Payload Management Unit design of MSC (Multi-Spectral Camera)

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Abstract: MSC(Multi-Spectral Camera) which is a unique payload for KOMPSAT-2, comprises main three subsystems of PMU(Paylaod Management Unit), EOS(Electro-Optical Subsystem) and PDTS(Payload Data Transmission Subsystem). The PMU, as a main controller of MSC, performs major tasks such as interfacing with S/C(Space Craft), controlling the MSC operation, distributing and controlling of operating power to all MSC including thermal unit, etc. In this paper the H/W configurations as well as the functions of PMU are introduced and possible changes for the future development are suggested.
Keywords: MSC, PMU, NUC, SBC, PSM

1. Introduction

PMU is a main controller for the management and power supply of the MSC Payload operation. The PMU shall handle the communication with the OBC in S/C for commands and telemetry data and communicate with the various MSC units using UART or discrete signals as well. In addition to these electrical interfaces of the PMU to MSC subsystems and to the S/C, PMU interface compatibility includes software interfaces of the PMU to MSC subsystems and to the S/C and mechanical and thermal interface of the PMU assembly to the S/C. The PMU consists of several sub-modules with an architecture that supports full redundant concept which is important for space applications. This paper describes mainly the H/W configuration and the functional capabilities of the PMU as it is designed for MSC.

2. Functional Capabilities

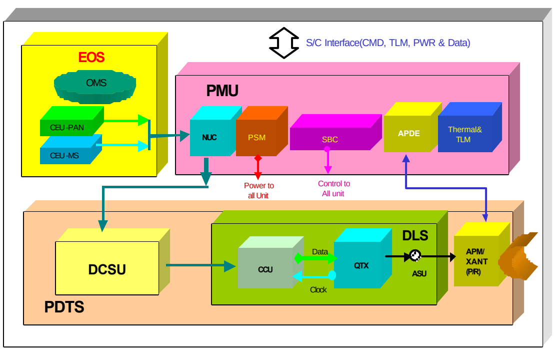

Fig. 1. MSC Block Diagram.

The MSC payload consists of EOS, PMU, PDTS and interconnection harness as shown in Figure 1. The EOS consisting of OM(Optical Module) and CEU(Camera Electronic Unit) is to obtain data of high resolution images by converting incoming light into digital stream of pixel data. The PDTS, which comprises of DCSU(Data Compression & Storage Unit), CCU(Channel Coding Unit), QTX(QPSK Transmitter), APM(Antenna Pointing Mechanism) and Antenna, stores and transmits digital image data coming from EOS to the ground station through X band antenna.

The functional capabilities of the PMU can be described by external interfaces and operational tasks. In terms of interface between OBC(On Board computer) and PMU, the S/C OBC controls and monitors the PMU through 1553B communication and discrete signal interface. The OBC controls the power supply to the primary and redundant PMU, controls which PMU should be the active one and resets by discrete signal the entire MSC system or shutdown the entire system in case of S/C electrical emergency. It communicates via RS422 interface not only with internal module like THTM(Thermal and TeleMetry), NUC(Non-Uniformity Correction), APDE (Antenna Positioning Driving Electronics) and CC(Camera Controller) but also with DCSU, CCU for commanding and gathering telemetry information. One of main tasks of the PMU is to initialize itself and its environment and to handle 1553B communication message in order to execute mission coming through it. It has, therefore, two main modes of initialization and operation, which support and enable successful completion of a mission. During initialization, PMU has to check whether it is assigned as active one by OBC, check one flag to see if there is a request for program patch and perform powered on process, etc. In operational mode PMU, first of all, has to maintain OBT time correctly and has to listen to OBC for commands and data in order to execute arriving commands from OBC. It also has to gather telemetry data and send it to the OBC while monitoring ranges of specific telemetry data value to take the relevant actions if necessary. And it shall update the ancillary data every second upon reception of data from OBC and additional telemetry data from internal units. It also shall perform shut down procedure when emergent situation happens and also one discrete signal from OBC is issued to indicate it. It also attaches ancillary and header data to image data, which is required for retrieving images after receiving them on ground station and performs non-uniformity correction to improve image quality which might be affected during compression in DCSU.

3. PMU H/W Design

PMU H/W consists of 7 kinds of function boards; one backplane, two PSMs, one THTM, two SBCs, one APDE and two NUCs. All function boards are implemented under primary and redundant concept and, by this, protected form single-failure error. Therefore, each one board functions as primary or redundancy in the case of PSM, SBC, and NUC, while both THTM and APDE have two identical functions within a single board. One backplane serves as mother-board to which all the PMU function-boards are connected. The active SBC and THTM operate at 100%-duty cycle and APDE and NUC at 20%-duty cycle per orbit. Below are detain design descriptions for each board.

1) Backplane & PSM

The PSS(power supply system) in the MSC consists of 3 different components of two power supply boards (PSM1, PSM2) and one backplane. It comprises a power interface between the S/C and the MSC loads as shown in the figure 2. The S/C interface at the left consists of eight 28V power lines and 24 control lines. The power lines are divided up into 4 pairs, V1 through V4. The power supply of MSC allocates each of the input lines to the MSC loads shown at the right. Each power line has over-current protection with fuses. The PSS input lines shall be DC isolated by not less than 1 Mohm from the MSC chassis, signal return and secondary power return.
For the purpose of power supply system two operating modes, Normal and Survival , exist. During Normal mode the MSC is fully operational and for each input channel only one of the input circuit(Primary or Redundant) shall be operating. During Survival mode, input channel V1, V2, V3 shall be inoperational and channel V4 shall have both its circuit operational.

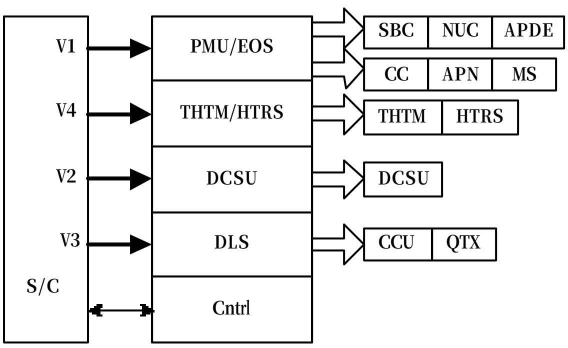

Fig. 2 Power Supply Interface

2) SBC(Single Board Computer)

As a main controller inside PMU SBC consists of 486-CPU, 1-Mbyte Flash ROM, 2-Mbyte SRAM, 1553B module, RS422 module, discrete and LVDS module. Most of its main functions are implemented in 3 FPGAs. One FPGA is used for PIC(Programmable Interrupt Controller) and control logics handling with interfaces between CPU and other modules, and two other FPGAs are mostly for RS422. The PIC is capable of receiving eight input interrupt signal including 10ms timer tick that is generated from programmable counter inside FPGA. It interfaces with S/C via 1553B communication and discrete signals to receive commands and to send telemetry information form/to ground station and communicates with sub-modules such as CEU, NUC, THTM, APDE, DCSU, CCU through RS422. The SBC receives 4 discrete input signals-TIMEMARK, RESET, SAFEHOLD, PMUACTIVE- from S/C which are all implemented in a cross-strap configuration. PMUACTIVE determines which SBC between primary and redundant should be active. RESET is used for reseting of SBC and SAFEHOLD for performing shutdown in case of emergency. The TIMEMARK signal, that is a 1 Hz pulse from S/C's GPS unit, is used to synchronize between S/C and PMU time. SBC sends 1 discrete signal named ACTIVESTATUS as well to inform which SBC is active to S/C. For imaging in NUC the SBC sends discrete LVDS signals to NUC as well as relevant parameters via RS422.

3) THTM(THermal & TeleMetry)

The THTM is mainly used to control and monitor the temperatures of the EOS(Electro Optic Sub-System) and switch on or off the power of MSC subunits according to the command from SBC. It also gathers all analog telemetry data from all MSC units for sending later to the ground station and sends PYRO ignition pulse which is amplified by BACKPLANE drivers. In addition to these, the board shall activate the focus motors and calibration lamp when required. A THTM board contains two same function blocks of primary and redundant to support cold and hot redundant design concept while sharing interface connectors and interface logic for telemetry. At power up the two same function blocks are activated together. In the initialization process the SBC try to communicate with one of them. After receiving acknowledge from primary THTM or redundant one the corresponding discrete signals should be set accordingly to activate responding THTM and to disable the other one.
The THTM has 3 operational modes and can be only in one mode at any given time. Whenever the THTM is powered up or resets, it enters to INIT mode, then does all necessary steps like H/W and S/W initialization and power-up BIT in order to be prepared to start normal operation. In NORMAL mode, THTM performs all the periodic tasks and stays in this mode until it is turned off by the SBC. THTM goes into IDLE mode when it has a critical failure and the software behavior is unpredictable

just to wait for turn-off command with minimum code running. And THTM has two modes in terms of heater operation. In NORMAL mode as an usual case, it uses thermistor value to decide whether to turn on or off heater, therefore heater operation is based on the average resistance of several thermistor each control zone with high and low limits of resistance. In case all thrmistors in specific zone are failed, it goes into BACKUP mode where the heater operation is based on a duty-cycle operating with definition of on/off time. This operation is supported by hardware timer. Other than these two modes for heater operation, OUTGASSING mode exists as a special and system operating mode. Its purpose is to clean the mirror and not to keep the mirror in proper temperature. THTM enters this mode by command from SBC and implements this mode by changing the mirror's thermal control set points to out gassing values.

4) NUC(Non-Uniformity Correction module)

Non Uniformity Correction module is a high throughput image processing unit that performs several tasks such as correcting non-uniformities in pixels of 8-video channels by gain and offset values stored in SRAM, rearranging pixels especially from the MS channel, combining video data with uploaded headers, and receiving and adding ancillary data to imagery head data. It receives video data from FPE boards via HOTLink communication and performs corrections upon the pixels according to commands and relevant tables received from the SBC. 5 FPGAs are implemented inside NUC board in order to handle a total of 8 different video data channels, 6 for PAN and 2 for MS channels. Three FPGAs are for PAN-channel with each dedicated to the processing of two video channels and two FPGAs are for MS-channel with each dedicated to one video channel. Among three PAN-channel FPGA, one ,what is called Master, has additional functions compared to other FPGAs in order to coordinate the entire operation of all FPGAs inside NUC. It is in charge of generating reset signals and synchronization signals for both PAN and MS element by receiving and processing the input signals of 1pps time-mark, reset and a signal that signifies when imaging is commenced from SBC. The video data that is processed by the NUC are transmitted to the DCSU for further data processing

5) APDE(Antenna Positioning Drive Electronics)

The APDE is an electronic device that serves as electronics interface between the APM and SBC. In order for the APDE to receive motor command from the SBC and return APM sensor data of gimbal angular position through resolver sensor, the SBC shall be connected to the APDE board via RS422 compatible interface. The APDE shall have two fully identical circuits, called Primary and Redundant channels respectively, corresponding to the appropriate APM. Each channel consists of four functional blocks of Motor Driver block, Antenna Resolver interface block, Motor Resolver interface block and Control block. The Driver block controls the motor by the PWM command and the built-in motor resolver is used to get the information of Rotor position to commutate the current in the motor winding. APDE is designed to operate at normal or cross-strap configuration. In the normal configuration only one APDE channel is active to which input operational voltage supply. The active channel shall interface with corresponding APM to measure the gimbal's angular position through resolver sensor and drive the APM motor. In the cross-strap configuration both APDE channels are powered-on. One channel, that is fully powered-on, is called to be in Master mode while the other partially powered-on in on Default.

4. Conclusions

As a main controller of a unique payload of KOMPSAT2 the PMU was described as regards H/W configuration, the functions of each module as well as its functional capabilities such as communication, data handling. It provides primary and redundant design concept which is important for space program to avoid single failure error. And in a current H/W configuration MSC can be divided into three categories in terms of its functionality. One is to generate image data based on the light it receives. The other one is to process those data by which data can be compressed or encrypted or packetized through error correction coding. The last one is to manage or control the whole system including antenna control loop for better transmission budget. Here, two things can be discussed according to these partitioning for next possible changes in PMU design. As first, NUC board inside PMU might be recommended to move into CEU for better modular design concept in which whole image-data relevant modules are packed into one unit. This design can provide whole system with better connectivity for image data reducing the number of heavy cables and with easy testability because then we can perform test for image data with just CEU without PMU in which NUC is resident in a current design. As second thing, APDE also might be moved into APS in favor of another modular design concept where APS becomes a complete antenna positioning system while it currently needs APDE outside to get PWM signals to operate. This design might also provide better testability and reduce the number of cable in a whole system. In that case, we can test APS easily through a simple computer with RS422 communication and with S/W module that runs antenna control loop.

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