Structure Design of TUUSAT-1A Microsatellite

Chin-Feng Lin\textsuperscript{1,2}, Zuu-Chang Hong\textsuperscript{3}, Jeng-Shing Chern\textsuperscript{4}, Chien-Ming Lin\textsuperscript{3} and Bo-Jyun Chang\textsuperscript{3}

\textsuperscript{1} Department of Electrical Engineering, National Taiwan Ocean University
\textsuperscript{2} Center for Marine Bioscience and Biotechnology, National Taiwan Ocean University
\textsuperscript{3} Department of Mechanical and Electro-Mechanical Engineering, Tamkang University
\textsuperscript{4} Department of Aviation Mechanical Engineering, China Institute of Technology
Taiwan

e-mail:lcf1024@mail.ntou.edu.tw

Abstract: - TUUSAT-1A stands for Taiwan Universities United Satellite NO.1A. The micro-satellite research team includes scholars from Tamkang University, China Institute of Technology, National Formosa University, National Taiwan Ocean University and National Chia Yi University. The micro-satellite is 28 cm in height and weighs 40 kg and it is powered by solar energy. For image acquisition using GPS and CMOS sensors as payload, the satellite must operate at an altitude of 500 km and at an inclination of 21\textdegree{} with the circular orbit for a period of 3-12 months. The structural subsystem is one of the major sub-systems of this satellite. The major functions of the satellite structure include decrease and preserve against compressive strength, support the space, and the requirements for other sub-systems. In this paper, we discuss the structure design of TUUSAT-1A.

Key-Words: - structure sub-system, TUUSAT-1A, micro-satellite, compressive strength, solar energy.

1 Introduction

One of the main advantages of micro-satellites is their small size. Currently, there are many micro-satellites in space, such as, AMSAT [1], PoSAT [2], KITSAT-3 [3], and SAPPHIRE [4]. In our previous studies [5-14], we focused on mobile telemedicine and biomedical signal processing. In [15], we discussed the TUUSAT-1A micro-satellite. TUUSAT-1A (Taiwan Universities United Satellite NO.1A.) is the first academic microsatellite developed by different universities in Taiwan in collaboration with one another and with support from NSPO. The micro-satellite research team includes scholars from Tamkang University, China Institute of Technology, National Formosa University, National Taiwan Ocean University and National Chia Yi University. Figure 1 shows the logo of TUUSAT-1A. Table I list the features of the TUUSAT-1A micro-satellite. TUUSAT-1A includes various electrical and mechanical systems. The electrical systems include an electrical power subsystem, a satellite computer subsystem, a communication subsystem and a payload subsystem.

The mechanical systems include a structural subsystem, a thermal control subsystem, and an attitude determination subsystem. The structural subsystem is described below.

Figure 1 TUUSAT-1A Logo.
### Table I The features of the TUUSAT-1A micro-satellite

| Mission | 1. GPS receiving  
| 2. Earth imaging and transmission  
| 3. Space qualification for COTS components:  
| (i) onboard computer;  
| (ii) transceiver;  
| (iii) camera;  
| (iv) structure;  
| (v) battery charger & regulator.  |
| Orbit | 500 km altitude;  
| 21 deg inclination circular orbit.  |
| Volume | Weight < 40 kg;  
| Height < 40 cm;  
| Diameter < 40 cm.  |
| Mission Life | 3 months  |
| Design Life | 1 year  |
| Power | GaAs Solar Panel;  
| Surface Mounted;  
| NiCd Flight Cells x 8.  |
| Attitude Control | Passive Magnetic Control;  
| Magnets;  
| Hysteresis rod;  
| Shorted coils.  |
| Communication | Amateur radio satellite communication,  
| Downlink/ Uplink on 435MHz,  
| Transmission rate up to 9600 bps.  |
| Onboard computer | 16-bit command processor and 32-bit image processor  |
| Structure | 6061 Aluminum Alloy  |
| Thermal | Passive thermal  |

### 2 Structure Design of TUUSAT-1A Micro-satellite

The reliability, safety, and effectiveness of the satellite structure play an important role in the normal operation of the satellite. The satellite structure should be so designed that it supports all sub-systems, and payloads. The satellite structure should be stable against vibration resistance and environmental resistance during rocket launching, in order to ensure normal operation of the other sub-systems and payload. When designing the satellite, we take into account the features of the attitude control subsystem, thermal control subsystem, and solar energy sub-system that are essential for stable operation, as well as the reliability of the structure. For attitude control of the micro-satellite, we consider symmetrical shapes such as spherical, tetrahedral, hexahedral, and octahedral.

The applicability of the microsatellite vibration resistance in space systems and the efficiency of solar energy utilization must be considered when designing the microsatellite structure. Maximum utilization of solar energy is achieved with a spherical micro-satellite. However, considering the cost factor, we choose satellites that are hexahedral and octahedral in shape. Figure 2 shows the structure of TUUSAT-1A. The satellite is in the shape of a cube with an edge of 28cm. The surface of the satellite is covered by six aluminum plates, each of which has a solar chip attached to it. The satellite mainly comprises four layers, are totally four layers, each layer is an aluminum plate at from a single aluminum alloy block. The components of the subsystems are deposited on each layer, and all the layers are adhered together by lamination.

### 3 Discussion
TUUSAT-1A is composed of four aluminum boxes and six solar panels. The structure is easy to assemble, and individually components can be electronically tested with ease. The objective of constructing TUUSAT-1A is to develop a simple, fast, and inexpensive method for microsatellite design and to familiarize students with the design, development, integration, and operation of a micro-satellite. We revised the industrial components of the payloads to meet the applications in space. Figures 3 and 4 show the stress distribution and mesh analysis of the TUUSAT-1A micro-satellite, respectively. We consider 135852 nodes and 511864 elements in the micro-satellite structure. The frequencies of the first and second modes are 288.75Hz, and 289.15Hz, respectively. The nature frequency of the system is assumed to be 50Hz. Our simulation results show that frequency of the first mode of the micro-satellite is higher than the nature frequency of the system. In addition, the design of the TUUSAT-1A structure is optimization of the system.

4 Conclusion

In this article, we discuss the structure design of the TUUSAT-1A micro-satellite. We used 6061 aluminum alloy to construct the micro-satellite, and include four Aluminum Alloy boxes in the satellite. Our structure design is inexpensive and helps achieve the desired compressive resistance, and efficiency of solar energy utilization.

Acknowledgements

The authors acknowledge the support of the National Space Organization (NSPO) of Taiwan, under contract 95-NSPO(B)-SE-FD04-01(II), the Teacher Research Project of National Taiwan Ocean University 95B60202, the grant from the National Science Council of Taiwan NSC 93-2218-E-019-024, and the valuable comments of the reviewers.

References:


