The Design of MSC(Multi-Spectral Camera) Calibration Operation

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Abstract— Multi-Spectral Camera(MSC) is a payload on the KOMPSAT-2 satellite to perform the earth remote sensing. The instrument images the earth using a push-broom motion with a swath width of 15 km and a ground sample distance (GSD) of 1 m over the entire field of view (FOV) at altitude 685 Km. The instrument is designed to have an on-orbit operation duty cycle of 20% over the mission lifetime of 3 years with the functions of programmable gain/ offset and on-board image data compression/storage.
MSC instrument has one(1) channel for panchromatic imaging and four(4) channel for multi-spectral imaging covering the spectral range from 450nm to 900nm using TDI CCD Focal Plane Array (FPA).
In this paper, the configuration, the interface of MSC hardware and the MSC operation concept are described. And the method of the MSC calibration are described and the design of MSC calibration operation to measure the change of MSC after Launch & Early Operation(LEOP) and normal mission operations are discussed and analyzed.
Keyword : *MSC, TDI, Operation, Calibration, KOMPSAT-2*

I. Introduction

KOMPSAT-2 is being developed to continue the earth observation after KOMPSAT-1. MSC on KOMPSAT-2 has the improved capability compared to 6.6m GSD of EOC(Electro-Optic Camera) on KOMPSAT-1. The main mission objectives of KOMPSAT-2 are to provide information for surveillance of large scale disasters and its countermeasure, acquisition of high resolution images for GIS (Geo-graphic Information Systems), composition of printed maps and digitized maps for the territories, balanced development of Korean territories, and survey of natural resources. MSC is a main payload on KOMPSAT-2 to comply with the mission requirements and images the earth using a push-broom motion with a swath width of 15 km.

MSC has one panchromatic band of 1m GSD and four multi-spectral bands of 4m GSD covering the spectral range from 450nm to 900nm using TDI CCD FPA. The MSC is designed to have an on-orbit operation duty cycle of 20% over the mission lifetime of 3 years.

MSC will be assembled, tested and calibrated in instrument level first, and then integrated with spacecraft bus, tested as a satellite level and launched. During the LEOP, KOMPSAT-2 will be checked and validated. After that, calibration operation of MSC will periodically conducted to allow inter-comparison of data on time scales exceeding that of an individual satellite and data exchange between similar spacecraft instruments.

In this paper, the configuration, the interface of MSC hardware and the MSC operation concept based on the mission requirements are described. And the method of the MSC calibration are described and the design of MSC calibration operation to measure the change of MSC after Launch & Early Operation(LEOP) and normal mission operations are discussed and analyzed.

II. General Description and Requirements

The MSC is specified to meet the performance requirements as shown in Table 1 and also has the functions of programmable gain and offset, and on-board compression and storage and the dark and white calibration by on-board calibration source. The acquired image data is formatted and transmitted to Ground station through X band as 320Mbps downlink rate.

Other requirements reflected to MSC design from spacecraft system are automatic normal operation capability, stereo imaging capability by spacecraft tilting.

Table 1. The performance of MSC PAN and MS bands

MSC Band	PAN	MS1	MS2	MS3	MS4
GSD (m)	1	4	4	4	4
Spectral Range(nm)	500 – 900	450– 520	520– 600	630– 690	760– 900
SNR	≥ 100	≥100	≥100	≥100	≥100

The MSC physically consists of EOS, PDTS, PMU and interconnection harness. The EOS comprises optical module including optical components and optical structure, panchromatic FPA, multi-spectral FPA and two CEUs. And the PDTS consists of DCSU(Data Compression Storage Unit), DLS(Data Link System) including CCU(Channel Coding Unit) and QTX(QPSK Transmitter), and APS(Antenna Pointing System).

III. MSC Electronics Design

The electronic parts of MSC consist of two CEU in EOS, CEU-PAN and CEU-MS, PMU which manages all MSC including PSM(Power Supply Module) for the distribution of power, and PDTS for compression, encryption, formatting and transmission of image data.

No single point failure, cold or hot redundancy, cross strap design(power control line, image data line and general communication line) and using of space qualified components are considered as reliability requirement for MSC electronics design. EMI(Electromagnetic Interfe-rence)/RFI(Radio Frequency Interference) design in accordance with EV(Environment) requirements, mini-mum weight and optimum power consumption and function of BIT(Built-In Test) are also considered as other design requirements.

A. The Configuration of MSC Electronics

The MSC front end is the CEU that is built of two independent units. The CEU-PAN and CEU-MS is based on a high-resolution panchromatic detector array and multi-spectral detector array that converts the same input light spectrum into a digital image data. The image data are sent to DCSU for compression and storage using still image compression algorithms and sufficient storage control mechanism. Compressed/uncompressed data is encrypted in CCU before CCSDS encoding. The en-coded data is translated into the RF signals that are sent through the antenna to Ground station.

B. MSC Electrical Interface

MSC electrical interface consists of external interface with spacecraft Bus and internal interface with MSC subsystems and units.

The MSC external electrical interfaces are power interface, analog and digital command/telemetry for general control and discrete interface with S/C Bus. Spacecraft supply unregulated 28V power to PMU with latching relay on/off commands under the protection of fuse, and PMU report the status of each relay as well as power returns. MSC is communicated with spacecraft for general control through 1553B bus and discrete commands, such as reset, safe-hold and PMU active and accurate 1Hz time mark signal are sent to MSC. The antenna pyro mechanism status, PMU status, and temperature are transmitted through discrete and analog telemetry interface and other interface is OBC data interface for X band transmission of playback data.

The MSC internal interfaces are digital command/ telemetry interface, high-level pulse command interface, analog telemetry interface and image data interface. RS-422 interface is selected for internal digital communication.

The design of interfaces configuration and the selection of interfaces type and related components are selected based on KOMPSAT-1 heritage and analysis results of required speed and concept of cross-strap so on.

MSC software interface with S/C OBC(On-Board Computer), command and telemetry is decided based on heritage with modification for optimum operation. MSC commands are divided to two(2) types of command. The first type are mission commands that are intended to be performed based on a defined schedule and the second type are the immediate commands for immediate or scheduled execution once the command had been received by MSC. The purpose of MSC Telemetry is to support the KGS in operating and monitoring the MSC as well as AIT activities, MSC SOH monitoring activities, uplink verification(com-mand link), the failure diagnostics in case of malfunction or performance degradation. The format of the S/C telemetry uses Minor frame transmitted each second, over a cycle of 32 seconds (major frame) and MSC telemetry consists of two(2) types, channel 1 and channel 2 telemetry.

IV. MSC Operation Design

A. MSC Operation Concept

The MSC images the earth using a push-broom motion with a swath width of 15 km and a ground sample distance of 1 m over the entire field of view at Nadir and is designed to have an on-orbit operation duty cycle of 20%.

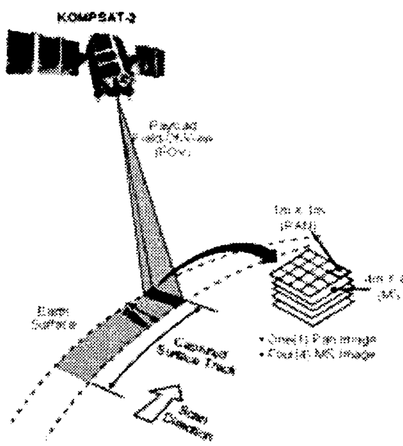

Fig. 1. MSC operation concept

In a standpoint of operation, MSC has a capability of automatic normal operation and stereo imaging capability by spacecraft tilting, that is, the compatibility of spacecraft roll tilting of ± 56 degrees and pitch tilting of ± 30 degrees. In order to meet these requirements, MSC mission commands will be stored with execution time in PMU prior to actual operation. And MSC can also change line rate from 7100 to 2200 lines per second to reduce the degradation of image quality due to mismatching incurred by change of satellite ground velocity, and satellite roll and pitch tilting.

As above example, MSC have several parameters for mission control, such as line rate, gain & offset, number of sector for recording, compression ratio, Huffman & quantization table, encryption key and so on. These parameters setting is very important to achieve good quality image data from MSC and they should be selected and commanded taking into account operation environment, situation and hardware status.

B. MSC Operation mode and mission

MSC operates in a set of operational modes and the defined MSC modes are the below.

- MSC OFF Mode
- MSC SURVIVAL Mode
- MSC Init Mode
- MSC IDLE Mode
- MSC STANDBY Mode

• MSC Mission Execution Mode
• MSC SHUT DOWN Mode

During the operation the system transits between the operational modes by a set of conditions is defined for each transition between modes. The diagram of MSC mode transfer is shown in Fig. 2.

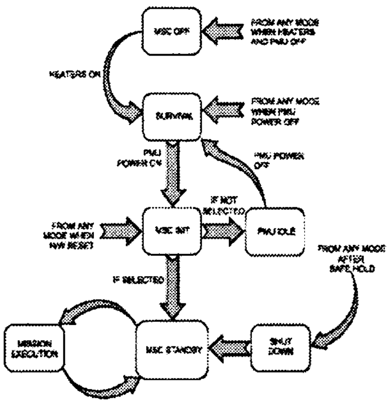

Fig. 2. The MSC mode transition

In normal MSC mission will be automatically operated by the mission script ordered by planed and stored mission commands as well as real-time which is a set of activities coordinated to achieve a define goal. Each mission will be initiated by the commanded start time and the sequence of immediate commands in each mission scripts will be executed in defined delta-time. Time of mission start shall be an absolute time based upon On Board Time (OBT) and no simultaneous mission execution is allowed.

MSC mission is the followings and each mission will be defined by mission script which is the combination of immediate commands with delta-time.

• DCSU Initialization
• Antenna deployment
• Direct Imaging
• Recorded Imaging
• Record & Playback Imaging
• Playback
• OBC Data Recording
• Calibration
• Service

As a matter of fact, the defined MSC missions will be implemented in MSC software and the delta-time in mission script should be obtained by real measurements through test of each unit and integrated MSC system

The design concept of MSC system operation is simple and easy for the operator in KGS and the design of MSC mission operation will be implemented in MSC software as mission commands and mission scripts. The operator will easily and accurately operate MSC on KOMPSAT-2 as designed.

C. MSC calibration mission

MSC has a three different calibration missions, radiometric, NUC(Non Uniformity Correction) and geometric calibration mission in order to meet experiment objectives such as: a) produce a data set of value to long-term monitoring programs and allow intercomparisons of data on time scales exceeding that of an individual satellite, and b) provide data synergism and allow data exchange between spacecraft instruments. Radiometric calibration is intended to gather response of the Electro-Optical detectors illuminated by the internal calibration lamp in order to find changes of the optical characteristics including detector. Non Uniformity calibration is intended to gather data regarding the correction of Non-Uniformity as done in the NUC module. Focus calibration is used to gather imaging data for various focus motor positions of the PAN or the MS cameras in order to evaluate the best focus position for best image data against space environments.

While the calibration operation is conducted, MSC will specially be controlled with no compression, lower line-rate and so on. In addition, the selection of location is one of importance for each calibration operation and it should be studied and prepared earlier and spacecraft operation should also be prepared to support the MSC calibration operation as well.

V. Conclusions

KOMPSAT-2 is being developed to continue the earth observation after KOMPSAT-1 and has improved capability by MSC which has higher GSD of 1m resolution than EOC on KOMPSAT-1. The MSC images the earth using a push-broom motion with a swath width of 15 km and a ground sample distance of 1 m over the entire field of view and is designed to have an in-orbit operation duty cycle of 20% over the mission lifetime of 3 years.

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REFERENCES

[1] C. B. Pease, 1991. *Satellite Imaging Instruments Principles, Technologies and operational systems*, Farnborough(UK) : Ellis Horwood Ltd.

[2] S.S.Yong and H.P.Heo, 2000. *The electrical design of MSC(Multi-Spectral Camera)*, Proceedings of International Symposium on Remote Sensing 2000, 148-152.

[3] S.S.Yong, H.Y.Paik and et al., 2001. The Analysis of MSC(Multi-Spectral Camera) Operational Parameter, Proceedings of International Symposium on Remote Sensing 2001, 198-203.

[4] S.S.Yong, G.S.Kang and et al., 2004. The Analysis of MSC(Multi-Spectral Camera) System Operation, Proceedings of International Symposium on IEEE Geo-science And Remote Sensing 2004.