DEVELOPMENT OF POTENTIAL MONITOR AND ELECTRON EMITTER MODULE FOR EDT EXPERIMENT ON HTV-6

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ABSTRACT

JAXA plans demonstration test of the electrodynamic tether experiment on HTV-6. The name of experiment is Kounotori Integrated Tether Experiment, KITE. For the experiment, we develop the potential monitor and electron emission module. The electron emission module generates the electric circuit through the tether and ambient plasma. The field emission cathode type electron emitter is used for this function. The potential monitor measures the potential of HTV-6 to check the influence of electrodynamic tether.

In this report, the performance of electron emission module and potential monitor are discussed. In addition, we carried out the following tests which were specifically necessary for potential monitor and electron emission module at the verification phase. The result of tests are discussed.

> Plasma environment test for potential monitor: The performance should be verified under plasma environment.

> Measurement of radio emission for electron emission module: It is necessary to check the level of radio emission due to electron emission to proof no influence for HTV system.

1. INTRODUCTION

Electrodynamic tether is well known as the new propulsion system without propellant. JAXA plans to perform demonstration test for mechanism of electrodynamic tether[1,2,3]. The name of experiment is “Kounotori Integrated Tether experiment”. The acronym is KITE. HTV is selected as the mission plat form because of its large capability for electricity, communication resources and physical space. KITE carries out the following operations after “Integrated operation phase” on the way to re-entry refer to Fig 1-1;

・To release the end-mass and deploy its 700m-tether in the zenith direction from HTV .

・To monitor the end-mass dynamics by the rendezvous sensors of HTV.

・To drive current on the tether by emitting electrons from HTV.

・To monitor the tether dynamics.

・To cut the tether at the end.

The system diagram is shown in Fig.1-2. Following components allows us to achieve the above mission purpose.

・Data Handling Unit/Power Control Unit(DHU/PCU)

・Field Emission Cathode(FEC) Module

・MAGnetic Sensor(MAGS)

・CaMeRa(CMR)

・End-mass Hold and Release mechanism(EHR)

・Tether Cutting Mechanism(TCM)

・Large Plasma current probe and Potential Monitor (LP-POM) module

Except LP-POM module, all KITE components are controlled by DHU/PCU. LP-POM module is based on Atotie-mini module and KASPER module which are launched with HTV-4 and -5. Therefore, LP-POM module directly interfaces with HTV system [4].

The components are installed on HTV as shown in Fig.1-3. The tether is installed in the end mass. The end mass is released from EHR. The tether is connected to FEC module through HTV surface. FEC module emits the electron to make the electric circuit between tether and the ambient plasma.

The camera allows us to see the deployment of tether from HTV. As the length of tether is 700m, it is impossible for us to see the end mass at the end of deployment phase. However, we can still check the movement of a part of tether near HTV. After finishing deployment of tether, the rendezvous system of HTV is used to check the position of the end mass.

We use LP-POM module to check the potential of HTV during KITE experiment. It is necessary to check the potential, because the potential of HTV is estimated at approximately 100V lower than ambient plasma. In addition, LP-POM module has plasma current sensor, in order to measure the ambient plasma environment. We need the plasma environment, especially plasma density, is necessary to investigate the electrical dynamics of tether.

In this report, we report about FEC module and LP-POM module which relates to the research area of spacecraft charging technology.

Fig.1-1 KITE operation configuration

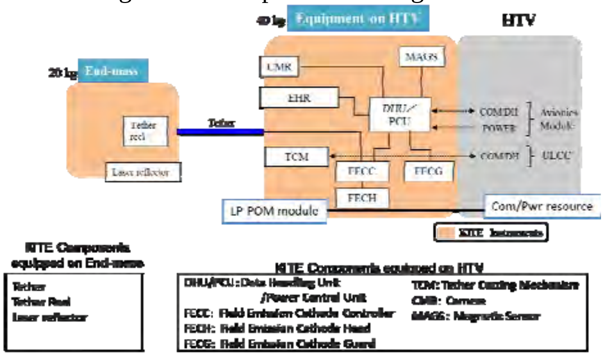

Table.1-2 List of sensors

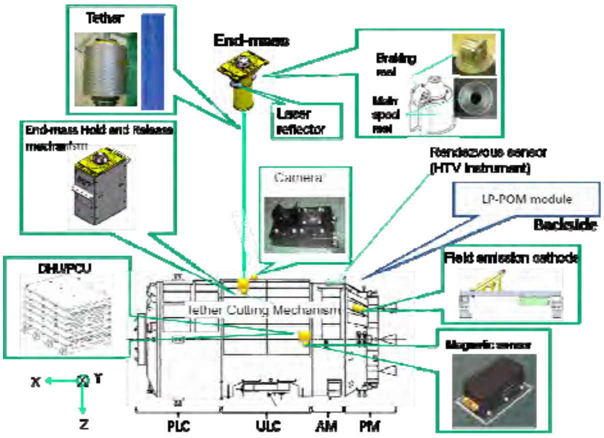

Fig.1-3 The components on HTV

2. LP-POM MODULE

2.1. Overview of LP-POM module

As it is written at Chapter.1, the design of LP-POM module is based on Atotie-mini module on HTV-4 and KASPER module on HTV-5. Figure.2.1-1 shows Fig.2.1-1. The sensors on LP-POM module is shown in Table.2.1-1. Two sensors, TREK-3G and SCM, are installed on LP-POM module. TREK-3G is main sensor, and SCM is a backup of TREK-3G. TREK-3G and SCM are demonstrated on Atotie-mini module on HTV-4. LP is the plasma current sensor. LP is the plasma current sensor. The mechanism of LP is same as KASPER module on HTV-5.

As the sensors are already demonstrated at former HTV, we need to verify the sensors after finishing the integration of LP-POM module. The several environment tests, vibration test and thermal vacuum test and the other, are required from HTV for their verification program. Out of HTV verification program, we performed plasma interaction test for LP-POM module to verify the performance of sensors. The detail is written in next chapter.

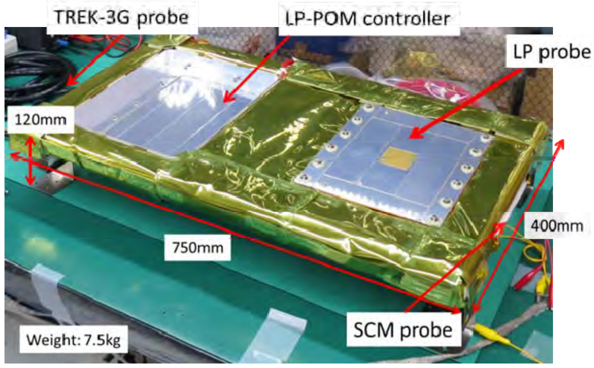

Fig.2.1-1 LP-POM module

Table.2.1-1 List of sensor

Name	Purpose	Characteristics
TREK-3G	Measure the potential of HTV.	Potential of HTV -50 to 150V. (Reference voltage is HTV)
SCM	Same as SCM. Backup of TREK-3G.	Same as TREK-3G
LP	Measure the plasma current.	Plasma density: 3.0×10^{10} m^{-3} to 3.0×10^{12} m^{-3}

2.2. Plasma interaction test

We perform the plasma interaction test in vacuum chamber which equips with ECR plasma source to simulate the plasma environment in low earth orbit. The configuration inside the vacuum chamber is shown in Fig.2.2-1. We put LP-POM module on the metallic plate which is insulated by the polyimide sheet. The beta cloth covers the interface parts between LP-POM module and metallic plate as it is on HTV. Langmuir probes are put inside the chamber. Langmuir probe besides the LP probe is used to check the data of LP. The other one is used to check the plasma environment inside the chamber.

The experiment system is illustrated in Fig.2.2-2. LP-POM GSE and the other components connected to LP-POM is biased by high voltage power supply.

The result of plasma interaction test is shown in Fig.2.2-3, -4 and Table.2.2-1. In Fig.2.2-3 and -4, we show the result of TREK-3G and SCM. X axis is the bias voltage. Y axis is the data which is converted from telemetry of LP-POM. As we can see in the figures, the linearity of the data is enough. Table.2.2-1 shows the result of LP. In case of LP, we cannot control the plasma density, therefore, we have only one point of data. The data is inside the spec range.

From the result of plasma interaction test, we confirmed the sensors of LP-POM module works very well.

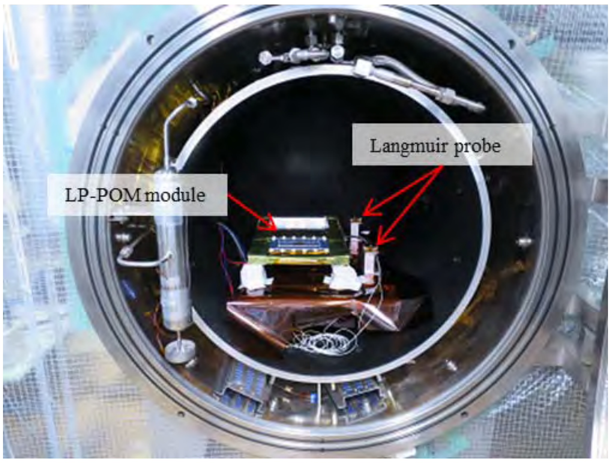

Fig.2.2-1 LP-POM inside the vacuum chamber

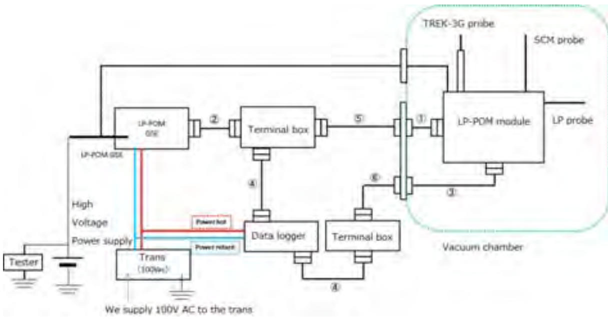

Fig.2.2-2 Block diagram of experiment system

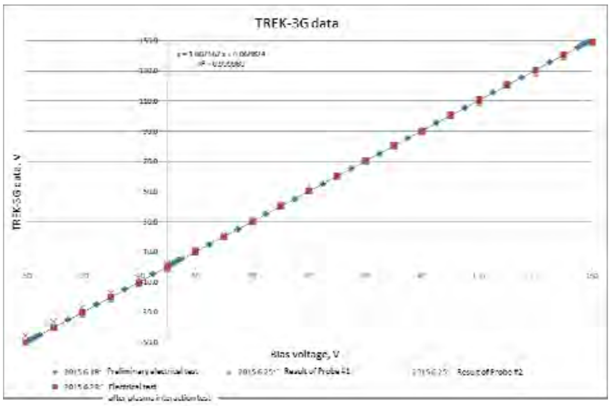

Fig.2.2-3 Result of TREK-3G

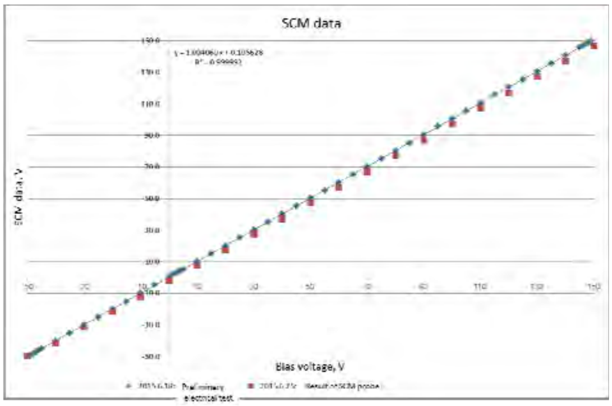

Fig.2.2-4 Result of SCM

Table.2.2-1 Result of LP

Spec	Number, A	Data, A
Upper limit	1.6e-2	2.5e-4
Lower limit	1.6e-4	

3. FEC module

3.1. Overview of FEC module

Figure.3.1-1 shows FEC module. FEC module is consists of several components which is listed in Table.3.1.-1. The carbon Nano tube is the key of field electron emission of FEC. The maximum application voltage to FEC is 1kV. FEC controller supplies high voltage to FEC. There are 8 FEC in FEC head. The maximum emission current from FEC head is 10mA. Although the amount of emission current is small, we have to proof the level of radio emission noise due to electron emission is enough small to ignore the influence to HTV. We performed radio emission test inside the vacuum chamber. The detail is written in next chapter.

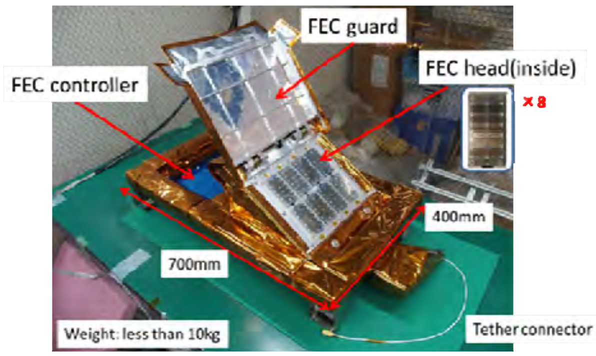

Fig.3.1-1 FEC module

Table.3.1-1 The components consist FEC module

Name	Purpose	Additional information
FEC head	8 FEC elements are integrated on this component. This component emits the electron to the ambient plasma.	
FEC guard	Protect FEC head from Atomic oxygen. Before starting experiment, this component opens by sending a command	
FEC controller	This component controls the bias voltage to FECs. Communication/Power interface with DHU/PCU.	

3.2. Radiation emission test

In order to mitigate the level of radio noise from outside of vacuum chamber, the conductive cloth covers the vacuum chamber as shown in Fig.3.2-1. Figure.3.2-2 shows the inside of vacuum chamber. In order to concentrate on the measurement of radio emission due to electron emission from FEC head, we perform the test without integrating as FEC module. FEC controller and FEC head are necessary to perform the experiment at least. To avoid the radio noise from FEC controller, the aluminium foil covers FEC controller and the cables between FEC head and FEC controller. Two antennas are installed on the vacuum chamber as shown in Fig.3.2-2.

The definition of dark noise in this measurement is following.

- Vacuum pump is working.
- FEC controller is off.

The dark noise is shown in Fig.3.2-3. We can recognize the noise from outside of vacuum chamber. The noise source is specified as mobile phone. Figure.3.2-4 shows the measurement result when the electron is emitting. The radiating noise due to mobile phone is recognized at same frequency as shown in Fig.3.2-3. We cannot recognize the noise due to electron emission in the data. As the result of measurement, radio noise due to electron emission must not be an issue for HTV.

Fig.3.2-1 Outside of vacuum chamber

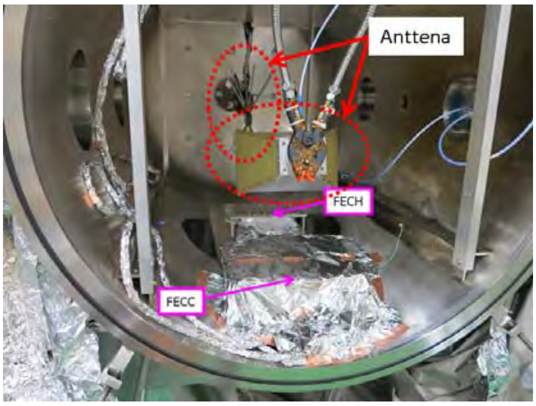

Fig.3.2-2 Inside of vacuum chamber

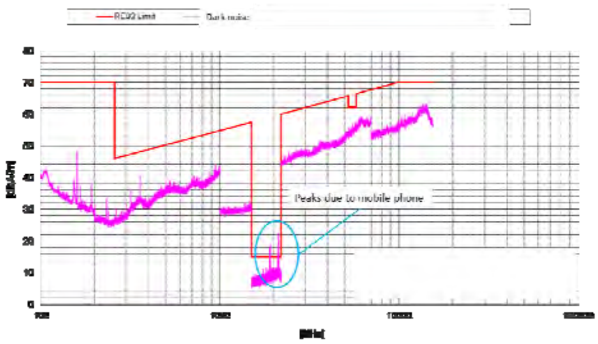

Fig.3.2-3 Dark noise

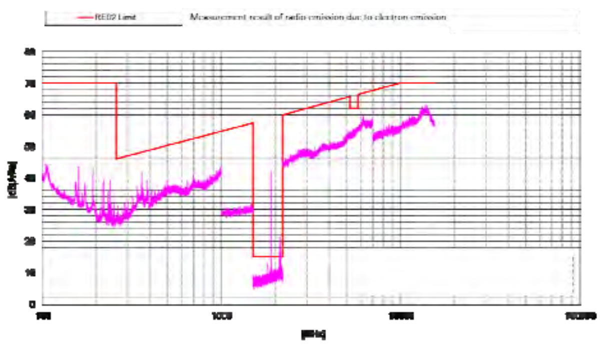

Fig.3.2-4 Radio emission due to electron emission

4. SUMMARY

LP-POM module and FEC module are still under development phase in Tsukuba Space Centre. The development phase will be finished at the end of June 2016. After finishing the development, the modules will be sent to Tanegashima Space Centre to integration to HTV.

5. ACKNOWLEDGMENT

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6. REFERENCES

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