Study on thermal design optimization of small satellite

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1. Backgrounds & purposes

Temperature range of onboard equipment for small-satellite

In order to establish international standards of environment tests, we estimate the on-orbit temperature range of onboard equipment for the 50kg class satellite.

Optimal thermal design for small-satellite

The main thermal control for small-satellite is passive due to limitation of power and weight. Therefore, it is difficult to maintain a narrow temperature range estimated based on thermal analysis. Moreover, ground thermal test result is very important similar to the on-orbit data. We consider the optimal thermal design through the data analysis of HORYU-II and thermal analysis of various small satellites.

2. On-orbit data of HORYU-II

Since HORYU-II was launched on 18th May 2012, we have obtained the on-orbit temperature data for about 6 months. The sampling period of temperature data is 10 minutes. So we superimposed the temperature data of each orbit and could understand the trend of temperature change as shown in Fig. 1.

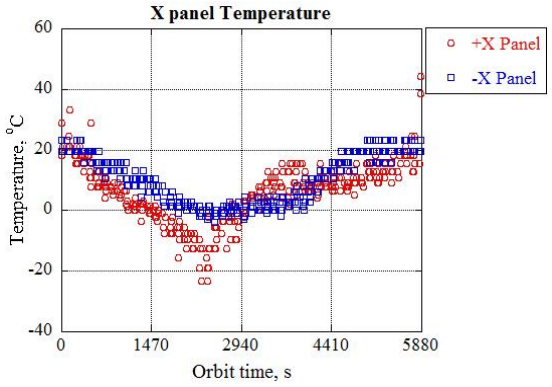

Fig. 1　Temperature change on orbit.

3. Test sample（Dummy satellite）

This satellite has been developed as a test sample to determine the standardization. As a bus system, this Dummy satellite has components similar to QSAT-EOS. So the function and quality is almost same as the flight model of QSAT-EOS. We made the thermal mathematical model of this satellite and estimated the on-orbit temperature range of onboard equipment. We analyzed thermal models by the Thermal Desktop commonly used in the thermal analysis of spacecraft. And we performed thermal balance tests in order to confirm the validity of the thermal model and estimate the thermal conductance.

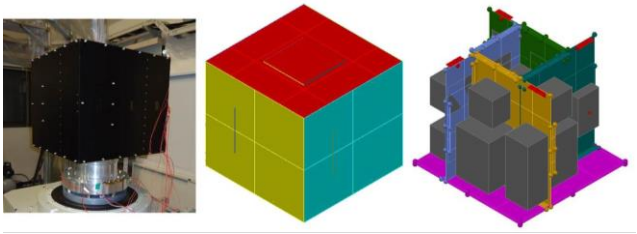

Fig. 2　Thermal mathematical model.

4. On-orbit thermal analysis

In order to measure the maximum and minimum temperature of internal equipment, 50kg class earth observation satellites have been developed, shown in Fig.2. We defined the specifications of various internal components of this satellite and set the worst analysis condition. From the analysis results, we could estimate that the on-orbit temperature range of onboard equipment is between -16˚C and +45˚C. Therefore, we suggest that the temperature range of qualification test of any QSAT-EOS of 50kg is from -16˚C to +45 ˚C.

Table1　Highest and lowest temperature of various components.

Component	Min. Temperature	Max. Temperature
Power Control Unit	－13℃	＋36℃
On-Board Computer	－14℃	＋44℃
RF transmitter	－16℃	＋45℃

5. Parametric analysis

We considered the optimal thermal design through the parametric analysis with the thermal mathematical model of the Dummy satellite. Analysis results are shown in the following.

・It is important to cut off the thermal conduction between the external panel and the internal structure.

・Temperature change does not depend on the internal structure.

⇒temperature of all internal structure is within the temperature range shown in Table1.

In thermal design for 50kg class satellite, we found that satellite temperature is estimated by 2 nodes analysis.