KOMPSAT-2 MSC DCSU Operational Concept

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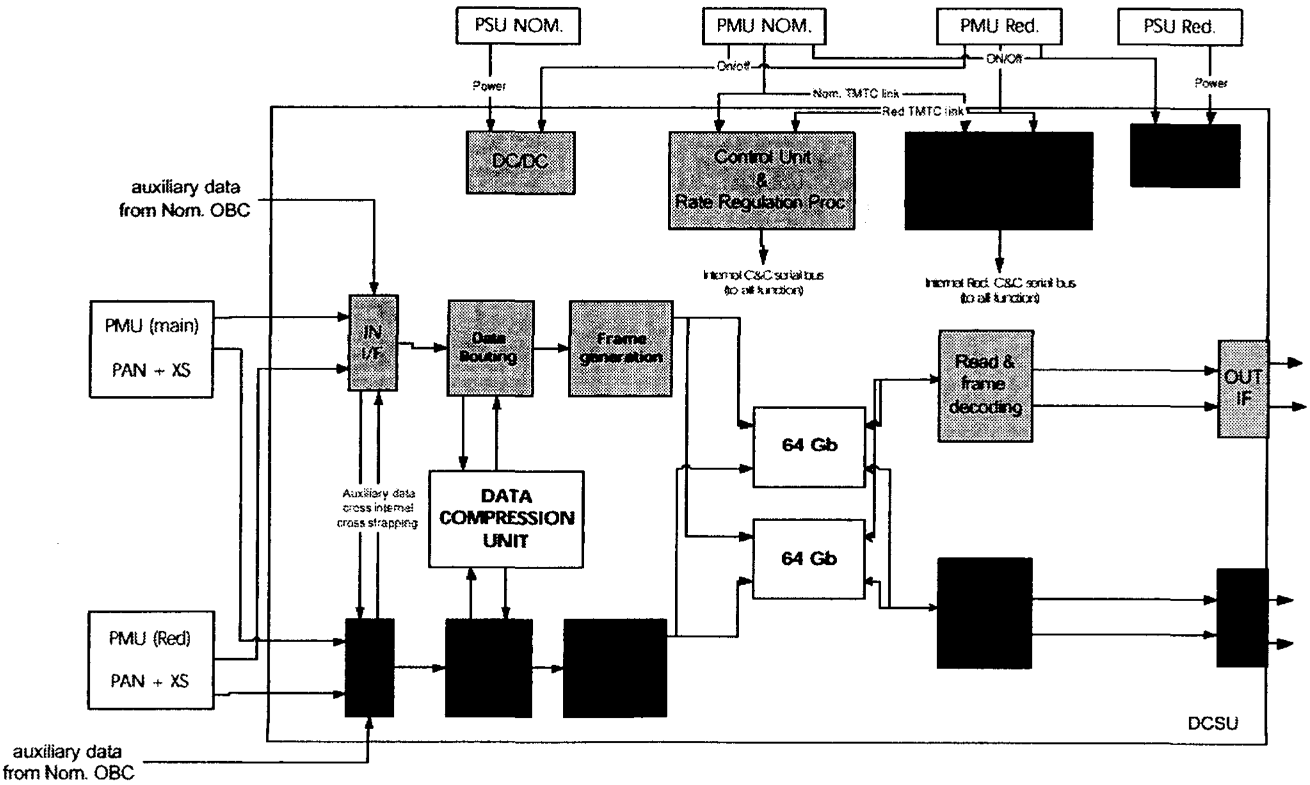
Abstract

The KOMPSAT-2 DCSU(the data compression & storage unit) performs the acquisition of image data from cameras, the compression with requested compression rate, the storage with specified file ID on the mission command and the distribution to the assigned DLS(Data Link System) channels per the mission and operation requirements. The worldwide observation using the MSC is able to be achieved by this DCSU's behavior. This paper presents the features of KOMPSAT-2 DCSU and provides proper ground operation concept after launch.

1. Introduction

The DCSU provides real-time compression, data recording, storage and playback capabilities in KOMPSAT-2 MSC payload system.

The data can be stored until the spacecraft is within communication range to down-link. The data compression is required in order to enable the real-time transmission of image data to the ground station due to the limited bandwidth of the space to ground data-link. The data compression is also used to reduce the storage space for imagery data and the time for transmission of imagery data to the ground station.



Several DCSU requirements are below here.

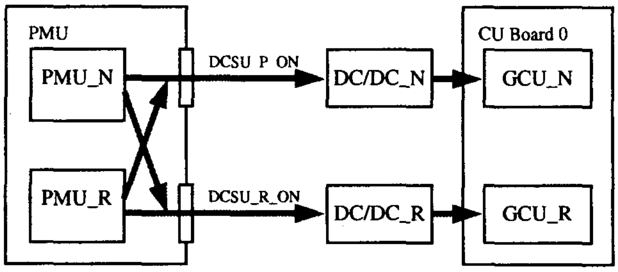
- Duty Cycle: 20 % of the nominal orbital period (Data compression and read/write maximum continuous operational duty cycle). DCSU power-on and data retention duty cycle shall be 100 % of the nominal orbital period.
- Operational Life Time: At least 3 years on orbit.
- Storage Life Time: Minimum 4 years after qualification and acceptance testing when stored with storage conditions.
- Reliability: At least 0.97 over an orbital life time.
- Fault Tolerance and Redundancy: No single failure shall cause serious performance degradation.
- Storage BER Performance: less than or equal to 1.10^{-10} per day.

2. DCSU Features & Ground Control

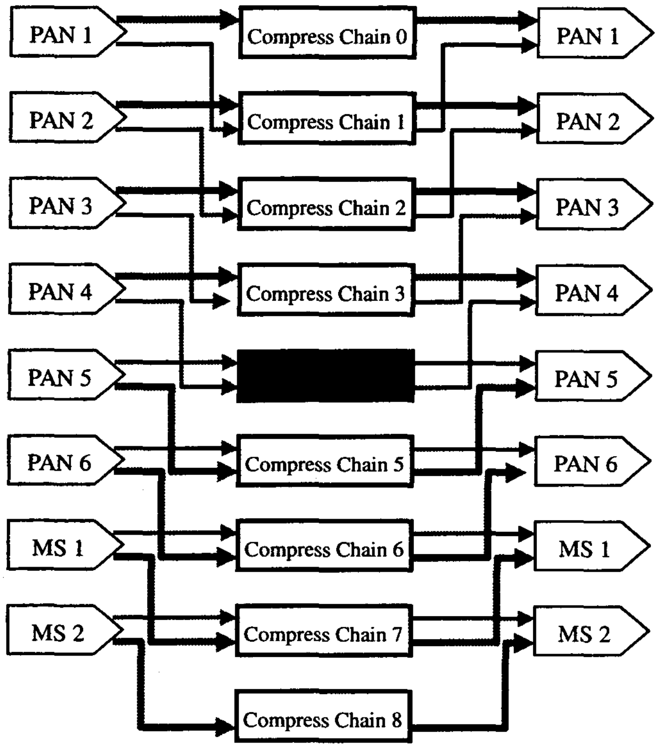
2.1. Redundancy Control

The DCSU consists of 2 control unit boards, 2 DC/DC converter boards, 2 interface boards, 3 compression chain boards and 2 memory boards.

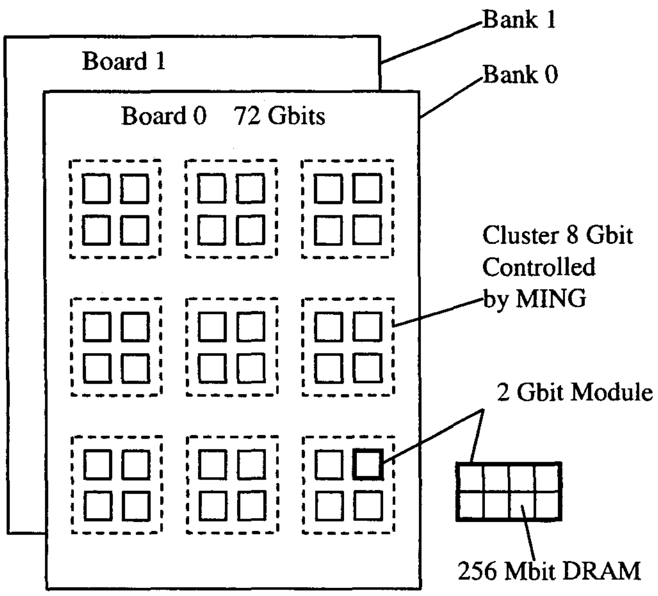
Control unit has GCU (Global Control Unit) board which runs DCSU management software and CCU (Compression Control Unit) which runs compression and rate control algorithm. Each CU board has their nominal and redundant units. Redundancy control of CU and DC/DC boards is done by "DCSU_ON" HLC(High Level Command) from PMU. This HLC line is cross-strapped inside of the PMU. The Redundant PMU can turn on/off the DCSU through nominal HLC interface line. If nominal DC/DC converter is turn-on then automatically nominal GCU gets powered on and start boot sequence. The interface among the PMU, the DCSU DC/DC converter and DCSU GCU is represented in the figure below.



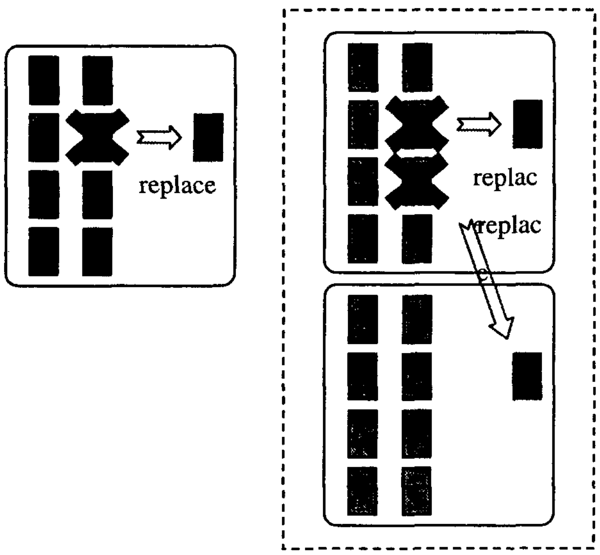
The DCSU is based on 9 compression chains to perform compression. Among 9 compression chains only 8 chains work in parallel. Those 8 chains are supposed to compress the incoming video data stream from one of the 6 PAN or the 2 MS detectors. The 9th chain can replace any of the 8 previous chain by using redundant in/out interface as below scheme.



The DCSU has total 144 Gbits storage capability including redundant memory. The cluster is the entity that can be reconfigured in the memory plan by the ground station. It is build with one control ASIC and 8 Gbits of memory, organized in four 3D module of 256 Mbits SDRAM. In normal operation only 8 clusters are working in parallel and one cluster is reserved for redundancy cluster.



If there is a faulty cluster in a board, it's easily replaced with redundant cluster by "TC_CONF_MEM" command. If there is two faulty clusters in a board and no invalid cluster in the other board, one invalid cluster can be replaced with a redundant cluster on the other board. In the case of more than two clusters are invalid in a board, the board is no longer available.



2.2. Built-In Test Execution

The DCSU performs 3 types of self-test.

- Self-test of the control function
- Self-test of internal control and monitoring communication
- Self-test of memory stack

The self-test of the control function will be performed during initialization phase of each DCSU control board in the frame of DCSU software activation. The self-test of internal control and monitoring communication will be performed by the DCSU upon request of the PMU.

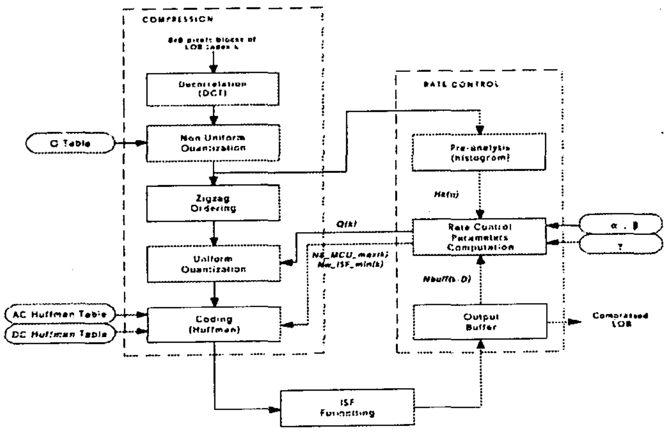
5 different types of user command BIT executable in SELF-TEST mode are:

- Compression function monitoring and control bus self-test
- Routing function monitoring and control bus self-test
- Storage function monitoring and control bus self-test
- Memory cluster short test
- Memory clusters long test

Compress function monitoring and control bus self-test is for testing DPCA and verifying that the CCU is able to communicate with each DPCA ASIC. Routing function monitoring and control bus self-test is for testing INOU and verifying that the GCU is able to communicate with each INOU ASIC. Storage function monitoring and control bus self-test is for testing MING and verifying that the GCU is able to communicate with each MING ASIC. Memory clusters short/long test will allow to verify the storage capability of each cluster by activating all memory boards or one memory board and switching one MING ASIC to test mode.

When self-test sequence execution is completed, the DCSU will perform sector level memory reconfiguration. The DCSU updates the self-test result tables and return autonomously to STAND-BY mode. The Ground station can acquire the self-test results by sending as many TC_DUMP STC as the number of self-test result tables and perform memory reconfiguration at cluster level by using LD_CONF_MEM STC.

2.3. Compression Table Management



To perform compression the DCSU needs three parameters: Compress ratio, Huffman table, Quantization table. DCSU can store 64 compression ratios with Beta and K parameter related with compression rate control, 16 Huffman tables and 8 Quantization tables. Half of theses tables will be stored EEPROM before launch and load into CCU SRAM working memory while CCU is initializing. So it takes some time for CCU boot-up. The rest tables can be uploaded by ground station command and will be stored GCU SRAM memory. Whenever these uploaded parameters are used, GCU have to hand over these values to CCU through GCU/CCU internal serial bus.

Many compression parameters have fixed value to simplify the operation. In example there are THL and THH parameter in compression rate control algorithm which define the minimum and maximum threshold of compression output buffer level. If the generated compressed image data reach the maximum threshold then the DCSU will do stronger quantization to reduce output rate. The value of THH and THL are fixed with 90 and 10 percentage of output buffer size.

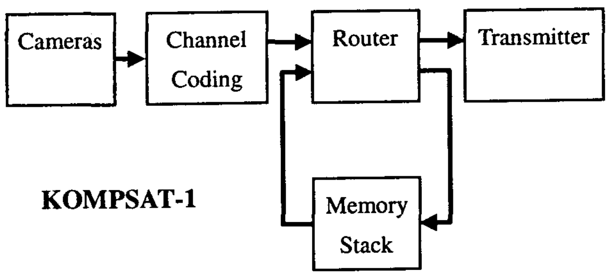
2.4. Elementary Operation List

An elementary operation is an operation, which can be requested by the operator in charge of mission execution. It can be:

-Store operation of one file
- Play-back operation of one file
- Quasi-direct acquisition of one file
- Store operation of OBCAUX data

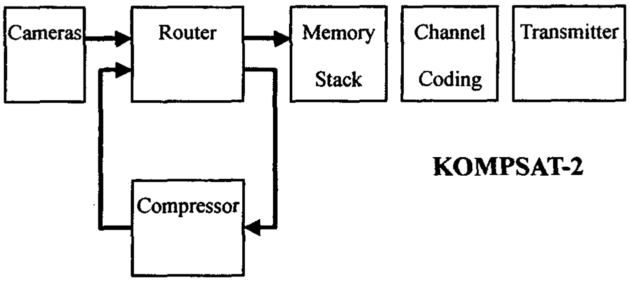
The DCSU has 6 different types of elementary operation list. Each list can store maximum 64 elementary operation. Using TC_RAZ STC, the ground operator can erase preloaded elementary operation list. All elementary operations in the elementary operation lists marked by TC_RAZ STC will be erased.

- Write with compression list
- Write without compression list
- Quasi-direct acquisition with compression list
- Quasi-direct acquisition without compression list
- Read operation list
- OBCAUX acquisition list



Due to output port to memory stack and to transmitter is separated in KOMPSAT-1, it's easy to perform real-time transmission and storage. All image data from cameras are first channel coded with CCSDS format and transmitted to transponder while same data is sending to memory stack.

In KOMPSAT-2 image data can be compressed or not. All uncompressed image data form cameras and compressed image data from compression chain are first stored in memory stack. In quasi-direct mode the DCSU uses the memory space as a circular buffer. After some interval from writing image data to circular buffer it can be read directly and transmitted to transponder. For the DCSU inner data processing minimum circular buffer size, 32 sectors, is required. After completion of quasi-direct operation, the circular buffer data can be erased by TC_ERASE STC or playbacked with the file ID later.



KOMPSAT-2

When the DCSU receives TC_EXEC STC from the PMU, it will check that it is correct STC and applicable in the current operational mode. If requested STC is quasi-direct or write operation, following operations will be occur:

- Search the first elementary operation included in the requested elementary operation list
- Check it's executable in current COMPRESSION or NO_COMPRESSION mode
- Verify that the storage capacity necessary to perform the requested operation is available.
- Verify the availability of the DCSY resources necessary for requested operation execution
  - Quasi-direct operation: If a write, a read, a quasi-direct or a TMHK operation is currently under execution, the quasi-direct operation will not be executed.
  - Write operation: If a write, a quasi-direct or a TMHK operation is currently under execution, the write operation will not be executed.
- If the check is correct, the DCSU will send to the PMU and ACK_STC STM indicating STC is accepted. If not, the DCSU will send to the PMU and ACK_STC STM indicating STC is rejected.
- If the STC is accepted, the DCSU will:
  - Create sector allocation table
  - Configure the internal DCSU components in order to execute the operation
  - Start the execution of requested operation
  - Stop the execution when requested data length is equal to acquired data length in number of sectors or TC_RESET STC is received
- When requested operation execution is completed, the DCSU will update DCSU mission execution report and will transmit the report upon reception of RP_REQUEST STC from the PMU

2.5. File System

The DCSU use 16 bits as a file ID and 12 bits as a folder ID. One file contains all the data coming from the same input video channel or auxiliary data from OBC. The minimum unit of read/write operation is a sector. A file always contains exactly same sector number as file sector size in GCU file catalog table. All recording, reading and erasing operation is initiated with the file name. The DCSU manages the files with file catalog that contains file ID, length, start sector location, CRC and etc. The DCSU has capacity to handle 65536 files but due to the memory size required to record that information and operational features, supports only 1024 files in current design.

Folder is a recorded data of an elementary write operation. 6 files for PAN channels, 2 files for MS channels and 1 file for OBCAUX file can be exist in a same folder. Folder ID is the MSB 12 bits of 16 bits file ID. Write operation is initiated with folder ID and the rest LSB 4 bits are generated by GCU automatically according to their origin source.

The video folders and the OBCAUX data files are resident in memory as long as the memory boards are powered-on. Only one folder can be read at a time over both outputs. The DCSU can playback the entire folder, a whole file or partial file.

The content of the read back folder is dispatched through both outputs I and Q according to a default configuration:

- Channel I = Pan 1, 3, 5, MS 1 and OBCAUX
- Channel Q = Pan 2, 4, 6 and MS 2

The DCSU allows the reading of a folder without an OBCAUX file, a type 2 anomaly will be risen just to inform operator the OBCAUX file is missing.

2.6. DCSU Mission Planning

To operate the DCSU properly following sequence must be under taken by the ground or by the PMU.

- DCSU Configuration
  - The redundancy control of the control units, routing boards, compression boards are available in STD-BY mode and RETENTION mode. Memory boards configuration is only available in STAND-BY mode.
  - All the compression parameters to be used must be selected and uploaded to the DCSU.
- Operation Mode Selection
  - If it is a imaging mission, first have to decide whether to use quasi-direct or not and whether to use compression or not.
- File Allocation Planing
  - Two files, which have the same file ID, can not exist on memory space at a same time. No read and erase operation performs without file ID. Only the dump operation of GCU file catalog table is the way to find out which files are stored in the DCSU. It's recommended that the ground station have a historical log.
  - The operation which requests more sector size than available sector size in the DCSU will be rejected. In spite of the good compression rate control algorithm, it's unable to predict exact number of sectors generated by the compression chain. If allocated sector size is smaller than acquired image data, the latest data will be lost in a write operation or the latest data will overwrite the earliest data in a quasi-direct operation. The camera line rate effects on calculating the file size.

Elementary Operation Loading into the elementary operation lists

- DCSU Operational Mode Transition
  - Change the current DCSU operational mode to COMPRESS mode or NO_COMPRESS mode. Read operations can be executed in both modes.
- Elementary Operation Execution

• When the DCSU receives TC_EXEC STC, the DCSU check the requested elementary operation and start execution.

- DCSU Retention Mode Transition
- Telemetry Verifying

• After complement of elementary operation, elementary operation report telemetry can be received by sending RP_XXX_OPS STC.

• Verify anomaly lists and dump GCU tables if it's needed.

3. Conclusion

The KOMPSAT-2 DCSU has many different features from the KOMPSAT-1 like compression, file management, and elementary operation list. These features make the DCSU complicate to configure the mission operations. In this paper, we described the features of the DCSU and recommended proper ground operational concepts.

4. Reference

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6) F. Cazaban, 2002, DCSU Compression Algorithm Specification, 02/-