The Implementation of Communication Unit for KOMPSAT-II

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Abstract: The Channel Coding Unit (CCU) is an integral component of Payload Data Transmission System (PDTS) for the Multi-Spectral Camera (MSC) data. The main function of the CCU is channel coding and encryption. CCU has two channels (I & Q) for data processing. The input of CCU is the output of DCSU (Data Compression & Storage Unit). The output of CCU is the input of QTX which modulate data for RF communication. In this paper, there are the overview, short H/W description and operation concept of CCU.

I. Introduction

The MSC overall project aims into the development, test and integration of a multi spectral camera as primary payload for the KOMPSAT-II satellite mission (≈700kg satellite class).

MSC itself comprises all elements to form a stand-alone payload. Beside the Optical Unit, the MSC performs the storage of the data and the data downlink by X-band. The MSC shall be integrated into the KOMPSAT-II

The KOMPSAT II satellite is located in a sun-synchronous low earth orbit (LEO). The main mission of the KOMPSAT II Satellite is to provide the follow Table.

Table 1. Mission of KOMPSAT-II

Resolution	PAN	1 m
	MS (4 Bands)	4 m
Swath	15 Km	
Data Rate(required)	Image	1.2 Gbps
	Overhead	0.4 Gbps

II. The CCU inside MSC/DLS

The operational environment of the CCU (Channel Coding Unit) including all major components and external interfaces is depicted in the overall functional diagram of the DLS (Data Link System, Fig. 1.) showing two CCUs (CCU 1 and CCU 2) that are operated in a 'cold-redundancy' strategy (only one unit operating at a given time) to improve the overall reliability

In the DLS system always one of the CCU is not powered and serves as cold redundancy. With the active low Ready signals and the AND gates after the RS422 receivers it is also possible to have the second CCU powered on (hot redundancy) in the system, even in case of possible errors (short circuits, open lines) in the harness

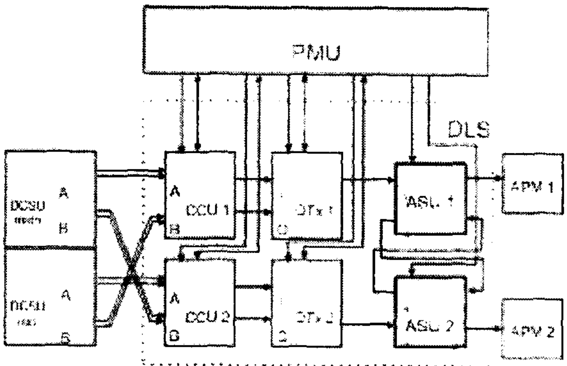

Fig . 1. Overall functional diagram of the DLS

III. Overview of the CCU

The Channel Coding Unit is a dedicated high speed data processing unit that operates on two independent input data streams.

The input data rate is 2*138.51 Mbit/s (max.), the output data rate is 2*160 Mbit/s constant. The input interfaces for the data stream is of type Hotlink (Trademark of Cypress Semiconductor), serial pseudo-ECL interfaces with 8B/10B encoding. For both interfaces the maximum data rate is limited to 144 MBit/s, the data rate reduction to 138.5 MBit/s is performed via handshake signals.

The output interface for the data stream is of type parallel LVDS, chosen due to power consumption reasons.

1) Encryption

The Data will be encrypted (on demand) in the IDEA standard with 128 bit key length in real-time. IDEA is a world-wide available symmetric encryption standard and has not been cracked up-to-now. The encryption itself is performed by dedicated hardware.

2) Reed-Solomon encoding

After the optional encryption the data stream will be encoded with a power burst error correcting code, the Reed-Solomon (RS) code. 223 Byte of the data stream form one code block and 32 check symbols are generated to provide error detection and correction capability for up to 16 erroneous bytes in the code block or the check symbols.

Five (5) RS-encoders are available for every data stream. The 5 encoders are operated in a byte-by-byte time multiplexed manner, which is called interleaving. Thus the correction capability of the encoded data stream is good for burst errors up to 80 bytes (640 bit) duration.

3) Header generation

The data is subdivided into packets of equal length, each packet owns a header information. Most of the header information is provided by the PMU to the CCU and the CCU inserts this information into the data stream in real time. The CCU itself delivers a packet sequence counter for the header and a control information that indicates the last packet of a sequence.

RS-encoding, header generation and ASM insertion into the data stream is in accordance with the CCSDS recommendations

4) ASM insertion

Each packet is provided with an asynchronous synchronisation marker, a fixed identifier that leads every packet. The CCU inserts this marker at the right position into the data stream.

5) Randomiser

All data except for the ASM are randomised in order to provide sufficient 1-0 transitions for transmission.

IV. Operation Mode

1) OFF Mode

In Off Mode the CCU is switched off. This mode is used when no data has to be transmitted or when power budget on the S/C requires minimum consumption.

2) Stand-by Mode

fter power-up the CCU initialises the Hardware components and the Software and then waits for the establishing of communication between the PMU and the CCU by the dedicated "Communication check command". In stand-by mode the configuration of the CCU with loadable encryption keys and mission scripts will take place as well as diagnostic test possibilities.

In stand-by no mission data transmission will take place, so the QTx needs to be powered off to avoid the transmission of unmodulated carrier. Power consumption will be low.

If the communication check command is not received during the waiting period of the CCU after initialisation, then the CCU will assume that communication is not possible. In order to be able to transmit data even in this error case the CCU enters the Default Mode

3) Transmission Mode

In the transmission mode the CCU accepts mission data from the DCSU and performs the nominal data processing that is defined in the mission script. The transmission mode is entered only on TM/TC Command and only if the CCU internal examination of the mission script shows no errors. Power consumption is high.

4) Default Mode

The Default mode is entered only if the CCU does not receive the communication check command from the PMU within a waiting period after CCU power-on. on TM/TC interface timeout

After this time the CCU will accept mission data from the DCSU through Hot-link channel and process the data according to a default mission script that is permanently available in the CCU. In the Default mode no data encryption will be performed. The transmission will be continuously until the CCU is powered off, if the communication cannot be established at a later point. The CCU is waiting at all times for the communication check command from the PMU, no other command will be recognised in before this command. If this command is received in the Default mode, then the operation from the PMU will be possible again

V. Mission Data Processing Level

1) Downlink Level

For the CCU each orbit (of about 100 minutes) is divided into 20% active and 80% inactive periods. Only in the active periods the CCU will be powered and able to downlink Mission Data.

2) Mission Level

A Mission is defined as a dedicated data set for a specific recipient in ground. It consists of real-time scanned images from up to 8 image sensor or played-back files from the DCSU. The data on both the I and the Q-channel belong to the same recipient.

3) Cycle/File Level

Cycles and files are the data structures that appear at the CCU's Mission Data Input Interface ("Hot-link interface"). The image information is provided in Data Sectors of fixed length (244736 bytes).

4) Sector Level

The data from each Sector on the I and Q channel is processed into 220 Channel Access Data Units (CADU) that appear on the CCU output to the QTx. Each CADU contains 1115 bytes of a Sector. Since the Sector size does not fit in exactly into 220 CADUs each 220th CADU is filled up with 564 zeroes

5) CADU Level

Each CADU consists of an Asynchronous Synchronization Marker (ASM) and a data packet.

6) Packet Level

Each Packet consists of a Primary Packet Header, 1115 Bytes of Sector Data that are used for Reed-Solomon encoding, but themselves are unmodified, and 160 bytes of Reed-Solomon check symbols. A secondary header is not defined.

7) Header Level

The Primary Packet Header consists of many kinds of fields such like Version Number, Type indicator, Secondary Header and so on. The sequence counter identifies each CADU that contains data (i.e. no idle) through a 14-bit number. The Packet Data Length is a constant value with the binary representation of the decimal value 1274. An 11-bit Application Identifier (APID) is used to distinguish between different Sectors of a cycle.

8) APID

The Application Identifier (APID) is structured into 4 sections. A 1-bit identifier indicates that the current CADU is the last CADU of the current sector and therefore is filled up with zeroes. A 4-bit instrument indicator shows the origin of the data. The DCSU use indicator shows possible compression rates and channel information from the DCSU. Finally the CCU encryption use indicator shows if data encryption is used and if so, indicates the index of the used key

VI. H/W Description

CCC(Central Control of CCU) has a microcontroller system with a supporting FPGA, RAM and ROM. The FPGA contains a boot control logic, an asynchronous receiver and transmitter for serial communication, a watchdog circuitry, an EDAC circuitry, a programmable interrupt source register, dedicated counters for status monitoring.

CCU has 2 separate CPC(CCU Processing Pipeline) each containing a data encryption module, 5 Reed-Solomon encoder, operated in multiplexed (interleaved) manner, a dedicated Multiplexer for insertion of synchronisation and header information, a randomiser for generating deterministic state changes in the output data flow, finite state machines for the control of the data processing pipeline (CPC, CCU Pipeline Control).

Power supply section consists of EMI/EMC filter, DC/DC converter for the 5.0V secondary main voltage and Low-drop-out voltage regulators (LDO) for secondary 3.3V and 2.5V supplies.

There are interface such like TM/TC Interface to the PMU, input Mission Data Interfaces to the DCSU, output LVDS interface to the QTX with buffering FIFOs, Discrete and Analog Telemetry Interface.

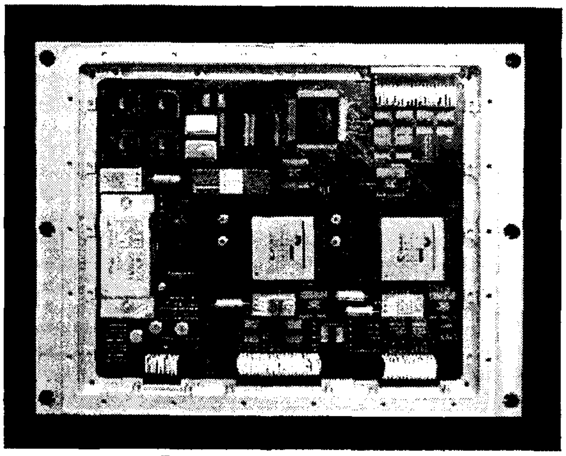

Fig. 2. Figure of CCU Inside

VII. Power Consumption

With the Engineering Model the following primary power consumption values have been measured:

Off Mode: 0.0 W
Standby mode: 5.0 W
Default mode: 8.9 W
<u>Transmission mode:</u>
Low entropy keys for I and Q: 14.0 W
High entropy keys for I and Q: 23.5 W

The power consumption in transmission mode is nearly independent of the input data.

VIII. Conclusion

Up to now, I showed detail about CCU. Currently, All kind of test is completed such like shock, vibration, thermal cycle, thermal vacuum cycle and EMC/EMI. And CCU integration to DLS is also completed.

References

[1] KOMPSAT-II MSC Payload Equipment Specification
[2] CCSDS 701.0-B-2, "Advanced Orbiting Systems, Networks and Data Links: Architectural Specification," Nov., 1882.
[3] CCSDS 101.0-B-3, "Packet Telemetry"
[4] CCSDS 101.0-B-3, "Telemetry Channel Coding"