CHAPTER - 4

INVESTIGATIONS INTO THERMAL LOAD MANAGEMENT OF BTS

This section describes the inner details of BTS, thermal modelling methodology and thermophysical properties study for the conjugate fluid and heat transfer study. The present BTS mechanical study is studied with CATIA modelling software and thermal model/analysis.

4.1. GEOMETRIC MODEL OF BTS

The proposed BTS thermal design has upper and lower chassis to form a single enclosure. It consists of three PCB’s namely System Board (SB), Base Band board (BB) and Power Board (PB). The replaceable Plug-in unit (PIU) will be connected to the BTS depending on the application. The geometric model and thermal model used for simulation is given in below Figures 4.1 and 4.2.

![CATIA Model](image1.png) ![CFD Model](image2.png)

Fig.4.1 Front View of BTS Geometric Model and Thermal Model
Fig. 4.2 Rear view of BTS Geometric Model and Thermal Model

Fig. 4.3 Bottom View of BTS Geometric Model and Thermal Model
Fig. 4.4 View with out Bottom Cover Geometric Model and Thermal Model

Fig. 4.5 Upper Chassis of BTS without Top Cover
4.2. THERMAL DESIGN METHODOLOGY

The present design problem is devised via conduction cooled methodology. Conduction-cooling is a method of cooling active and passive components on a PCB by direct heat conduction from an area of higher temperature to an area of lower temperature (outer heat sink). Here the fan is used to enhance the external heat convection to the ambient.
4.2.1. Thermal Model Inputs

- Ambient condition is taken as 65°C

- PCB’s are modeled with orthotropic thermal conductivity properties. The layer stack up information is fed to the thermal simulation tool to determine the equivalent thermal conductivity.

- System board is a 12 layer stack up and through plane thermal conductivity of 29.632 W/m°C and normal to the plane conductivity of 0.32 W/m°C are assigned.

- Baseband board with 16 layers has through plane thermal conductivity of 38.7 W/m°C and normal to the plane of 0.333 W/m°C.

- Power board 6 layers has through plane thermal conductivity of 40.69 W/m°C and normal to the plane of 0.335 W/m°C.

- Components which don’t have thermal resistance (R_{jb} and R_{jc}) are modeled as cuboids with thermal conductivity of K=8 W/m°C (System board components: Sl.No. 4, 6, 7, 8, 9, 10, 11, 13, 16, 17 and 18; Base band board components: Sl.No. 6, 7, 8, 12, 13, 15 to 23, Power board: Sl.No. 3, 4, 5, 6)

- Switching regulators in baseband board (Sl.No. 5, 9, 10, 11) are modeled as PCB with power dissipation modeled as source.

- Components are placed in thermal design as per electrical layout/real estate of the PCB.

- Remaining power other than component dissipation is applied over the board.

- Heat towers, bosses, lower and upper chassis are modeled with thermal conductivity K=150 W/m°C

- Thermal conductivity of thermal gel is considered as 1.8 W/m°C
• SFP cage is modeled as cuboids with thermal conductivity of 90 W/m\(^{°}\)K.

• Mosfets on PB having sl.no. 1, 7, 8 and 9 are considered with thermal vias. Equivalent thermal conductivity is considered based on number of vias.

4.2.2. Mechanical Model Considerations

The Fan details considered for dimensions having 60mm X 60mm X 25.5mm. Fan curve is scaled down to 85% of maximum speed. Fan curve is based on the experimental result. In this case Thermal gel thickness is considered 1.2mm and vents near fan are approximated with rectangular geometry of equal area.

4.3. PCB LAYOUT & COMPONENTS POWER DISSIPATION

The BTS unit has to be operated at maximum ambient temperature of 65\(^°\)C. This higher ambient temperature is selected to ensure that the unit can work at any geography in the world without thermal issue. The whole unit is ingress protected and complies with IP65.

4.3.1. System board (SB) layout

![System Board Component Layout](image)

Fig.4.7 System Board Component Layout
The figure 4.7 explains the components placement over the system board on top and bottom side. All numbers mentioned on the components refer the serial number in the Table 4.1.

### 4.3.2. SB and PIU component power details

The Table 4.1 provides details of the System board critical package power dissipation and its thermal characteristics that are required to capture the heat transfer path during thermal design.

<table>
<thead>
<tr>
<th>Table 4.1 Component details in SB and PIU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: Please note Mcompo for LIU is 4335160.</td>
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</table>
4.3.3. Base band board layout (BB)

The figure 4.8 explains the components placement over the baseband board. All numbers mentioned on the components refer the serial number in the Table 4.2.
### 4.3.4. Base Band component power details

Table 4.2 Component details in BB

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>MComp Number</th>
<th>Component Name</th>
<th>No. of Components</th>
<th>No. Power dissipation per component (W)</th>
<th>Total Power (W)</th>
<th>Rie (DegC/W)</th>
<th>Rfb (DegC/W)</th>
<th>Reference Designators</th>
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<td>0.3</td>
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<td>2</td>
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<td>DSPMEMORIES</td>
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<td>23.0</td>
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<td>3</td>
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<td>2.0</td>
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<td>6.0</td>
<td>16.6</td>
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</table>

**Total Power: 115.80**

Table 4.2 describes the Base band board power dissipation and its thermal characteristics.

Also reference designators are given on the board.
4.3.5. Power board layout (PB)

Fig. 4.9 Power Board Component Layout

The figure 4.9 explains the components placement over the power board. All numbers mentioned on the components refer to the serial number in the Table 4.3.

**Note:** The individual component power details are given in the Table 4.3. The total power considered for this simulation in power board (PB) is 56 Watts where around 27 watts power is considered as apply over the board. Simulation will be carried out in future depending on the updated latest power distribution on individual components.

4.3.6. Power Board component power details

Table 4.3 has information on the Power board components and its power dissipation. Thermal ressitance of the packages are considred for capturing the heat transfer.

Table.4.3: Component details in PB
4.4. FAN DETAILS

Flow bench test is carried out to verify the vendor fan characteristic curve at mean sea level condition. Fan curve is considered for 85% of maximum speed condition. There is a slight difference in the curve with respect to the experimental results as the speed tolerances vary with fan.

![Vendor specified fan data curve](image1)
![Experimental fan curve](image2)

**Fig. 4.10 Fan Curve details**

**Table 4.4: Flow Vs Static Pressure values**
Fan non linear curve data mentioned in the Table 4.4 are used for thermal simulation. Experimental fan curve has lower static pressure for same flow rate compared with vendor specified curve. Since experimental fan curve delivers less flow rate at lower static pressure, it is considered for simulation. This is worst case condition considered for simulation to achieve better result during validation testing.

### 4.5. SIMULATION INPUT

Software tool used for thermal analysis is Flotherm V8.1Simulation carried out with three dimensional model having ambient condition of 65°C. The simulation solution has flow and heat transfer to achieve steady state condition. Radiation option is activated in energy equation to enhance the radioactive heat transfer and automatic algebraic method is activated for turbulence. The gravity vector is in negative Y direction having the value of 9.81 m/sec².

Grid constraints are given to capture the results in optimized condition. Grid sensitivity has been carried out and optimum grid cell count is reached for better solution. The cumulative total grid cells in all directions are 7.8 million cells. Nonlinear fan curve data is supplied for obtaining the fan operating point. Multigrid option is chosen for better control for
overall solution control. Simulation is performed with fan boundary conditions (fan curve scaled down to 85% max speed).

4.5.1. Simulation methodology

The thermal model is analyzed for heat transfer from the individual components and PCB to internal ambient air. Temperature distribution within the unit is solved using CFD techniques. The entire domain is discretized into small computational volumes. The solution is obtained through finite volume approach. The below governing equations of mass, momentum and energy are solved simultaneously to obtain the solution in the computational domain to capture the fluid and thermal distribution.

\[
\begin{align*}
\text{Mass} & \quad \frac{\partial \rho}{\partial t} + \text{div}(\rho \mathbf{u}) = 0 \\
\text{x-momentum} & \quad \frac{\partial (\rho u)}{\partial t} + \text{div}(\rho u \mathbf{u}) = -\frac{\partial p}{\partial x} + \text{div}(\mu \text{ grad } u) + S_{Me} \\
\text{y-momentum} & \quad \frac{\partial (\rho v)}{\partial t} + \text{div}(\rho v \mathbf{u}) = -\frac{\partial p}{\partial y} + \text{div}(\mu \text{ grad } v) + S_{Me} \\
\text{z-momentum} & \quad \frac{\partial (\rho w)}{\partial t} + \text{div}(\rho w \mathbf{u}) = -\frac{\partial p}{\partial z} + \text{div}(\mu \text{ grad } w) + S_{Me} \\
\text{Internal energy} & \quad \frac{\partial (\rho e)}{\partial t} + \text{div}(\rho e \mathbf{u}) = -p \text{ div } \mathbf{u} + \text{div}(k \text{ grad } T) + \Phi + S_i \\
\text{Equations of state} & \quad p = p(\rho, T) \text{ and } i = i(\rho, T) \\
& \text{e.g. perfect gas } \\
& p = \rho RT \text{ and } i = C_{v} T
\end{align*}
\]