Analysis on the Measurement Results of the Focus Motor Position in MSC (Multi-Spectral Camera) on KOMPSAT-Ⅱ

H.P.Heo, J.P.Kong, Y.S.Kim, J.E.Park, Y.J.Chang, S.H.Lee

Optical Payload Department, Korea Aerospace Research Institute
45 Eun-dong Yusung-gu, Taejon 305-600, Korea
(hpyoung, kjp123, yskim1203, pje, yjchang, shlee) @kari.re.kr

Abstract: The MSC is a high resolution multi-spectral camera system which is mounted on the KOMPSAT-Ⅱ satellite. The electro-optic camera system has a refocusing mechanism which can be used in-orbit by ground commands. By adjusting locations of some elements in optics, the system can be focused precisely. The focus mechanism in MSC is implemented with stepper motor and potentiometer. By reading the value of the potentiometer, rough position of the motor can be understood. The exact location of the motor can not be acquired because the information from the potentiometer can not be so accurate. However, before and after certain events of the satellite, like a satellite launch, the direction of the movement or order of the magnitude of the movement can be understood. In this paper, the trend analysis of the focus motor position during the ground test phase is introduced. This result can be used as basic information for the focus calibration after launch. By studying the long term trend, deviation from the best focal point can be understood. The positions of the focus motors after launch are also compared.

Keywords: KOMPSAT-Ⅱ, MSC, Focus Motor, Potentiometer, Calibration, Trend Analysis

1. Introduction

The EOS (Electro-Optical Subsystem) of the MSC consists of two separate camera systems for panchromatic and multi-spectral channel. They are sharing two mirrors and have separate focal correction lens group. Refocusing mechanism is incorporated on the lens group for both panchromatic and multi-spectral channels. By changing the position of some elements in the lens group, minor deviation of the optic alignment can be compensated. The refocusing mechanism is based on driving stepper motor. The position of the focusing motor is obtained by reading the potentiometer even though the measurement accuracy is not so high compared to the control step accuracy. The best position of the refocusing mechanism was decided while its performance test was being performed in the thermal vacuum chamber. After the MSC is installed on the spacecraft bus, during the integration and test phase, the focusing mechanism was not activated but only the position of the focusing motor has been recorded and checked. However, the measurement results of the focusing motor position were not constant during the entire period of the satellite functional test, performance test and environment test. In this paper, the measurement results of the focusing motor position throughout the integration phase till launch site test will be summarized and analyzed. The trend of the position change, even though it may not be actual movement but just a measurement error, will be explained. Understanding the trend is very much important because it will be the basic information to understand how much actual movement occurred during the satellite launch phase. It will also be used for refocusing calibration during the satellite LEOP (Launch and Early Operation Phase).

2. Measurement Method

There are two focus mechanisms, one for panchromatic camera and the other for multi-spectral camera. Both of them are implemented and operated independently. The mechanism consists of a stepper motor which moves the position of some optical elements and a potentiometer which is tightly coupled with the gear of the stepper motor. When the motor moves forward and backward, the resistance of the potentiometer is changed. In order to read the change of the resistance, there is an electrical circuit to provide constant reference voltage to the potentiometer. The reference voltage is applied to the potentiometer together with a resistor which is connected serially. Therefore, the voltage is divided by the two resistors one is fixed and the other is variable by the position of the focus motor. The position of the focus motor is calculated by following formula. Voltage on the potentiometer is sampled by ADC (Analog to Digital Converter) and it is converted to the resistance and the position of the focus motor is obtained from the resistance using following formula.

$$R_p = \frac{V_m * R_{ref}}{V_R - V_m} \Omega$$

R_{ref} – Thermistor specific resistor value (Ω)

V_R – Sampled Reference voltage (V)

V_m - The measured voltage (V)

R_p – Computed potentiometer resistance (Ω)

$$P_C(um) = (4.1e^{-7} * R_P + 4.09e^{-5}) * 10^6$$

Valid limits for both positions are as follows.
PAN Focus Motor Position: 1500 um ~ 6950 um

MS Focus Motor Position: 3450 um ~ 7000 um

Due to the fact that the position is strongly affected by the change of the reference voltage which is provided from the output of the DC/DC converter, the measured value from the system needs to be compensated using the minor change of the reference voltage. Because the focus motor position is recorded to the EGSE as long as the system is operating, there are plenty of data to be used for trend analysis of the focus motor position for a long period.

3. Measurement Results

After the EOS system had been assembled and aligned, finding and adjusting the best focus position for both panchromatic and multi-spectral camera was accomplished during the thermal vacuum test phase. The position change and trend are shown in the following figure. Almost thirty samples are plotted in almost all the figure.

The positions of the focus motor during EOS thermal vacuum test are shown in the fig 1 & fig 2.

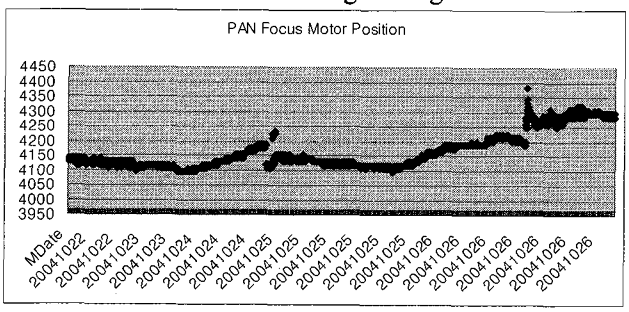

Fig 1. EOS T/V Test [PAN]

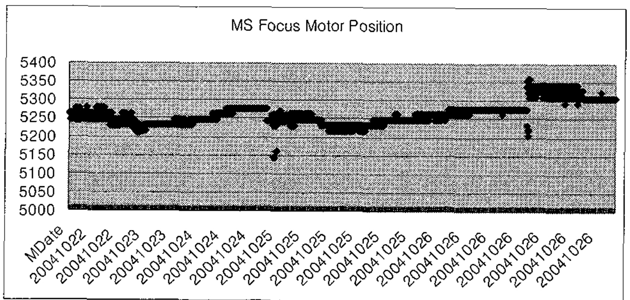

Fig 2. EOS T/V Test [MS]

In the fig 3 and fig 4, a big displacement was observed even though the reference voltage was constant (13.8volt) all the time and the temperature of the EOS were at room temperature. During that period, final functional test before shipping to KARI was performed. As for now, it can not be confirmed what happened to the system at that time, but there might be a movement of the EOS system on the trolley.

In the fig 5 and fig 6, the position change before and after MSC system delivery to KARI. A displacement could be found around December 16, 2004 that might be caused by the shipment. But, it could be found in the figure that the position change occurred before were being reduced gradually and returning to the original position.

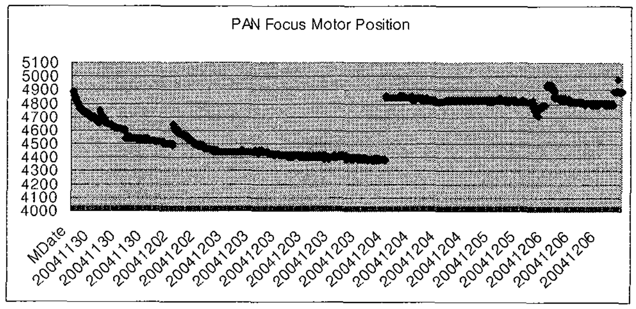

Fig 3. EOS Installation & FFT [PAN]

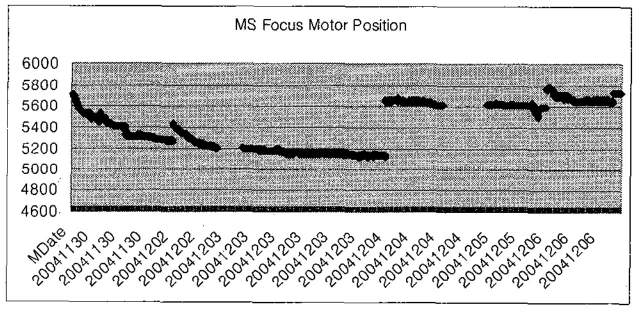

Fig 4. EOS Installation & FFT [MS]

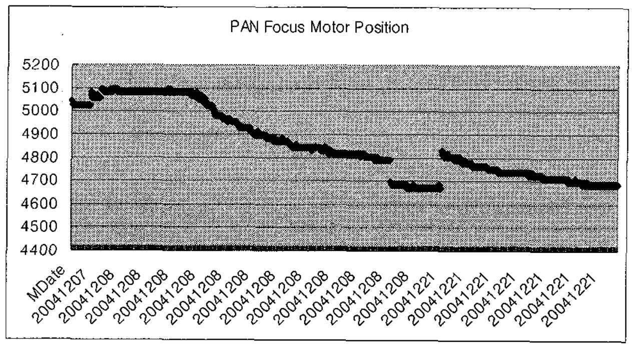

Fig 5. Before & After MSC Delivery [PAN]

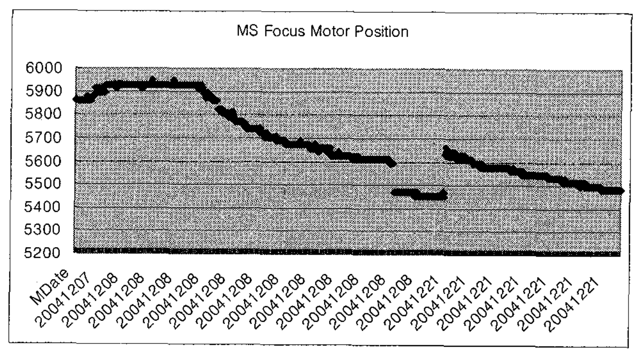

Fig 6. Before & After MSC Delivery [MS]

In the fig 7 and fig 8, they are returning to the original position to compensate the displacement occurred before. During that period, aliveness test of the MSC system has been performed at KARI just after delivery.

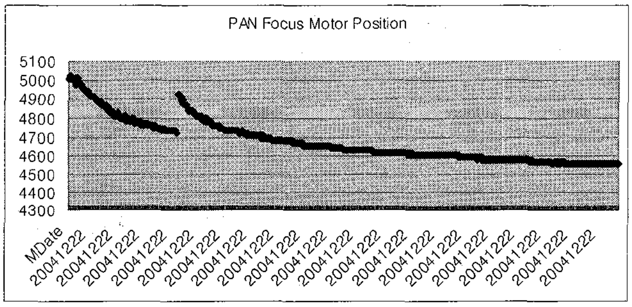

Fig 7. MSC Aliveness Test after Delivery [PAN]

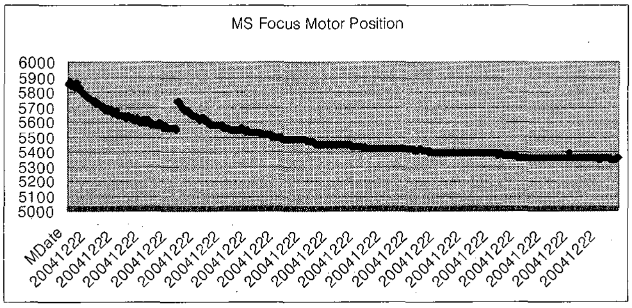

Fig 8. MSC Aliveness Test after Delivery [MS]

The position data in the fig 9 and fig 10 were collected after MSC was installed on the satellite bus. It can be found that there are big displacements compared to the previous figure. It might be caused by the installation activities. At the end of these figures, big displacements are observed. The satellite was moved to the EMC chamber for EMI/EMC test during that period.

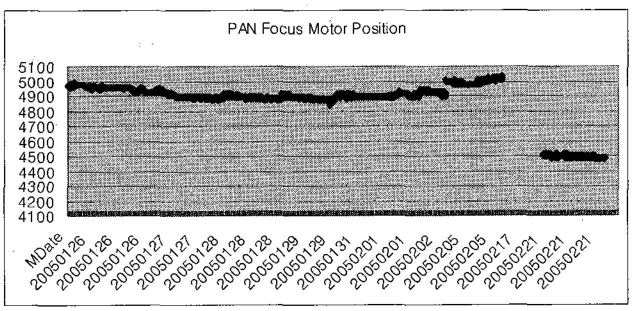

Fig 9. Before & After EMC Test at Satellite Level [PAN]

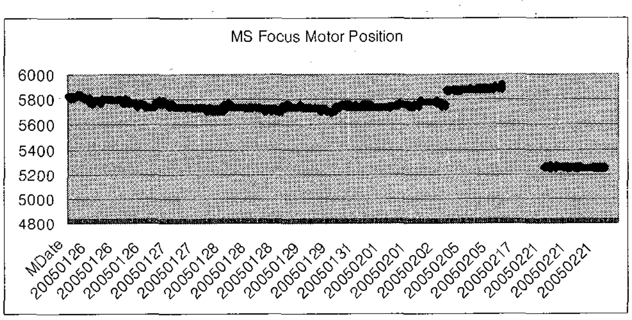

Fig 10. Before & After EMC Test at Satellite Level [MS]

The position data in the fig 11 and fig 12 were collected from the IST (Integrated System Test). During that period, the functional test of the satellite has been performed. The focus motor positions are gradually changed toward the direction of the original position in the figure though the focus motors never commanded to move throughout the test period in KARI.

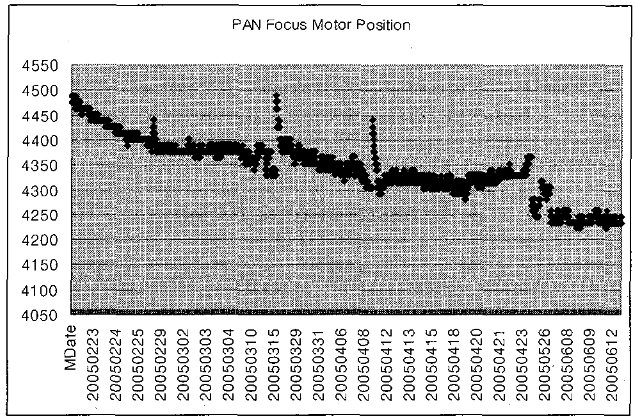

Fig 11. MSC Test at Satellite Level [PAN]

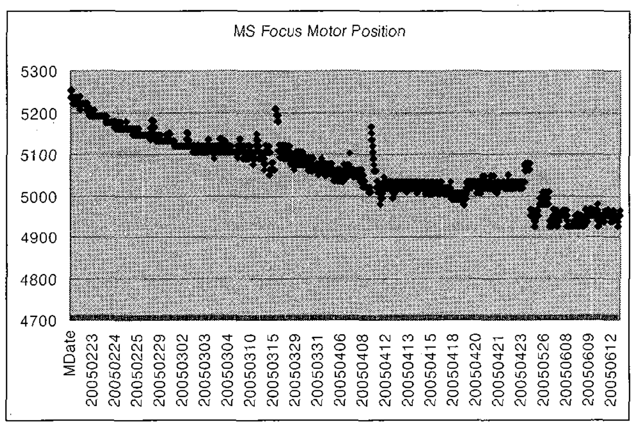

Fig 12. MSC Test at Satellite Level [MS]

The data in the fig 13 and fig 14 were collected before, during and after spacecraft thermal vacuum test. The satellite was under the condition of vacuum from July 15, 2005 to August 5, 2006. The locations of both focus motors were remained constant with different values collected in ambient environment.

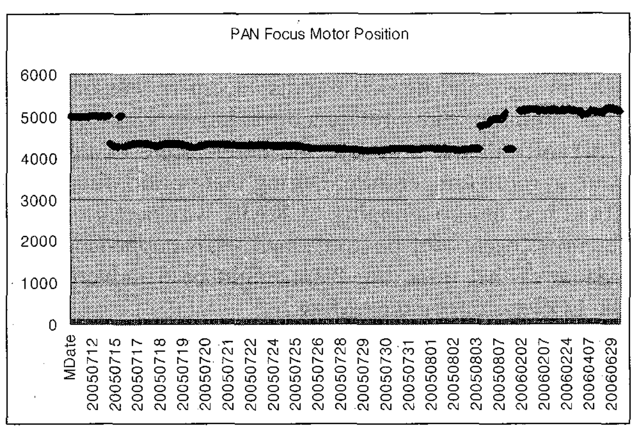

Fig 13. Satellite T/V Test & Launch Site Test [PAN]

After returning to ambient pressure without changing any mechanical configuration of the satellite, post T/V IST had been performed. The measured focus motor position values from that test showed much different values from that of T/V test. The measured values were slightly influenced by the temperature cycles during the thermal vacuum test. But, the variations were not significant in a big scale.

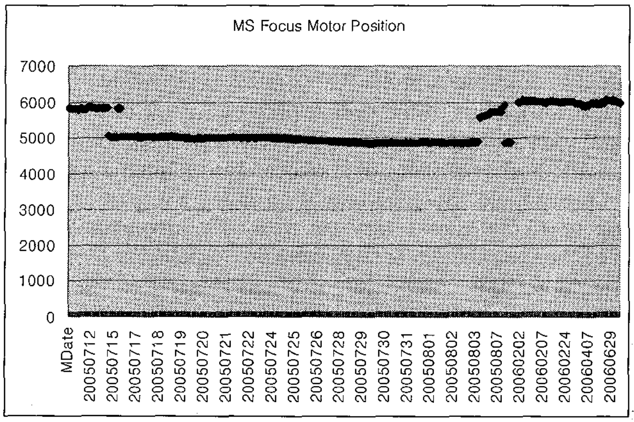

Fig 14. Satellite T/V Test & Launch Site Test [MS]

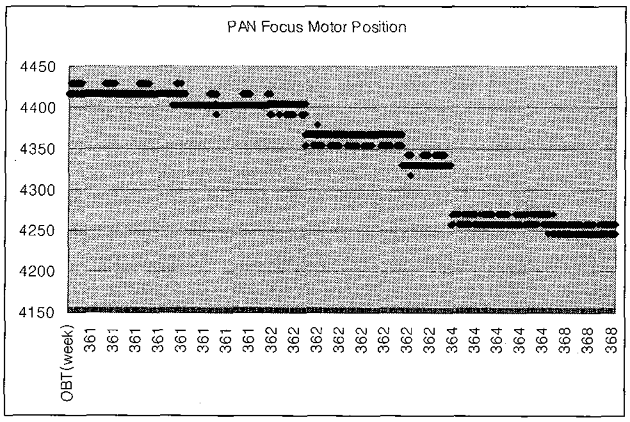

Fig 15. After Launch [PAN]

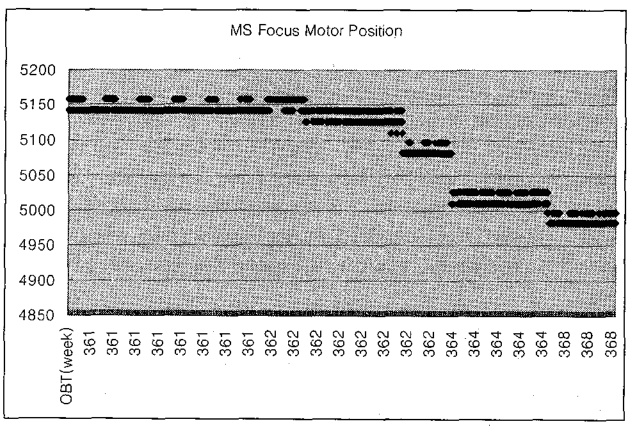

Fig 16. After Launch [MS]

KOMPSAT-II satellite has been launched successfully on July 28, 2006. The measured focus motor positions after launch were shown in fig 15 and fig 16. X-axis in these figure shows the absolute time in week (one digit is one week). There are position displacement between the end of the fig 13 and fig 15. And the same is also true for fig 14 and fig 16. The last values in the fig 13 and fig 14 were collected for the launch campaign period. The positions might be changed during the satellite launch phase. As we can understand from the fig 15 and fig 16, the measured values are changing gradually.

4. Summary of the Measurement Results

In the previous chapter, the measured focus motor positions from the MSC level test phase to the satellite launch campaign phase, even from on-orbit operation are depicted graphically. The values simply show that there were some position displacements several times during entire AIT (Assembly, Integration & Test) phase.

If we match the trend of the measured values with actual AIT activities, the reason of the changes can be understood. Because the measurement errors can be caused by the changes of the reference voltage, when we analyze the measured data, in the first stage, the trend of the reference voltage were checked. The measured values which were collected while the reference voltage was deviated from the nominal value were not used for the trend analysis.

Judging only from the measured data, the focus motor position changes were caused mainly by the change of the satellite (including MSC) mechanical configuration and by the vacuum environment. The first reason means that there was actual movement and the second reason means that there was no actual movement but only the changes of the resistance in the potentiometer. In the vacuum condition, the humidity on the potentiometer will definitely be changed. The change of the humidity on it can change the resistance which results in the changes of the measured position, even though it is very hard to quantify all these phenomena. Another thing we can get from the results is that the change caused by the mechanical reasons was being recovered by itself as time went on. And the same phenomenon is also observed on the measured position data after launch.

Very much important thing we should not miss from these results is that the final position after launch is very much similar with the values from the thermal vacuum test at both MSC level and satellite level.

5. Conclusion

Judging from the measurement results of the focus motor positions for a long time period, current positions and trends in-orbit are not deviated much from the best focus position adjusted on ground. Focus calibration during the LEOP can be performed based on these results.

References

[1] MSC THTM SRS (Software Requirement Spec.)
[2] K2-D1-760-017, K2 Test Report for FM T/V IST