Development of Self-Powered Beacon for a CubeSat

Kyushu Institute of Technology, Applied Science for Integrated System Engineering

Rahmi Rahmatillah (14350941), Supervisor : Prof. Mengu Cho

1. Introduction

The number of satellites launched annually into the space is growing. However, the high rate of failure is still one of the issues for space projects. Satellite failure may be caused by insufficient power generated, communication system failure, damage from debris, deployment failure, and so on. Lost communication from the satellite is the worst condition that can happen in satellite mission. To mitigate this problem, Self-Powered Beacon (SPB) is developed in this research. SPB is a separated communication system in the satellite which sends beacon signal continuously to the ground.

2. Overview of SPB System

The basic principle for the SPB system is shown in Figure 1:

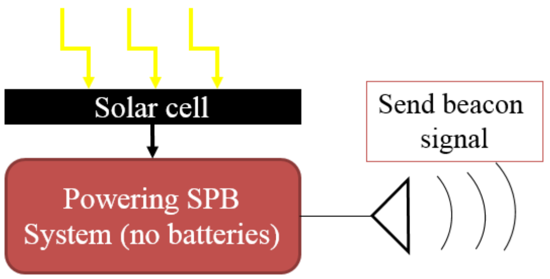

Figure 1 Basic principle for the SPB

SPB is supposed to be attached on one surface of 1U CubeSat. This system will start to work when the solar cell is illuminated by the sunlight and provide current to SPB load. The system is self-powered without using battery. The SPB consists of: 1) a Solar cell, 2) transmitter for beacon, 3) antenna, and 4) environment switch as the requirement of activation system. In this research, part 2) to 4) are developed.

3. Part's Development

3.1 Patch Antenna

To avoid failure because of deployment system, patch antenna is used. The patch antenna is designed and simulated in CST design studio software. There are two designs in the development: a) design for 437 MHz and b) design for 421 MHz.

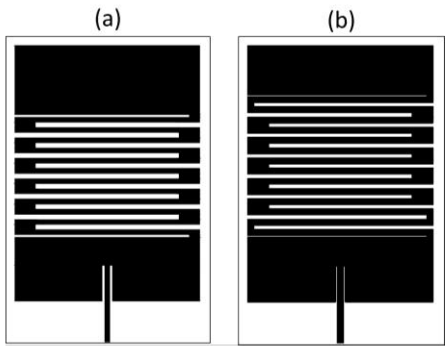

Figure 2 Patch antenna design

The antenna designs are fabricated by etching process and give frequency resonant value for design (a) is 436 MHz with S_{11} = -13.5 dB, gain 0.66 dBi. For design (b) is 421.25 MHz with S_{11} = -34.1 dB, gain has not been tested.

3.2 Transmitter and Microcontroller Circuit Design

Transmitter that is used in this research is ADF7021 N with microcontroller PIC16F876A for programming. It is programmed with register value. The PCB model for the transmitter is shown in Figure 3. The transmitter is configured to send the signal in frequency 437 MHz.

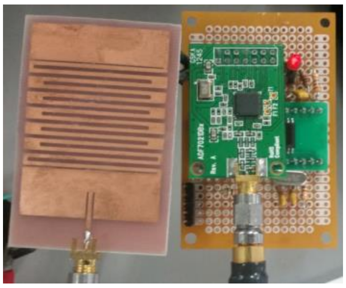

Figure 3 Tx – antenna integration

The spectrum result is shown in Figure 4. It is programmed in FSK modulation with 4KHz deviation.

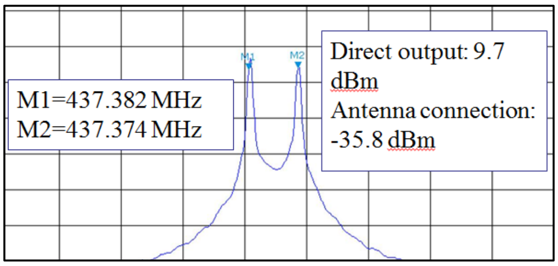

Figure 4 Output spectrum for 437.3 MHz

3.3 Environment Switch

The switch is used to activate the SPB system. There is a requirement from the launcher that no signal is transmitted prior to separation. To avoid electrical failure, switch based on environmental condition of space is developed. The concept for the switch is shown in Figure 5.

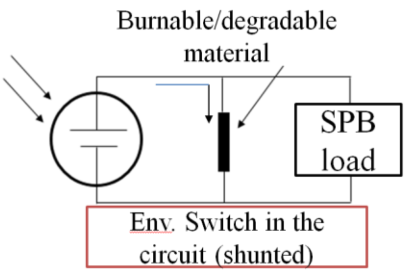

Figure 5 Environment switch concept

The switch is expected to prevent current from going to the load. When the switch is exposed to the space environment, it is supposed to be degraded, burned, or broken. There are 2 environment conditions considered here: Atomic Oxygen (AO) and Thermal Cycle. For AO condition, the switch is made of silver wire with thickness of 0.1 mm. After experiment, the switch was not fully degraded. It will require longer time to make the silver wire fully degraded. For thermal cycle condition, the switch is made of metalized polyimide attached to a substrate. The design is shown in Figure 6.

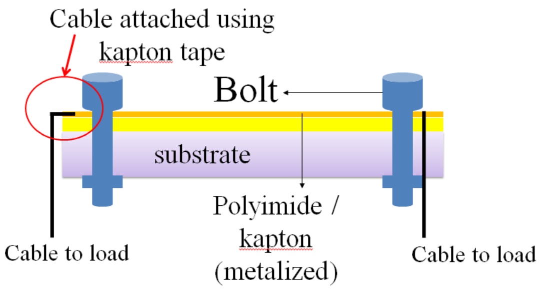

Figure 6 Environment switch design

There are two substrates used in the experiment: aluminum and rubber. For aluminum, the sample breaks after 12 cycles, while for rubber the sample breaks after 10 cycles. Both of those experiment were done with temperature range -100 to +100 ^{0}C.

4. Conclusion

Patch antenna, transmitter-microcontroller, and environment switch are developed in this research. The design for patch can give the resonant value of 436 MHz. Transmitter is programmed and can transmit data in range 437 MHz, but the data decoding has not finished yet. Environment switch is required for the activation system. From the experiment, it is better to choose substrate for the switch that has thermal coefficient larger than Kapton's thermal coefficient.