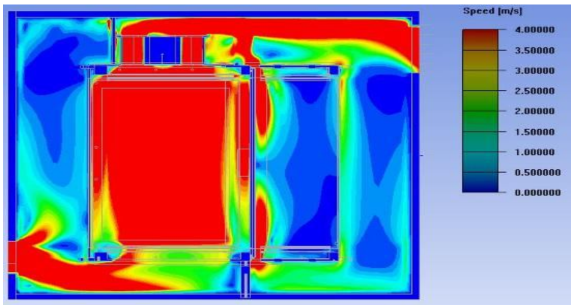


Fig. Velocity Distribution over DSP (VPX Slot 2)

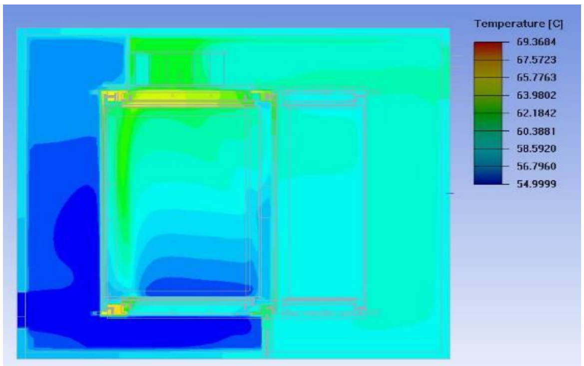


Fig. Temp. Distribution over DSP (VPX Slot 2)

As we can see in above figures that the flow over the DSP (VPX Slot 3) Heat Sink is 4m/s and the maximum temperature reached is 60°C which is safe temperature for DSP Cards.

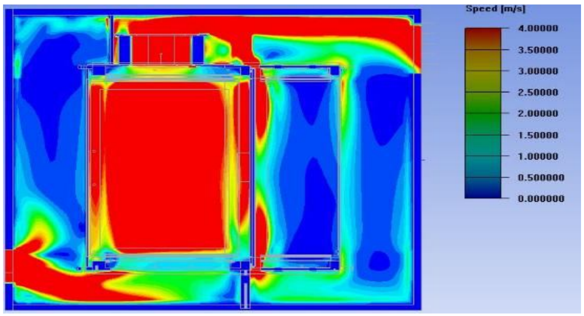


Fig. Velocity Distribution over DAC (VPX Slot 1)

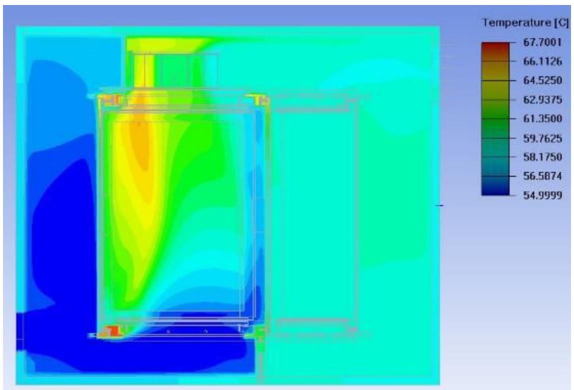


Fig. Temp. Distribution over DAC (VPX Slot 1)

As we can see in above figures that the flow over the DAC (VPX Slot 1) Heat Sink is 4m/s and the maximum temperature reached is 64°C which is less than the maximum safe temperature

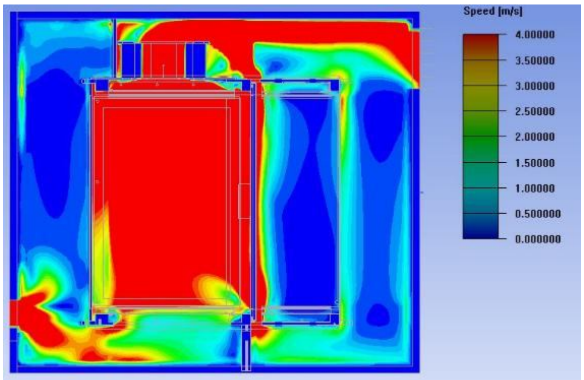


Fig. Velocity Distribution over VPX PSU

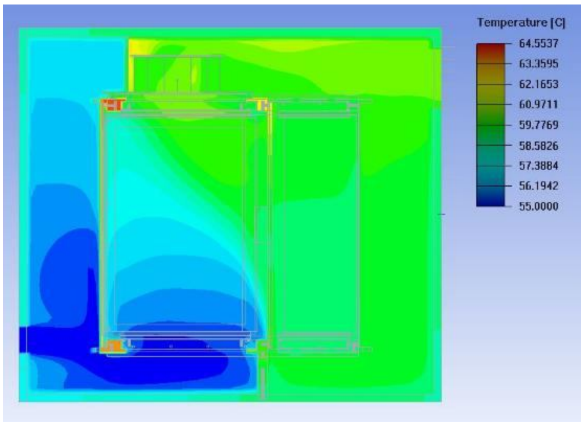


Fig. Temperature Distribution over VPX PSU

As we can see in above figures 26 that the flow over the VPX PSU Heat Sink is 4m/s and the maximum temperature reached is 59°C which is less than the maximum safe temperature

CONCLUSIONS

Thermal calculation and Analysis was done to ensure that the card does not reach maximum safe operating temperature. After the analysis, Maximum temperature obtained on each cards was less than its maximum operating temperature. Also, design modification was done to ensure that the natural frequency of chassis is less than the subjected frequency on the chassis to avoid resonance.

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