SYSTEM INTEGRATION AND PERFORMANCE TEST OF DREAM ON STSAT-2

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ABSTRACT:

Dual-channel Radiometers for Earth and Atmosphere Monitoring (DREAM) was developed as the Korean first spaceborne microwave radiometer for earth remote sensing. It is the main payload of the Science and Technology SATellite-2 (STSAT-2). STSAT-2 will be launched by Korea Space Launch Vehicle-1 (KSLV-1) at NARO Space Center in Korea in 2008. The DREAM is a two-channel, total power microwave radiometers with the center frequencies of 23.8 GHz and 37 GHz. The bandwidths of radiometer are 600 MHz at 23.8 GHz and 1000 MHz at 37 GHz. The integration time is 200 ms and the required sensitivity is less than 0.5 K.
In this paper, we summarize the specification and performance of the developed DREAM firstly. And we describe system integration and performance test of DREAM mounted on spacecraft.

KEY WORDS: DREAM, STSAT-2, Radiometer

1. INTRODUCTION

For many years, the microwave radiometer has played an important role in the research of the earth's environment because it has a capability of global, day and night, and nearly all-weather remote sensing. The several advanced spaceborne radiometers such as AMSR, MWR, TMR, and ATSR have been developed for investigating the earth environmental phenomena such as soil moisture, precipitation, snow, liquid water and water vapour (Ulaby, 1981; Tachi, 1989; Guijarro, 1998; Ruf, 1995; Prata, 1990). Near future, Chinese lunar exploration program will observe the characteristic of the lunar soil using the multi-channel (Huixian, 2005).

Dual-channel Radiometers for Earth and Atmosphere Monitoring (DREAM) was developed as the Korean first spaceborne microwave radiometer for earth remote sensing. It is the main payload of the Science and Technology SATellite-2 (STSAT-2) which is a 100 kg micro-satellite. The mission orbit is an elliptical low earth orbit with the perigee 300 km and the apogee of 1,500 km. The DREAM will measure the earth 14 times per one day for 2 years. For the mission life, the DREAM will measure the brightness temperature at 23.8/37 GHz and analyze the data to retrieve the physical parameter such as liquid water, total precipitation, sea surface, and so on.

The DREAM units had been developed for 2 years. The DREAM was performed with the vibration test and thermal-vacuum test to simulate the environmental conditions to be experienced in space. To evaluate the performance of DREAM, the liquid nitrogen and microwave absorber as the calibration sources were used (Kim, 2005; Kim, 2006a). After the payload development, the system integration and test were performed in this year. All tests were controlled by spacecraft and repeated with the procedure which was used for DREAM unit level test. We set the hot and cold source on the front of spacecraft and tested performance of DREAM. In this paper, we present the specification and performance of the developed DREAM firstly. And we describe system integration and performance test of DREAM mounted on spacecraft.

2. SYSTEM DESCRIPTION AND PERFORMANCE

2.1 DREAM System Description

The DREAM is two-channel, total power microwave radiometers with the center frequencies of 23.8 GHz and 37 GHz. The bandwidths of radiometers are 600 MHz at 23.8 GHz and 1000 MHz at 37 GHz. The integration time

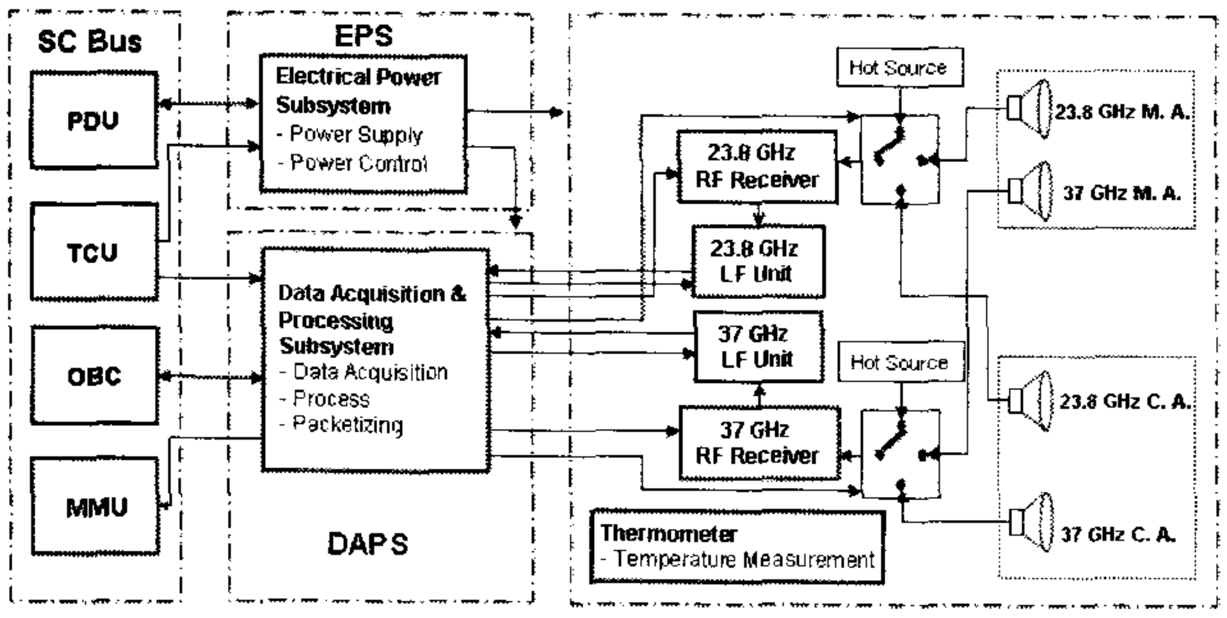


Figure 1. DREAM system block-diagram

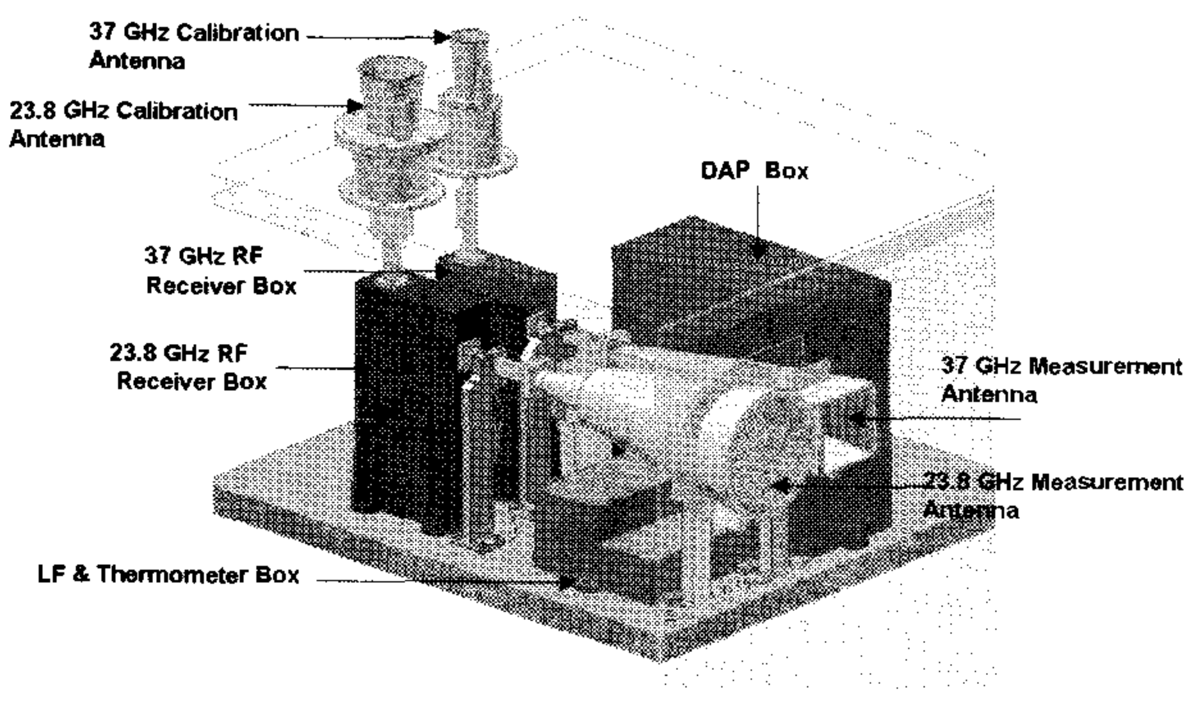


Figure 2. DREAM configuration

are 200 ms and the required sensitivity are less than 0.5 K. The allowed mass and power for the payload are 15 Kg and 20 W, respectively. The DREAM measures the brightness temperature of the earth at the direction of nadir without antenna scanning and the field of view (FOV) of the earth observation antennas for both frequencies is 10 °. The equipment swath width shall be changed from 52 km to 262 km in orbit (Sim, E., 2004).

The DREAM consists of functionally four subsystems such as antenna subsystem, radiometer receiver subsystem, LF & thermometer subsystem, and data acquisition and processing subsystem. The antenna is composed of two measurement antennas and two calibration antenna. The measurement antennas are the corrugated horn-type antennas with low side-lobe, high main-beam efficiency, and the beam-width of 10 °. The calibration antennas are horn antenna and have the beam-width of 10 °. Each radiometer has a heterodyne receiver and operates in a double-side band mode. The RF receiver is composed of a RF switch, a RF LNA, a mixer, a local oscillator, a IF AMP, and a IF BPF. To calibrate the measured data from the radiometer, two point sources are used. A cold source is the deep space radiation received by the calibration antenna and a hot source is an on-board matched load. From these calibration sources, the dynamic range of the radiometer is 3 K to 340 K. To switch the receiver to the matched load, the calibration antennas, and the measurement antennas, a SP3T RF switch is used at the input port of each of the two RF front-ends. So, the calibration and observation will be conducted repeatedly in orbit. In DREAM, the period including two calibration

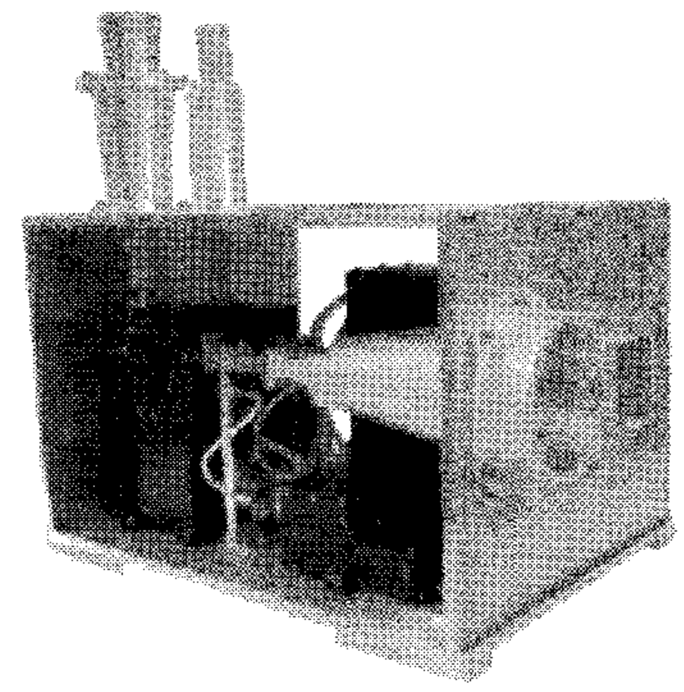


Figure 3. DREAM FM

and observation is 10.2 seconds and each calibration is executed every 9 seconds. The LF & Thermometer subsystem consists of LF unit and thermometer. The LF unit includes a detector, a LF AMP, and an integrator. Thermometer unit is to measure the temperature of the components for the calibration of the measured brightness temperature. The points of the temperature gauge are ten which are two for each measurement antenna, two for each calibration antenna, and unity for each RF receiver. The accuracy of the platinum resistors is less than 0.5 K. The data acquisition and processing subsystem contains a data acquisition and processing unit (DAPU) and a dc-dc conversion unit (DCU). The DCU supplies the power received from the spacecraft for the DREAM operation. The DAPU execute two main roles. One is to communicate with the on-board-computer (OBC) of the spacecraft. The DAPU receives telecommands from the OBC, executes the commands. Fig.1 and 2 show the system block-diagram and configuration of DREAM, respectively (Kim, 2006b; Lee, 2007).

2.2 DREAM Performance

Fig. 3 shows the developed DREAM FM. To measure performance such as sensitivity and linearity, two stable reference sources were used. One was cold source using the liquid nitrogen with the temperature of 77 K and the other was hot source using the microwave absorber with the ambient temperature. An integration and sampling time was 200 ms. The sensitivity and linearity measurement were performed simultaneously. For linearity measurement, the many different temperature inputs are needed. In this test, a variable attenuator was inserted between the antenna and receiver to get the various temperature inputs using its loss and physical temperature. For sensitivity measurement, the long time measurement is performed at the stable input. The measurement was performed at 10 different temperature inputs for 2 minutes. And the sensitivity was determined from the standard deviation of the measured data. Our specification is 0.5K. The experimented sensitivity was less than 0.20 K at 23.8 GHz and less than 0.20 K at 37 GHz. Linearity is larger than 0.99 at two channel. Table I shows the performance results of DREAM FM.

TABLE 1. DREAM FM Performance Results

Parameters	Specification	
	23.8 GHz Rx	37 GHz Rx
Center frequency	23.8 GHz	37 GHz
Bandwidth	680 MHz	1020 MHz
Noise figure	< 4.8 dB	< 6.4 dB
Integration time	204 ms	208 ms
Dynamic range	3 – 340 K	3 – 340 K
Radiometric accuracy	< 2.0 K	< 2.0 K
Radiometric sensitivity	< 0.20 K	< 0.20 K
Linearity	> 0.99	> 0.99

3. SYSTEM INTEGRATION AND TEST

The STSAT-2 has four platforms to mount the subsystems of spacecraft and payloads. The DREAM subsystems except the antennas were located on the upper platform which is the 3rd floor of the spacecraft. The measurement antennas were mounted on the + Z closure panel which views the earth. The calibration antennas were mounted on the sensor platform which is the 4th floor of the spacecraft and has many sensors such as star sensor, GPS, RF transceiver. Fig. 4 shows the DREAM integration on spacecraft. After the harness work, ten thermometers were connected each subsystem finally. In the electrical integration, power and communication test were performed. All integration tests were finished successfully.

To test the performance of DREAM on the spacecraft, we set the hot and cold source on the front of spacecraft as shown in Fig. 5. All tests were controlled by spacecraft and repeated with the procedure which was used for DREAM unit level test. To confirm normal operation in system level, we set the cold source on the calibration antennas and the hot source on the measurement antennas. We tested the DREAM with different methods for eight hours in three days. In the test, we checked the operation mode, receiver AGC control, interference from X/S-band transceiver. We also examined long-term stability and sensitivity. From the Power-on of DREAM, the transient period of the measured data continued over about two hours at the ambient temperature and the sensitivity is less than 0.2 K at both channels. Fig. 6 shows the test result of DREAM on spacecraft.

4. CONCLUSIONS

This paper presents the specification and performance of the developed DREAM. And the system integration and test results are introduced. The measured sensitivity and linearity of the developed DREAM was 0.2 K and 0.99 at both channel, respectively. DREAM was mounted

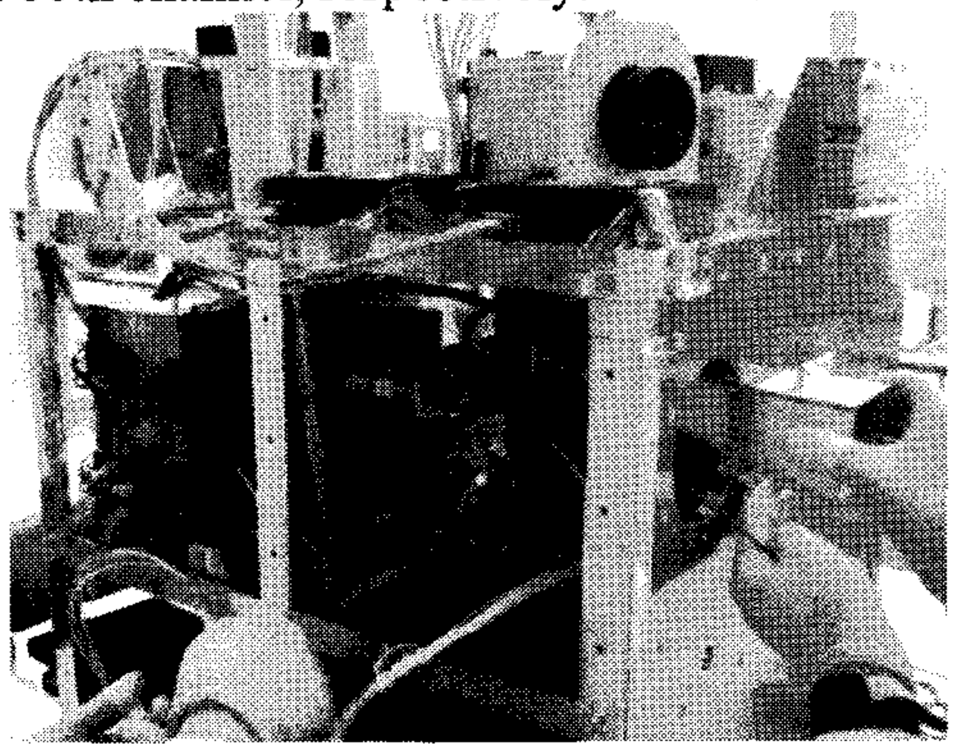


Figure 4. DREAM integration on spacecraft

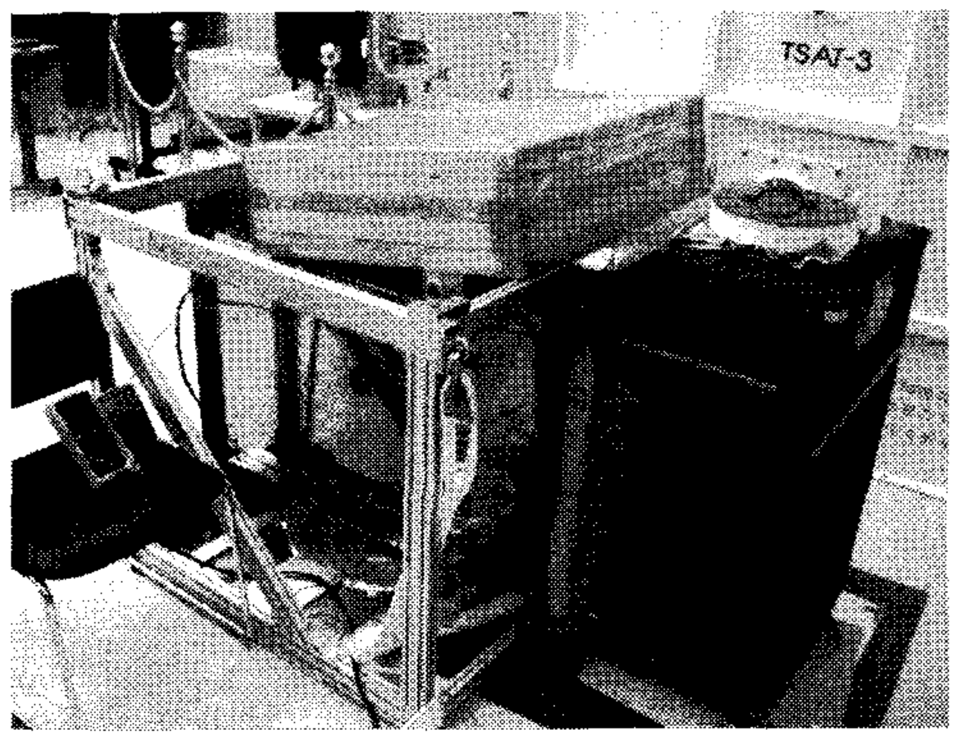
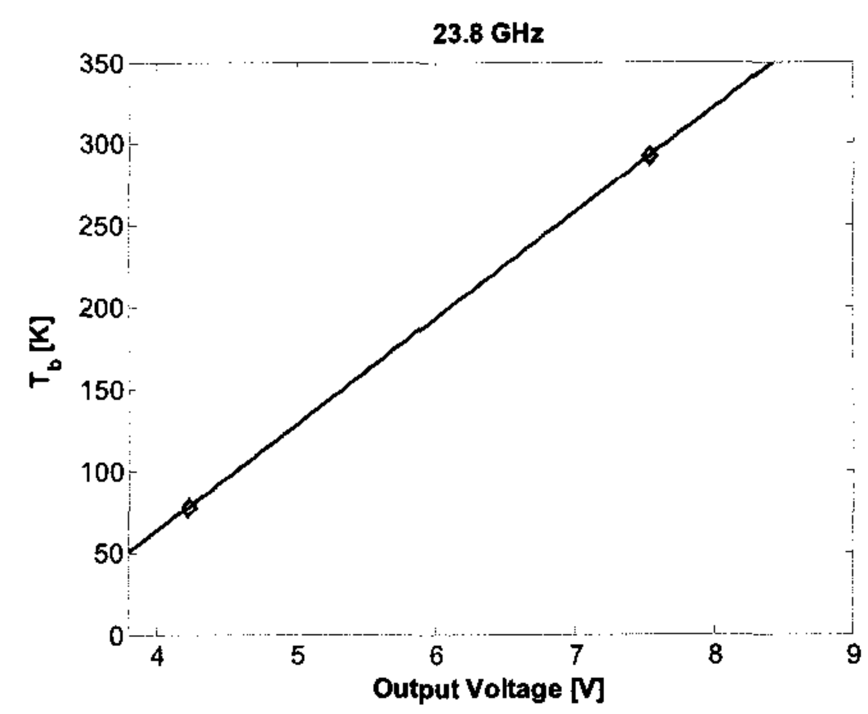
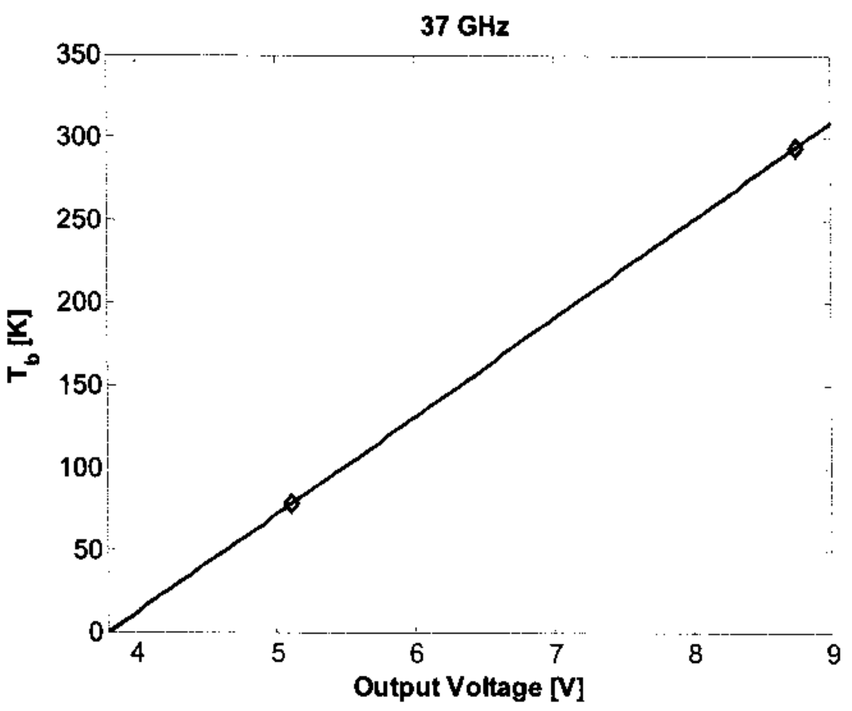


Figure 5. System performance test



(a)



(b)

Figure 6. System performance results. (a) 23.8 GHz recevier, (b) 37 GHz receiver

on the spacecraft and performed mechanical and electrical integration test. The DREAM was integrated with the spacecraft successfully and passed the electrical test such as the power, communication, and interference between the payload and spacecraft. To check the performance the DREAM on the spacecraft, two reference sources were used with same as unit level test. The system test shows the similar results with the unit level test.

DREAM will start the mission after launch in the end of 2008. In the mission life, DREAM will measure the brightness temperature at 23.8 GHz and 37 GHz to provide a meaningful data for the investigation of atmosphere and ocean.

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