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DESIGN AND MANUFACTURE OF POCKETQUBE FOR LOW EARTH ORBITAL (LEO)

Muzaffer DUYSAL, Çağla Aytaç DURSUN, Özgür TUZCU, Durdali ATILGAN, Kerim USLU, Serdar DOĞAN

Scientific Coordinators: Prof. PhD Bülent EKMEKÇİ, Assist. Prof. PhD Hakan KAYA, Assist. Prof. PhD Serkan KARAKIŞ, R. A Engin KOCAMAN, R. A Ferdi KARA

Zonguldak Bulent Ecevıt Unıversity, İncivez Mahallesi, Üniversite Cd., 67100 Merkez, Zonguldak, Turkey, Phone: +90 372 291 11 00, Fax:+90 372 257 21 40,Email: aytac.drsn@gmail.com

Corresponding author email: muzafferduysal@gmail.com.

Abstract

The project aims to design and produce a 5x5x5 cm pocketqube satellite that will be positioned in low earth orbit (500 km). The satellite will transfer the data obtained by the sensors and the camera to the earth. The satellite will be produced to serve for about 3 years on the earth's orbit. The satellite will include the Power Sub-System (EGS), the Built-in Computer Sub-System (MIS), the Communication Sub-System (HS), the Orientation Identification and Control Sub-System (YBKS) and the Useful Load Subsystem (FAS). All of the systems will be designed and produced in the laboratories of Zonguldak Bülent Ecevit University. A ground station will be established within our university for communication with the satellite. The data to be obtained via the ground station will be shared over the internet. The presented study explains the proposed system design of the pocketqube.

***Keywords**: communication, observation, pocketqube, satellite, space.*

INTRODUCTION

Due to the long-term and high cost of space work, satellites with a lower budget (Twiggs and Kuroki, 2002) and shorter time were needed. For this reason, the first cube satellite (CubeSat) standard emerged in 1999 with the initiative of Stanford and California Polytechnic Universities in the United States. Satellites with a length of 10 cm (Chester et al., 2014) and a weight of less than 1 kg are defined in the cube satellite standard. Today, according to the desired science payload, one unit (10x10x10 cm3), two units (10x10x20 cm3) and three units (10x10x30 cm3) new cube satellite dimensions have been developed. Works on Cube satellites have been rapidly increasing in the last 10 years due to their low cost and short production time. Nowadays, as cube satellites are sent to asteroids and different planets in line with the different mission (Li et al., 2017), they are launched to test observation and different science payload in the low earth orbit.

The most critical factor that determines the cost of satellite works is the dimensions of the designed satellite. With the development of technology, it is preferred to produce smaller sized satellites to reduce these costs. As a result, pocket satellite (PocketQube) standard with a lower cost and size (5x5x5 cm) than cube satellites has emerged. Pocket satellites are available in a Pico satellite class with dimensions ranging from 250 g to 1000 g (5 cm and multiples) in dimensions 1P, 2P, 3P (Soriano et al., 2016; Baldacchino et al., 2017). The satellites developed in the pocket satellite standard are preferred because of the low cost of communication systems and task load testing in space studies.

Figure 1. A pocketqube design

MATERIALS AND METHODS

When we look at the materials used in today's spacecraft, we often see materials that have special properties such as kevlar, and alloys made of aluminum, as well as materials whose mechanical properties are increasing and at the same time light. The ASTM E1997-15 standard sets an example for the studies in this area (ASTM, 2015).

After the design of the body, the design and production of sub-systems are in progress. Among these subsystems, the useful science payload subsystem has a prominent place. Up to now, they have been designed to perform tasks such as pocket satellites, signal spectrum noise analyzes, communication system tests sent to low earth orbit. Launched pocket satellites send these data to the ground station using sub-systems in the orbit where they are located (Dudas and Gschwindt, 2016). It provides orientation detection and control subsystem in order to ensure that the pocket satellites placed in a particular orbit are balanced in orbit (Baldacchino et al., 2017). A passive control systemis generally preferred due to the size of the pocket satellites (Rawashdeh, 2010). The communication sub-system in the pocket satellite is realized by communicating with the ground station. Communication with the ground station is provided by the antenna included in this subsystem (Zack et al., 2014). The pocket satellites take their energy directly from the sun through solar panels and charge the battery. Thus, it is ensured that it can work for long periods in space conditions (Li et al., 2017; Olaszi et al., 2015). The electrical power subsystem controls the control of the energy system of the pocketqube. The effectiveness of the power control system in space conditions is a critical and efficient use of solar energy is required (Olaszi et al., 2015). In the design and production of other components, studies are concentrated in the point of communication and task load test. The pocket satellites are composed of different subsystems. The pocket satellite to be constructed within the scope of this project will consist of 5 sub-systems connected.

SUBSYSTEMS OF POCKETQUBE

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The Pocketqube block diagram is shown in Figure 2.

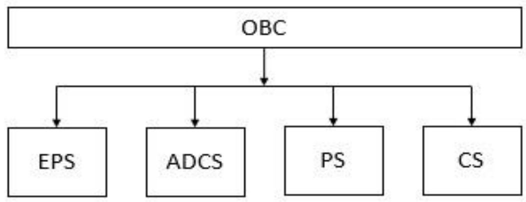

Figure 2. Pocketqubeblock diagram

1) Electrical Power Subsystem (EPS)
2) On Board Computer (OBC)
3) Communication Subsystem
4) Attitude determination and control subsystem
5) Payload Subsystem

1) Electrical Power Subsystem

This sub-system is an electronic board which makes the necessary power supply of the satellite by making necessary transformations of the energy taken from the solar panels. There will be a maximum power point monitor (MPPT) charge integrator capable of converting energy from the sun to the energy efficient, a flow monitor for controlling the current value of the electricity transmitted to the satellite, a rechargeable battery for storing an integrated and energy to monitor the charge-discharge status of the battery. This sub-system, which meets the general electricity need of the pocket satellite and allows it to be spent efficiently, will charge the battery of the pocket satellite by using the solar power with the maximum power point viewer.

On-Board Computer

This sub-system is an electronic card with a low power consumption microcontroller, a safety timer integral and a DC-DC voltage regulator. Built-in Computer Sub-System will supply DC-DC voltage regulator and control and stabilization of all satellite subsystems via RS-485 digital communication protocol. Data will be stored in a Ferroelectric Memory (FRAM) to minimize data loss. The system state can be controlled from outside by adding indicators that indicate different situations for instant control and error analysis. The system that will control all subsystems will be designed with appropriate algorithm design and will be done by the Joint Test Action Group (JTAG) industry standard.

2) Communication Subsystem

Communication Subsystem Consists Of A Microcontroller, 433 Mhz Rf Transmitter Module, Power Amplifier, And A Quarter-Wave Antenna.

It is the electronic card which sends the measurements and other data made by the pocketqube to the ground station in a telemetry package format. All data collected by Pocketqube will be sent to the communication subsystem with RS-485 communication protocol by On-Board Computer. The received data will be converted to a Radio Frequency (RF) transmitter module by converting it into a specific telemetry format with a microcontroller in this subsystem. All data received by the communication subsystem will be backed up using a FRAM memory to minimize the potential for loss. The RF transmitter module will send all data received to its output by making appropriate signal modulations. With the power amplifier at the RF module output, the signal will be amplified approximately three times and transmitted to the antenna. Two-piece antenna shall be designed with 180° difference between them and two-way data transmission shall be provided.

3) Attitude determination and control subsystem (ADCS)

The attitude determination and control system (ADCS) will be used to determine, control and direct the movement of the pocketqube in various orbits.

ADCS has two functions. The first is the damping of the rotational movements that occur during the orbit after the launch, and the second is the attitude of the pocketqube in the desired direction.

The pocketqube will remain a fixed attitude throughout the mission. ADCS systems are divided into two as active and passive. The decision to use the passive or active control system is based on the purpose of the mission and the stability of the attitude, the needs of the settlement and the response time. Passive ADCS system is used where long response time is acceptable, does not require precise orientation control and energy resources on the satellite are limited. Pocketqubethe size of (5x5x5 cm) of power to be produced due to the small size will be proportional to the surface area of the solar panels placed on pocketqube.

Due to the small amount of Pocketqube surface area, the energy it will produce will be limited. Therefore, the orientation of the pocketqube will be achieved by using the passive magnetic stability system. The main features of the passive magnetic stability system are that they are cheap, simple and reliable.

4) Payload Subsystem

Payload subsystem consists of a microcontroller, magnetic meter, accelerometer, gyroscope and temperature sensor, a 640x480 resolution camera.

It is an electronic board which can make measurements and takes pictures from the environment through sensors and camera on the subsystem. Photos will be taken with the camera located in the payload subsystem. At the same time, data from the magnetic meter, accelerometer and gyroscope sensors will be analysed and the movements of the pocketqube position and current conditions will be analyzed.

Precise outside temperature measurements will be made with the temperature sensor. Data obtained by sensors and photo microcontroller will be transferred to OBC via RS-485 communication protocol.

CONCLUSION

The design of the pocketqube, which will be designed and produced, is intended to serve as an image capable of taking images under the conditions of low earth orbit (500 km). With the realization of the project, a much lower cost Pocketqube design will be realized in a short time compared to large satellites in the spacefield. In the field of The Pocketqube, the basic infrastructure will be established and academic and technological outputs will be achieved.

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