GLAST LAT TECHNICAL REPORT	Document # **LAT-TD-01114-01**	Date Effective 30 Oct 2002
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	Subsystem/Office Calorimeter Subsystem	

Document Title

Thermal Analysis for Calorimeter AFEE PCB

1 SUMMARY

The thermal analysis was conducted to predict the temperature of board and heat dissipating parts on the printed circuit board (PCB) of AFEE by the GLAST flight conditions. This analysis used the layout of drawing LAT-DS-00896-01 for the mounting location of heat dissipating parts for AFEE PCB.

The temperature profile of AFEE PCB for the hot case is shown in Figures 3, and the ranges of junction temperature of heat dissipating parts are listed in Table 2.

2 AFEE PCB DESIGN

The design of AFEE PCB is shown in Figure 1. The material of board is Polyimide, and the multiple patches of Copper layers are sandwiched between Polyimide layers. The total thickness of board is 0.062 Inches and the thickness of each Copper layer is 0.0014 Inches. The nominal size of

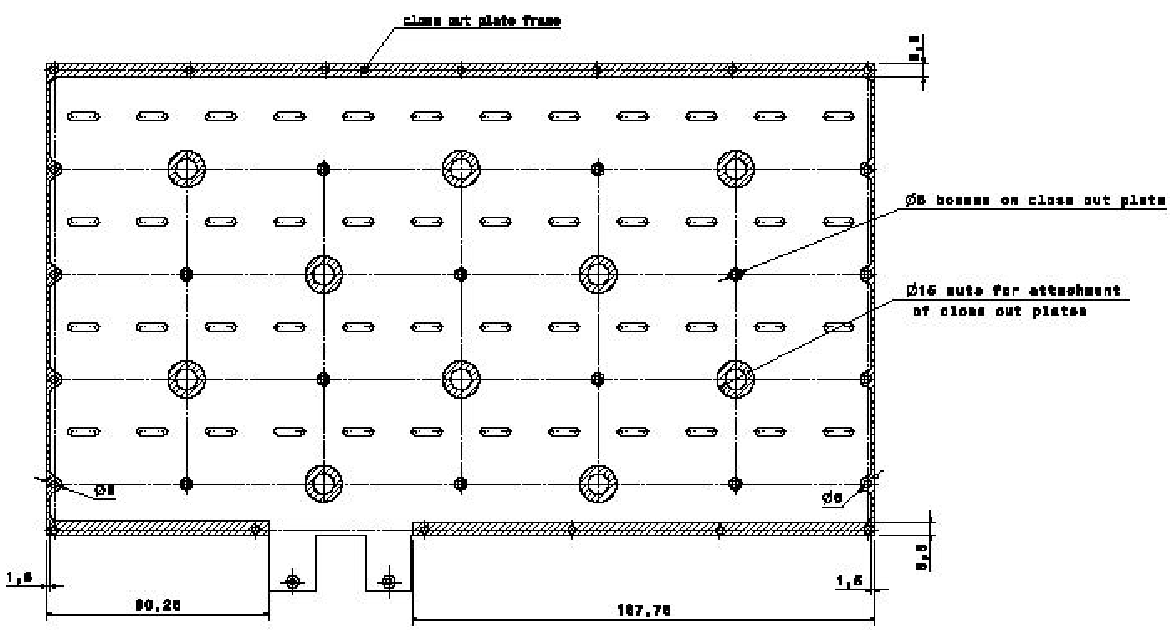

Figure 1. AFEE PCB

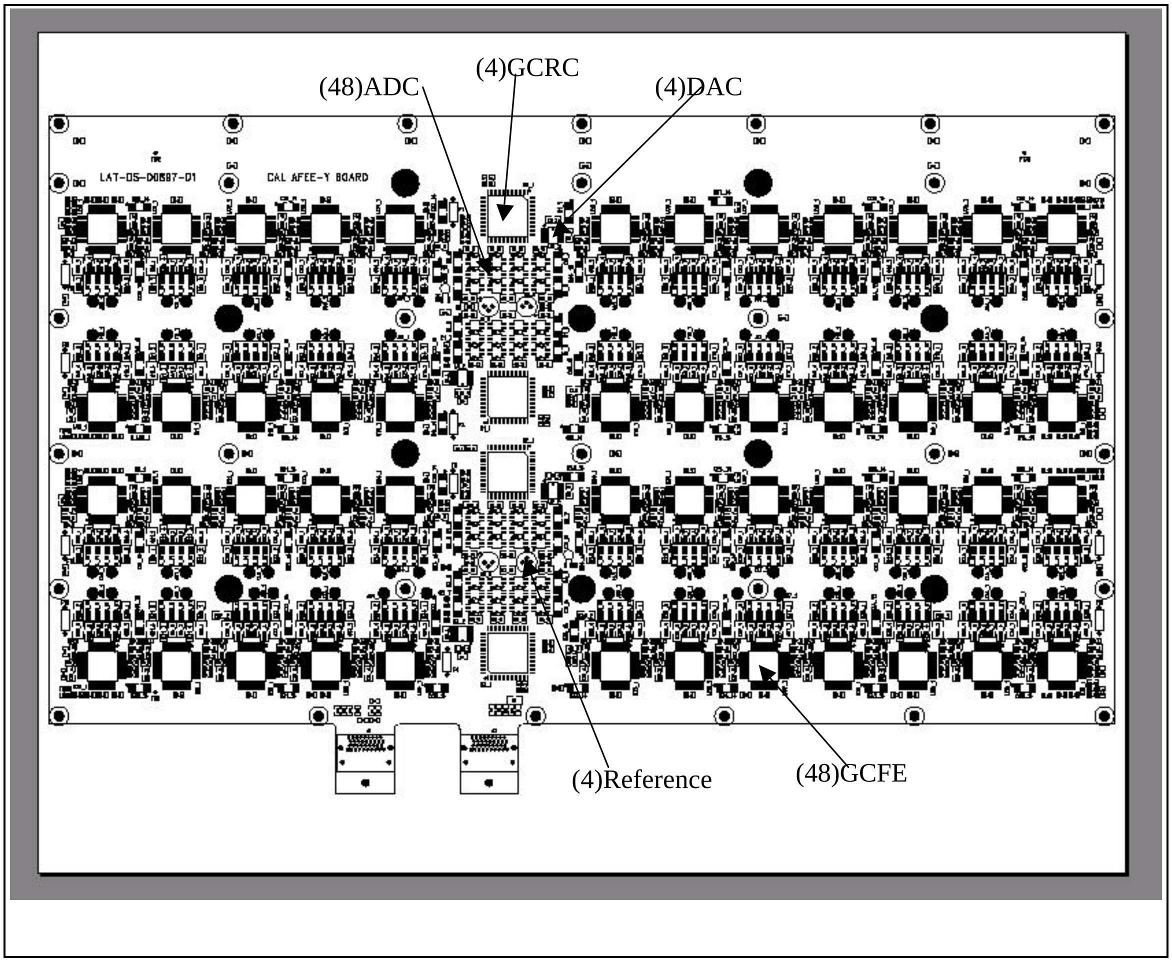

Figure 2. Heat Dissipating Parts Layout on the Board.

board is 336 MM wide and 192 MM high.

The heat dissipating parts on the PCB are 48 GCFE, 48 ADC, four GCRC, four DAC, and four References. The layout of parts on the board is shown in Figure 2. As shown in Figure 2, four rows of GCFE (12 per row, total 48) are mounted on the end-to-end of board with nearly even spacing, but all others are bunched on the middle column of board.

Four identical AFEE boards are mounted at each side of Calorimeter box. All four sides of box design are also identical.

3 THERMAL ANALYSIS

Since the Calorimeter consists of four identical boards at each side of box and all four sides of box design are also identical, thus the thermal model for only one AFEE PCB was generated with adjacent structure units of Calorimeter. The analysis used the Systems Integrated Numerical Differencing Analyzer (SINDA) as thermal analyzer.

The board has 117 nodal breakdowns and was conductively coupled among nodes. This analysis assumed that two copper layers are sandwiched in the polyimide board and the copper layers are continuously laid at the end-to-end of board horizontally and vertically.

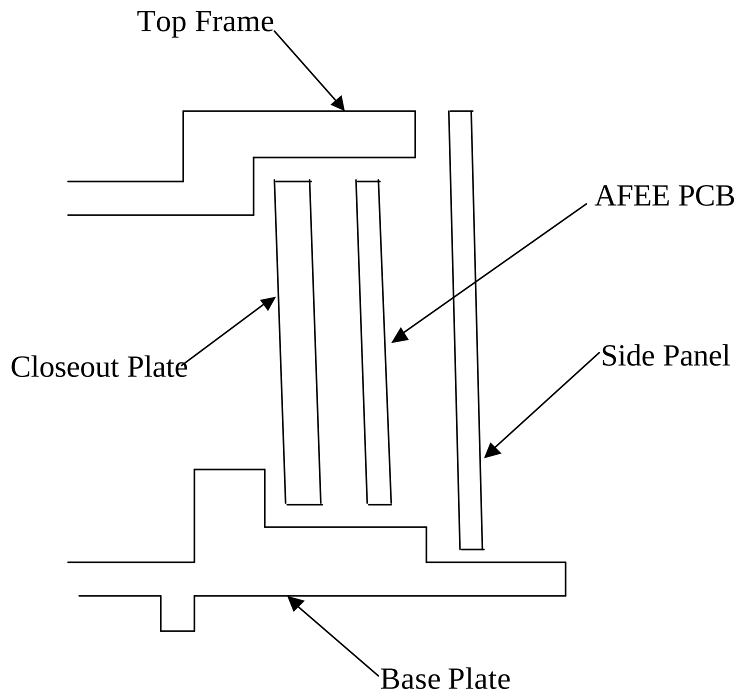

Figure 3. AFEE PCB Installation at Calorimeter Box

The Figure 3 below shows one board installation with other adjacent units of box. The AFEE PCB is connected onto the Closeout Plate of Calorimeter with 19 bolts by the pattern of boltholes at the perimeter of board as shown in Figure 1. Also, ten additional bolts are used at the middle of board to connect the PCB with Closeout Plate. The shaded area on the perimeter of Figure 1 is representing the interface area of board with Closeout Plate of Calorimeter. Accordingly, the board was conductively coupled to the Closeout Plate with a high conductance value (25 W/°C) at the vicinity of bolt area and a low value (5 W/°C) at non-bolt area. The Closeout Plate is bolted onto the Base Plate and Top Frame of Calorimeter. The Side Panel, which is enclosing the AFEE PCB with the Closeout Plate, is also bolted onto the Base Plate and Top Frame as shown in Figure 3. The Closeout Plate and Side Panel are conductively coupled to the Top Frame and Base Plate of Calorimeter. The model also included the radiation couplings between the board and Closeout Plate and Side Panel. Since the Closeout Plate and Side Panel have the alodine surface (emissivity = 0.1 assumed), the radiation interchange is very small.

The values of heat dissipation and thermal resistance from junction to board (θ_{jb}) for the heat dissipating parts are listed in Table 1. The Calorimeter Electrical Engineer, Jim Ampe defined the value of heat dissipation. He also extracted the thermal resistance data from the part manufacturing data sheet. Only the values of resistance from junction to air, θ_{ja} were available in the manufacturing data sheet. Since the thermal resistance from junction to board (θ_{jb}) is considered to be less than the thermal resistance from junction to air (θ_{ja}), this analysis used the manufacturing data of θ_{ja} as θ_{jb} for the conservative junction temperature computation.

Table 1. Heat Dissipation and θ_{jb} for Heat Dissipating Parts

Part	Heat Dissipation (mW)	θ_{jb} (°C/W)
GCFE	10	105.0
ADC	4	135.0
GCRC	50	44.5
DAC	6	62.3
Reference	15	57.0

The nodal numbers were assigned for all heat dissipating parts, 48 GCFE, 48 ADC, four GCRC, four DAC, and four References. The heat dissipations were imposed on these part nodes and parts were conductively coupled to their interfaced board nodes by using thermal resistance data (θ_{jb}) of Table 1.

4 ANALYSIS RESULTS

For the hot case, the analysis assumed the Base Plate of Calorimeter was at 25 °C boundary. Figure 4 thru Figure 6 show the temperature profile of AFEE PCB, Closeout Plate, and Side Panel of Calorimeter for the hot case. The temperature of Top Frame was calculated at 27.2 °C.

To illustrate heat path from the board to thermal sink of Base Plate of Calorimeter, the temperatures (°C) are shown in Figure 7. These temperatures represent the ones of middle column of board and its adjacent structure.

By viewing the thermal gradient of units, it can conclude that first the heat is transferred from board to the Closeout Plate. Most of heat conducted downward from top to bottom of Closeout Plate and then to Base Plate. Some of heats are also conducted to Top Frame from top of Closeout

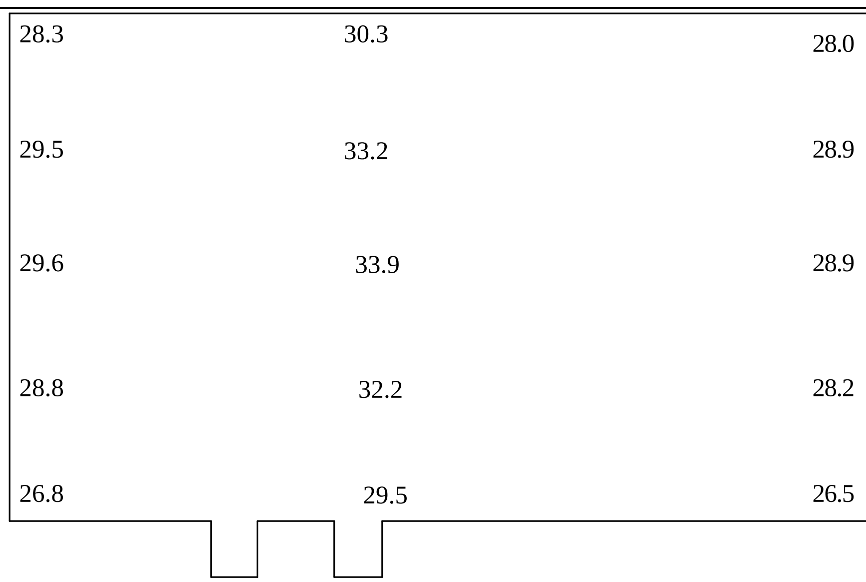

Figure 4. Temperature Profile of AFEE PCB, Temperatures in °C

27.5	27.5	27.3
27.4	27.4	27.3
27.0	26.9	26.9
26.4	26.4	26.3
25.9	26.0	25.9

Figure 5. Temperature Profile of Closeout Plate, Temperatures in °C

Plate, then through the Side Panel to Base Plate. The radiation interchange between board and Closeout Plate and Side Panel is very small because of small temperature differences and very low effective emissivity value between them.

For the board itself, the results indicated that, because of high concentration of heat dissipating parts at the middle column, the high temperature plateau is profiled at the center of board. Multiplying heat dissipation and thermal resistance (θ_{jb}) calculates the temperature gradient from the junction to board for the heat dissipating parts. The gradient from junction to board for GCFE is therefore 1.1 °C, 0.5 °C for ADC, 2.2 °C for GCRC, 0.4 °C for DAC, and 0.9 °C for Reference. The highest junction temperatures for parts are resulted where parts are located at this center plateau area.

Table 2 lists the ranges of junction temperature for heat dissipating parts for the hot case.

26.9	26.9	26.8
26.6	26.7	26.6
26.3	26.3	26.3
25.9	25.9	25.9
25.6	25.6	25.5

Figure 6. Temperature Profile of Side Panel, Temperatures in °C

Table 2. Ranges of Junction Temperature of Heat dissipating Parts of AFEE PCB

Part	Junction Temperature (°C)
GCFE	29.3 to 33.5
ADC	32.8 to 34.5
GCRC	34.4 to 36.2
DAC	30.7 to 34.3
Reference	31.2 to 34.8

For the cold case, the Base Plate could be at the worst –10 °C. The AFEE PCB and all heat dissipating parts are warmer than this temperature. Therefore, since it is thermally no problem at this level of temperature, no analysis for the cold case was conducted.

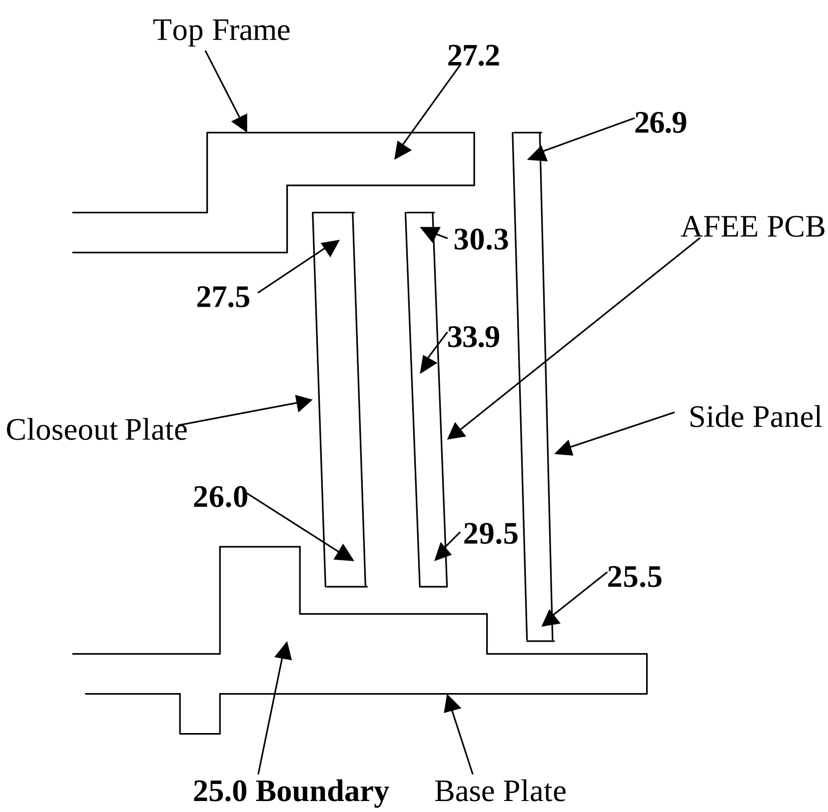

Figure 7. Temperature variations near middle column.