큐브위성 아마추어 지상국 개발 및 시험

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Amateur ground station development and testing for university CubeSat operations

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Introduction

Ground station is a key segment in the success of a CubeSat mission, as it is considered the only way in acquiring data from the satellite. Seoul National University (SNU) developed a CubeSat as part of the QB50 mission, also using amateur radio frequencies and thus an amateur ground station using VHF and UHF amateur radio frequencies was developed. As launch and early operations (LEOP) is critical in mission success, it is important to perform tests on the ground station before launch. As the ground station is developed for amateur radio, uplink and downlink tests can be performed on variety of existing CubeSats, which is a big advantage.

This paper introduces the amateur radio ground station in Seoul National University and presents the series of communication tests that were performed during the ground station development phase. This paper only focuses on technical aspects of the ground station and the details on administrative procedures such as frequency allocation or ground station registration are not dealt in this paper.

SNU Ground Station

Ground Station Hardware

SNU Ground Station (hereby SNUGS) was specifically designed to support SNUSAT-1/1b, SNUSAT-2 and future CubeSats to be developed in SNU. An overview of SNUSAT-1/1b and currently being developed SNUSAT-2 communications are described in table 1.

Table 1. Overview of SNUSAT communication

	SNUSAT-1/1b	SNUSAT-2
Downlink		
Frequency	UHF	UHF/S-band
Modulation	BPSK	BPSK/DQPSK
Polarization	Linear	Linear
Misc.	AX.25	TURBO
Uplink		
Frequency	VHF	VHF
Modulation	AFSK	AFSK
Polarization	Linear	Linear
Misc.	AX.25	AX.25

As multiple frequency and modulations are required, SNUGS uses a software defined radio for downlink and regarding amplifying issues commercial radio is used for uplink. The overview of the hardware is shown in figure 1, and its list is shown in table 2.
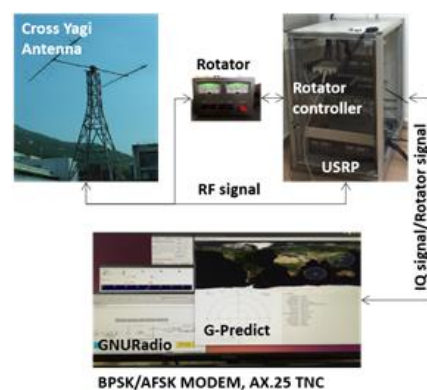

Fig. 1. Overview of SNUGS hardware

Table 2. SNUGS hardware

Antenna	Cross Yagi (13/19 elements)
Rotator	G-5500 + GS232A
Radio	USRP-2920, USRP-2900, TM-D710A
TNC	KPC-9612+

Ground Station Software

Two different sets of software were used in testing SNUGS for test simplicity reasons. First set was used in testing antenna hardware, and the second set was used in testing the grounds station software. The two sets are described in table 3.

Table 3. Ground station software set

	Set 1	Set 2
Downlink		
O.S.	Windows 10	Ubuntu 14.04 LTS
Library	HamLib 3.1	
Software	HDSDR+ExtIO USRP	GNURadio
Uplink		
O.S.	Windows 10	
Software	HyperTerminal	
Satellite tracking and antenna Control		
O.S.	Ubuntu 14.04 LTS	
Library	HamLib 3.1	
Software	Gpredict	

Ground Station Testing

SNUGS hardware was tested in order to (1) verify antenna rotator pointing capability and to (2) verify antenna connectivity.

Antenna rotator pointing capability test was performed by comparing the G-5500 azimuth and elevation readings with measured pointing angles. Calibration in G-5500 was performed and antenna mount was modified during the test.
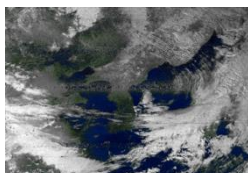

Fig. 2. NOAA 19 APT image

Antenna connectivity was performed by receiving images from NOAA 19 automatic picture transmission (APT) using USRP-2900, as shown in figure 2. Antenna connection problems were found during the test, and the antenna lines are currently under maintenance.

As the antenna connection had problems, direct testing of Ubuntu system connected to the antenna was not possible. Therefore, the raw RF signals were recorded using software set 1 of table 3, and fed into software set 2, as in figure 3. Raw RF signals must be saved in wav file format, which can be fed using the 'wav file source' of GNURadio. PRISM beacon signals are acquired for CW tests (USB mode) and QB50P1 signals are acquired for BPSK tests.

Fig. 3. Wav file fed for software veification

The AFSK uplink tests is to be performed on ISS APRS using TM-D710A[1]. As ISS ARPS protocol is
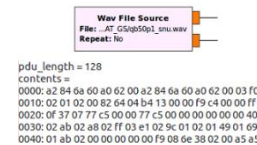
AX.25 TNC such as KPC-9612+ is required. In case of TM-D710A, TNC is embedded internally, so the internal TNC can be used.

Conclusion

SNUGS hardware and software were tested in order to verify its functionality before LEOP using amateur satellites. Hardware faults were detected during the test and is currently under maintenance. Software was successfully tested by feeding raw files.

Acknowledgement

References

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