Quantitative Study of Received Power fluctuation by Nano-Satellite

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1. Introduction

In recent years, many universities have already launched nano-satellite on-orbit. Many of these nano-satellites have installed horizontal polarization antenna. We have already proposed establishment of the attitude estimation method by means of the received radio power. Those measurements have been conducted for past two years since October 2006 at Hokkaido Institute of Technology Ground Station. The measurement target of spin satellite is HIT-SAT which was launched in September 23 2006, and the measurement target of spin satellite is KKS-1 which was launched in January 23 2009 [1][2]. In this study, we measured received power for spin and non spin satellite. As a result, the orbit elevation angle altered by a change in received power. The effect is guessed to be an ionosphere and the multipath fading by optical path difference.

2. Measurement System

Received power of small satellite was measuring ground station in Sapporo-city Hokkaido Japan. Cross YAGI antenna and horizontal YAGI antennas were set up in the ground station. Table1 shows specification of ground station. Fig 1 is shown the antennas in ground station. We measured the signal of receiver by A/D conversion. The sampling rate is 11.36 milliseconds. Accuracy is 10 bit because it used the microcomputer board. The pursuit of the antenna and the correction of the doppler shift were done with software for the satellite tracking that I had made. The orbit calculation with this software was done by using the orbital element open to the public in the TLE form on the homepage of SPACE TRACK based on SPG4. SGP4 is a theory to calculate an arbitrary satellite position of time and the speed of the satellite from orbit information on the TLE form. This system can be measured only by the reception. Therefore, there is no obstacle to the satellite operation even if this system measures.

Figure 1: Antennas of ground station

Table 1: Specification of ground station

Lat/Lon	43.131N, 141.2537E
Sea level altitude	69[m]
Cross YAGI antenna gain	16.15[dB]
Horizontal YAGI antenna gain	18.55[dB]

3. Quantitative study of received power by spinning nano-satellite

3.1 Ground experiment

We did quantities study about received power change of spin nano-satellite and non spin nano-satellite. The measurement target of spin nano-satellite is HIT-SAT. We make comparison between received power orbiting HIT-SAT and antenna radiation pattern of HIT-SAT. The method of ground experiment was turned HIT-SAT model. Radiation pattern of dipole antenna e-plane of rotation around x-axis is shown in Fig. 2.Null point level and peak point level mismatching was by antenna asymmetrical of dipole antenna.

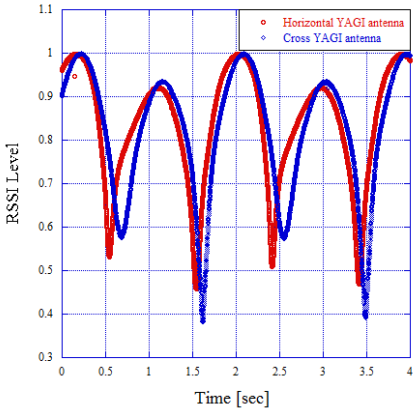

Figure 2: X-axis radiation pattern by HIT-SAT

3.2 Measurement result

We measured HIT-SAT which is spin nano-satellite between October 28 2006 and January 30. As a result, the received power date fluctuated periodically. Fig. 3 shows data of January 1 2007. This received power fluctuation established by spinning nano-satellite [3][4].

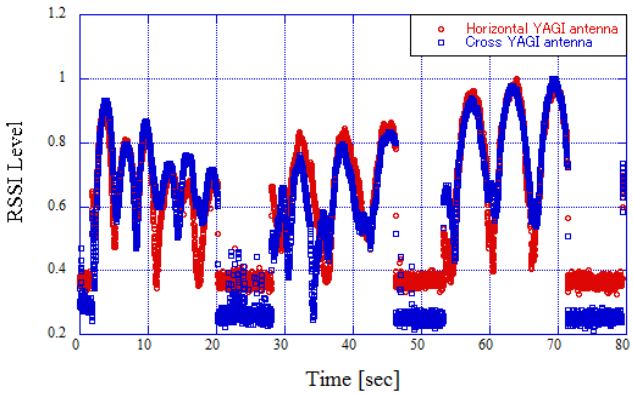

Figure 3: Received power date in January 1 2007

3.3 Discussion

We study cumulative distribution of received power fluctuation by spin satellite. Fig. 4 of ground experiment result and Fig. 5 measured in January 1 2007 shows cumulative distribution. As a result, both the received power orbiting HIT-SAT and antenna radiation pattern of HIT-SAT reconciled cumulative distribution. For this reason, the received power fluctuation is guessed by spin of nano-satellite.

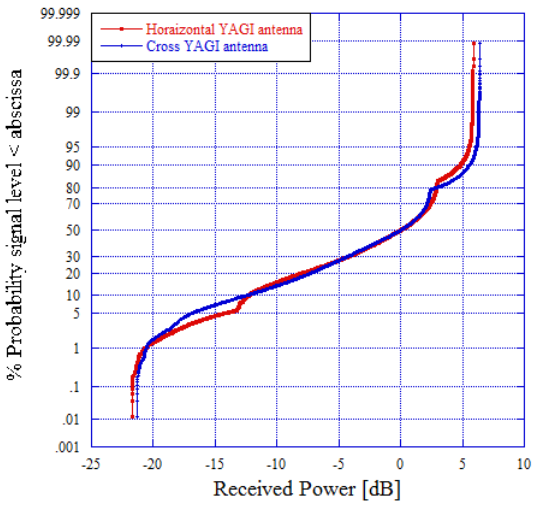

Figure 4: Ground experiment result

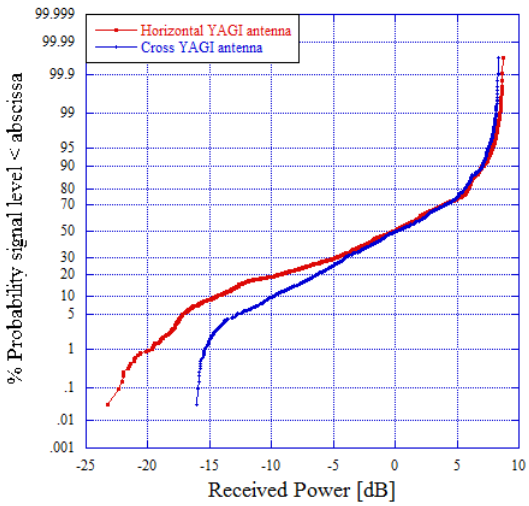

Figure 5: The measurement received power

4. Received power by non spinning satellite

The measurement target of non spin satellite is KKS-1. It is a square, 15cm on a side. KKS-1 was developed by Tokyo Metropolitan College of Aeronautical Engineering group. Received power and free space propagation loss is divided by each the maximum value followed by normalized. Therefore free space propagation loss is assumed to be C/N. Fig. 6 shows C/N looks like the change in received power value. Accordingly KKS-1 is none spinning satellite. But, there is Fig. 6 shows wave in the neighbourhood of out of seeing length. It is remaining an open question. It is thought that the cause of wave is multipath fading and the Faraday Effect by ionization layer. We study from all angles it under advisement.

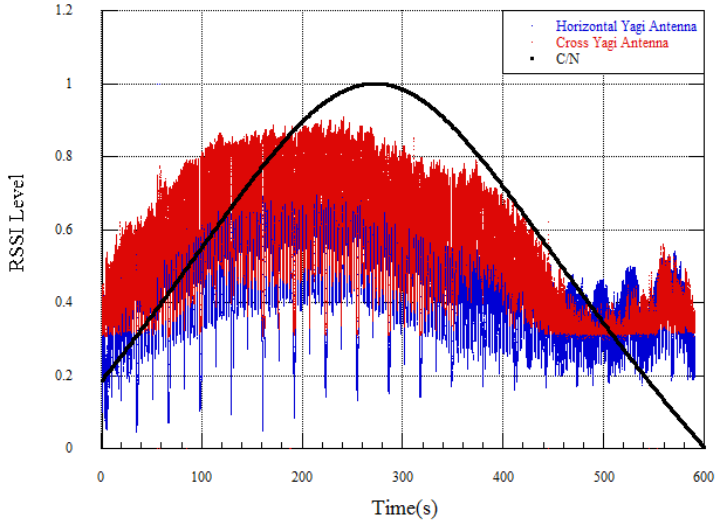

Figure 6: Received power and C/N by KKS-1 in March 5 2009

5. Conclusion

In this paper, it is quantitative study received power fluctuation by spin of nano-satellite. Also, received power fluctuation of non spin satellite is fluctuation of C/N. Accordingly, it is guessed that non spin satellite spin does not spin. It will be possible that high sampling rate and multi position measurement as demonstrated in this experiment gives us more information about satellite attitude.

Acknowledgments

This work was supported by KAKENHI (20560363)

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