IMAGE DATA CHAIN ANALYSIS FOR SATELLITE CAMERA ELECTRONIC SYSTEM

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ABSTRACT ... In the satellite camera, the incoming light source is converted to electronic analog signals by the electronic component for example CCD (Charge Coupled Device) detectors. The analog signals are amplified, biased and converted into digital signals (pixel data stream) in the video processor (A/Ds). The outputs of the A/Ds are digitally multiplexed and driven out using differential line drivers (two pairs of wires) for cross strap requirement. The MSC (Multi-Spectral Camera) in the KOMPSAT-2 which is a LEO spacecraft will be used to generate observation imagery data in two main channels. The MSC is to obtain data for high-resolution images by converting incoming light from the earth into digital stream of pixel data. The video data outputs are then MUXd, converted to 8 bit bytes, serialized and transmitted to the NUC (Non-Uniformity Correction) module by the Hotlink data transmitter. In this paper, the video data streams, the video data format, and the image data processing routine for satellite camera are described in terms of satellite camera control hardware. The advanced satellite with very high resolution requires faster and more complex image data chain than this algorithm. So, the effective change of the used image data chain and the fast video data transmission method are discussed in this paper

KEY WORDS: satellite, camera, CCD, image, transmission, system

1. INSTRUCTION

The purpose of the MSC in KOMPSAT-2 is to obtain data for high-resolution images by converting incoming light into digital data. The OM (Optical Module) of EOS (Electro-Optical Subsystem) includes an optical objective, in order to image the objects on its detectors. The detector consists of 3 parallel arrays in the MSC. Each array consists of 5200 active elements with 32 TDI stages. All pixel video of each detector are output through one output. The number of TDI stages is externally selectable in predefined stages. This control module shall be included in the FPE (Focal Plane Electronics) of CEU. The FPE board receives operating voltages from an external source. The FPE board supplies voltages (required power) as well as clocks (timing) to the CCD detector. Precise timing is supplied to the detector to ensure optimal operation in each operational mode.

Every output from CCD port has a separate video-processing channel that incorporates CDS(correlated double sample), PGA(programmable gain amplifier) and a 10 bits A/D. The outputs of the A/Ds are digitally multiplexed and driven out using differential line drivers. Every two consecutive detector outputs are then MUXd, converted to 8 bit bytes, serialized and transmitted to the NUC module within the PMU(Payload Management Unit).

The ideal CCD has to give uniform signal level for the uniform light source. It is necessary to overcome the non-uniformity of the CCD's photo-response. The correction is performed with multiplying gain value and adding offset value according to the predefined NUC table. The NUC is a high speed and high throughput image processing unit. It performs the correction of 8 video channels for pixel gain and offset. The video data that is processed by the NUC is transmitted to the DCSU board for further handling and transmitted to the Ground Station. This characteristic can usually be compensated in the ground station after receiving image data from satellite. But, the loss compression due to real time image transmission in MSC needs the NUC operation.

2. IMAGE DATA PROCESSING SYSTEM

The MSC system is a space-borne Electro-Optical system. The OM of MSC includes an optical objective, in order to image the objects on its detectors. The PAN channel has a high-resolution image and produces a black-white picture at the spectral region of 500nm-900nm. The MS channel consists of four spectral bands and its resolution is four times greater than the PAN channel. The PAN channel has up to 1m ground resolution and the MS channel has up to 4m ground resolution in each of the 4 spectral bands. The figure 1 shows the image data flow.

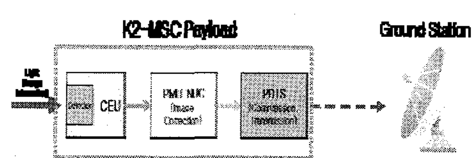

Figure 1. Image Data Flow

The MSC consists of two Electro-optical channels. A single internally CC (Camera Controller) that performs the communication and control functions and serves both the PAN-CEU and the MS-CEU. The incoming light is converted to electronic analog signals by the detectors. The analog signals are amplified, biased and converted into digital signals (pixel data stream) in the FPEs. Each of the detectors is supported separately with the required timing and power supply circuitry. The FPE assembly shall support the detector with the required power and timing command. It shall process the analog signals which come out of the detector and convert them to digital form. The FPE assembly shall consist of a single detector, up to six video channels, clock drivers, voltage regulators and control lines. (figure 2)

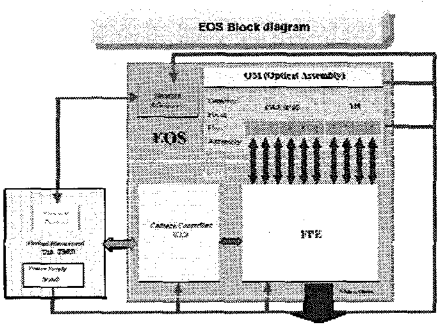

Figure 2. EOS Function Block Diagram

The digital data is transmitted to the NUC for pre-processing to correct for non-uniformity and to add header data for identification and synchronization.

The figure 3 is the PAN FPE data output block diagram. As the figure 3, the acquisition video signals from the detector (four-output, each mode Primary and Redundant) are amplified, converted, mixed, and transmitted. The figure 4 is the MS FPE data output block diagram. In the MS mode, the video data output mode has only one channel, because of the slower video data rate for MS channel.

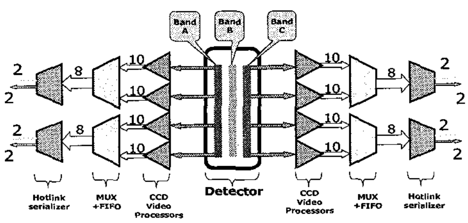

Figure 3. PAN FPE Data Output Block diagram

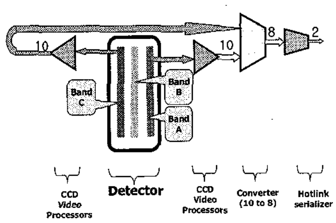

Figure 4. MS FPE Data Output Block diagram

The data is transmitted through two differential channels (two pairs of wires) for cross strap requirement. The FPE-MS consist of 2 detectors (video output through 4 pairs of wires) and the FPE-PAN consist of 3 detectors (video output through 24 pairs of wires, 12 pairs for the primary bands and 12 pairs for the redundant bands). The figure 5 is the converting 10 bit to 8bit.

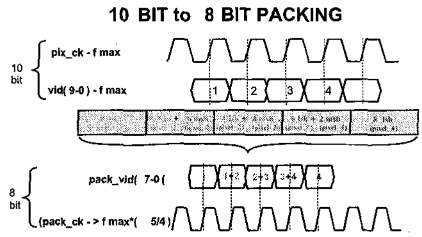

Figure 5. Conversion 10 bit to 8bit

All the Hot-Link transmission lines are terminated with termination resistors and transformers on both sides to match the characteristic impedance of the line. Each video data output contains multiplexed data from 2 outputs of a detector's band. The video data rate at the input of the Hotlink serializer is 25 MHz according to the requirements of the DCSU, which receives the data through the PMU. The outputs of the Hotlink serializer are of differential type.

3. HIGH RESOLUTION SYSTEM

The used system has the limitation of the increasing data rate. In the increasing data rate (more high resolution image data acquisition), the image data processing and transmission system must be changed.

The figure 6 is the PAN FPE data output block diagram of the changed system (more high resolution system). As the figure 6, the acquisition video signals from the detector (four-output, each mode Primary and Redundant) are amplified, converted, mixed, and transmitted. The figure 7 is the MS FPE data output block diagram of the changed system. In the MS mode, the video data output mode has only two channels, because of the slower video data rate for MS channel.

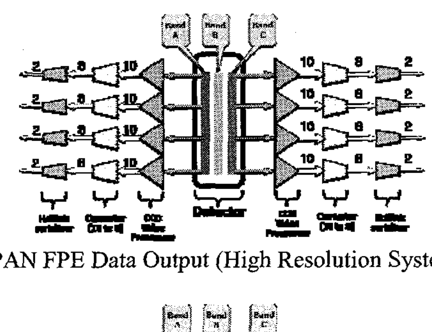

Figure 6. PAN FPE Data Output (High Resolution System)

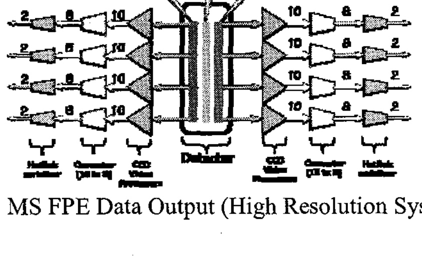

Figure 7. MS FPE Data Output (High Resolution System)

4. IMAGE DATA TEST AND ANYLSIS

The EGSE (Electronic Ground Support Equipment) designed to conduct the testing of the EOS system, shall be used for checking and verifying the functionality and performance of the EOS unit tests and the NUC. Also, it's used for supporting this system testing by providing display services for the image data that is collected from the EOS output and providing simulated image data at the input of the NUC under test and acquiring image data at the output of the EOS under test. For operating in the EOS test mode and testing the EOS, the EGSE shall supply the power, command and control, telemetry and thermal control, image data acquisition.

In image data acquisition mode, it acquires image data at the output of the EOS under test while (Figure 8).

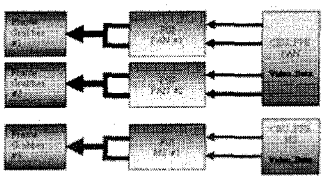

Figure 8. Image Data Processing in EGSE

The figure 9 is the simulated data in CEU FPE board. It's used for verification of the video data transmission system. The EGSE receives the simulated data and displays it (figure 10, 11).

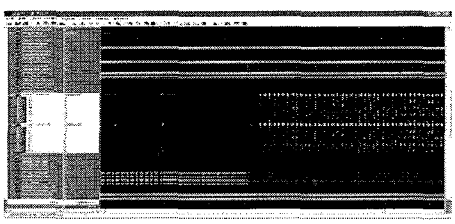

Figure 9. Simulated video data in FPE

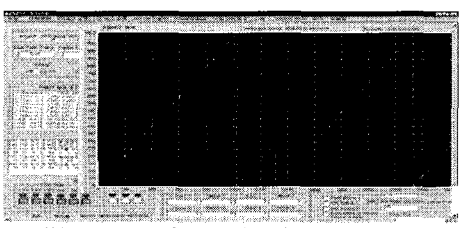

Figure 10. EGSE video data output

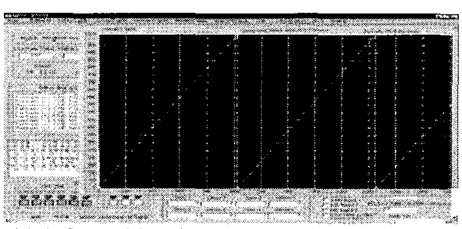

Figure 11. EGSE video data output for the improved system

5. IMAGE TRANSMISSION METHOD

The other communication methods are used in Satellite image data transfer system. For example, the G-link system is used. Below the table show the difference with Hotlink system and G-link system. (Table 1)

Comm. Method	HotLink	G-LinK
USED	K2 MSC	Other Satellites
Chip (Company)	CYPRESS Chip (CY7B923/933)	Agilent Chip (HDMP-1032A/1034A)
Power/Power Consumption	5V 350mW(Tx), 650mW(Rx)	3.3V 660mW(Tx), 792mW(Rx)
Data Format	10bit	16bit
Data Rate	160Mbps - 330Mbps (Standard) 160Mbps - 400Mbps (High Speed)	208Mbit/s - 1120Mbit/s (Data Rate) 260Mbit/s - 1400MBaud (Baud Rate)
Chip Type	28-Pin SOIC/PLCC/LCC	64-Pin PQFP

Table 1. *Communication method comparison*

There are several methods will be used to the satellite image data transformation system. These systems (components) have the different data format, data rate, type, and power consumptions. The proper system or component will be selected to use effectively.

6. CONCLUSIONS AND FURTHER WORK

In this paper, the image data transfer system is described in terms of the image data size and configuration. The purpose of the satellite camera is to obtain data for high-resolution images by converting incoming light into digital stream of pixel data. The high resolution image data must be used more complex and fast data transmission system. This system will be used by very accurate observation and other multi-purposes.

In the future, it is needed that the multi-purpose satellite camera has more high resolution. It needs the fast speed, the high confidence, the low power consumption, and the small size. These image data transfer method and correction system will be used for high resolution image acquisition.

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