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DEVELOPMENT AND PERFORMANCE OF DSP BASED 16-BIT HIGH-RESOLUTION CCD CONTROLLER

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Abstract. Hyperspectral imaging systems are becoming more and more important concerning a great variety of systems with commercial and military purposes. The valuable fact about hyperspectral sensor of a given spatial resolution or pixel size is that it will give data on the scene that is not obtainable by single band or multi-spectral sensors. Several approaches have been applied to use a single higher spatial resolution band to improve the spatial resolution of the hyperspectral data.

The following items are described in the proposed research work:
• the electronic block of the video-spectrometric system;
• the used elements' base and scheme solutions;
• its alignment with the optic system.

Thanks to the usage of digital signal processors (DSP) and high-speed, high resolution ADC an extra flexibility and speed of processing is achieved. According to the task, the number of received channels may be reduced in the spectrometer itself.

Schemes of the optic part and of the electronic block are presented.

1. INTRODUCTION

During the last decade, the remote sensing sciences have progressively moved towards the development of the spaceborne and airborne based hyperspectral devices, making use of the hyperspectral sensors (Birk, 1994; Kramer, 1996; Kunkel, 1997; Gekov 2000). Part of this development has been spurred on by systems capable of acquiring and fusing accurate globally referenced data in fully digital form with short turn-around-time in a cost-effective fashion. Therefore, it raises the requirements to the input-output controllers (precision timing generators) and digitalization devices of the spectral video signal. It necessitates higher request to:
• the readout speed of the information,
• the resolution of the ADC,
• the digital signal processing, and
• the compression and transmission of the data.

The proposed work gives a description of the hardware configuration of the input-output controller, worked out in the Onboard Section, for remote sensing hyperspec-

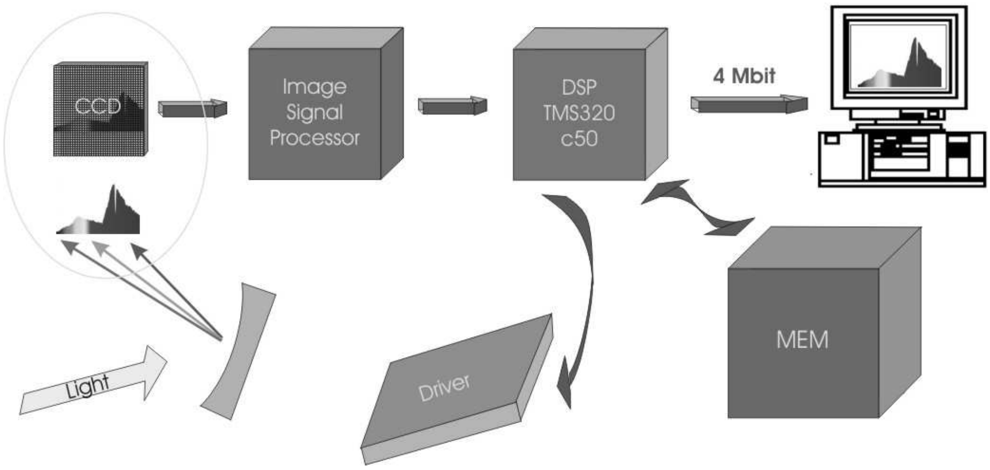

Figure 1: Workflow of the video spectrometric signal processing – hardware configuration.

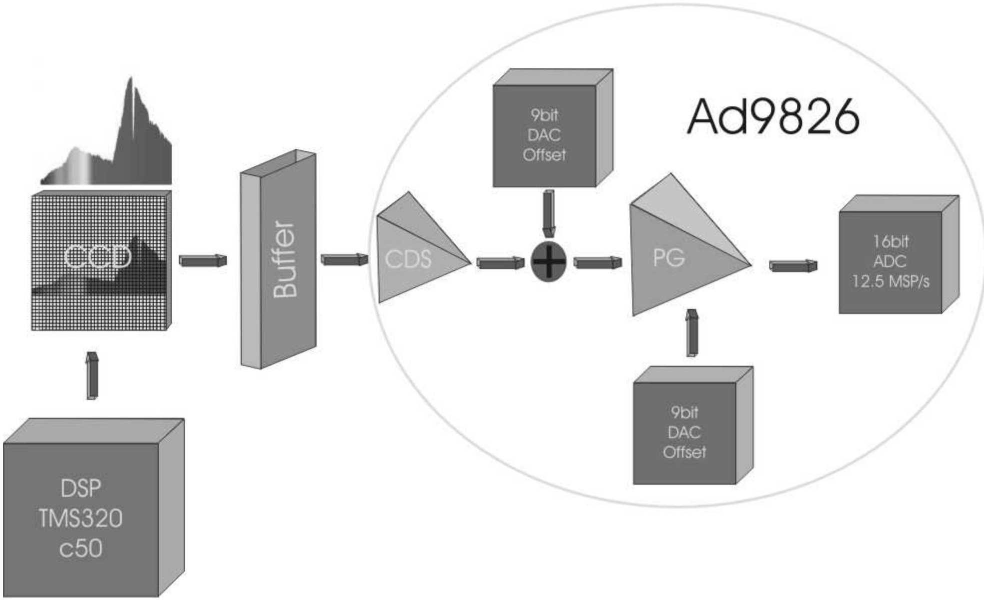

Figure 2: Workflow of the video spectrometric signal processing – image signal processing.

tral applications. The newest devices for CDS and ADC of "Analog Device" and DSP of "Texas Instrument" are used. The RMS output noise histogram is presented. The prototype level of the videospectrometric system is designed in spectral range 530 – 680 nm. The radiometric and geometric calibration is accomplished with using monochromator.

2. HIGH-RESOLUTION CCD CONTROLLER

High-resolution CCD controller includes (Fig. 1):
- CCD area image sensor
- Compete analog signal processor
- Digital signal processor (TMS320C50), with memory (MEM),
- Drivers for vertical and horizontal transfer,
- IBM-PC.

2.1. CCD AREA IMAGE SENSOR

There is a suggested possibility for the worked out controller to switch on two types of matrixes: Texas Instruments' "TC217" and *"CCD 02-06"* of the E2V Company. TC217 is a high-resolution matrix with small pixels and big dynamic diapason. It can be used for scanning the Earth in one spectral channel. The second type of matrixes "CCD 02-06" of the E2V Company is proposed for spectrometers in the diapason 420-1060 nm. Its major advantage to other similar matrixes is the big pixel size – 22 22 μm. This adds both a higher sensibility on one side and on the other for bigger coverage of the spectral diapason. Additionally it has very small noise of reading the elements and big dynamic diapason. It is recommended in systems with cooling which will be necessary in our case. The CCD receiver is a standard three- phase matrix of the type "frame transfer" with dimensions of the sensitive part 12.7 x 8.5 mm. The quantum efficiency is 45% at 700 nm and the dynamic range is 25000:1.

2.2. COMPETE ANALOG SIGNAL PROCESSOR (Fig. 2)

The video signal of the CCD receiver is amplified by a buffer and is transmitted to the analog-digital video processor AD9826, worked out by the "Analog Device" company, operating in a mode of double correlated sampling (Correlated Double Sampling, CDS). A 9bit DAC (OFFSET) runs the shift of the DC part of the signal. The amplification of the signal is regulated by a 6-byte DAC programmable gain amplifier (PG). Each mode is selected by programming the configuration registers through the serial interface. The analog-digital converter has a operating frequency up to 12.5 MSP/s.

2.3. DIGITAL SIGNAL PROCESSOR (TMS320C50), WITH MEMORY (MEM),

The received 16-byte digital signal is transmitted to the signal processor TMS320C50. It supports the time diagram of the CCD, the analog video processor and it does the transfer to the PC. Apart from this, a local processing of the data is possible as a correction of the image, compression or other. With suitable software the standard filters of SPOT, LANDSAT and other satellites can be realized.

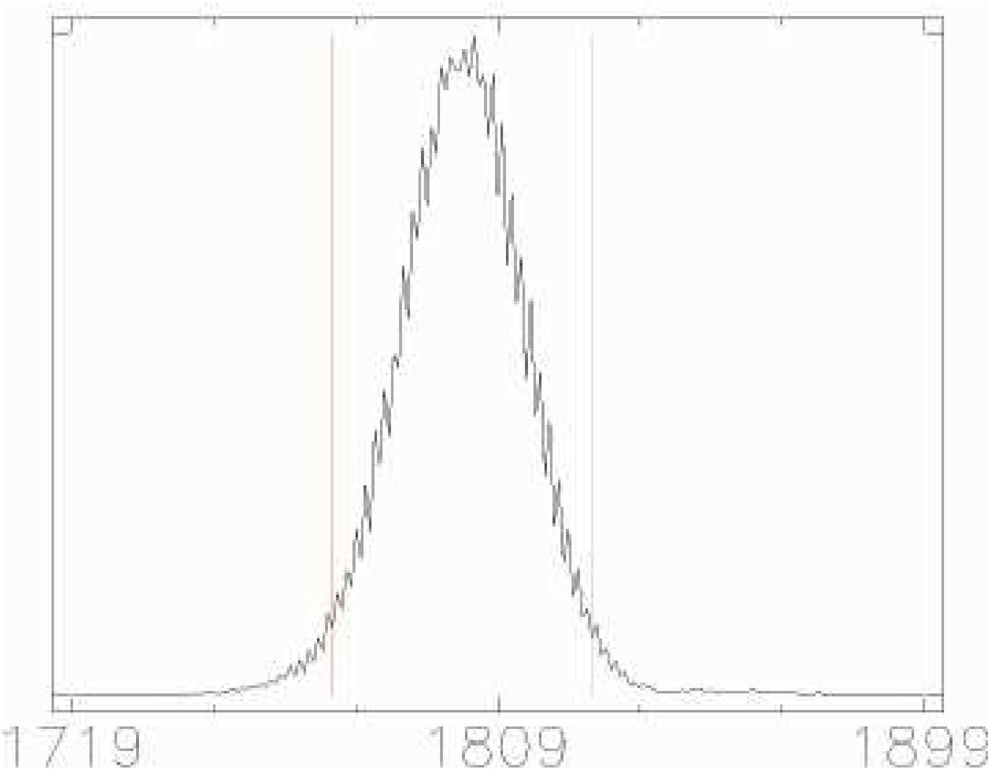

Figure 3: RMS output noise histogram of the precision timing generator.

2.4. IBM-PC

The memorizing of the received information is done on a PC. The requirements to it are not very big only to have the ability to store the vast data source. Experiment – 1-3 hours with a speed of 500kB/sec.

3. RESULTS

Fig. 3. shows the results of dark current research of matrix TC217. Experiments at different values of offset and power gate amplifier were conducted. The histogram graphic of the best result is shown. RMS of dark current 12.01 is received at maximum level of saturation 15 000. Obviously the S/N ratio is better than 1000.

Figs. 4, 5 and 6 illustrate the first experiments with grating monochromator. The graphic represents that there is background and low level of input signal. But definitely the results are very promising. The spectral lines at 560, 530 and 680 mm are steep and the resolution at wavelength is 8 – 10 nm at 0.5 levels. There is still work to be done for the precise calibration of optical part and of the electronic block.

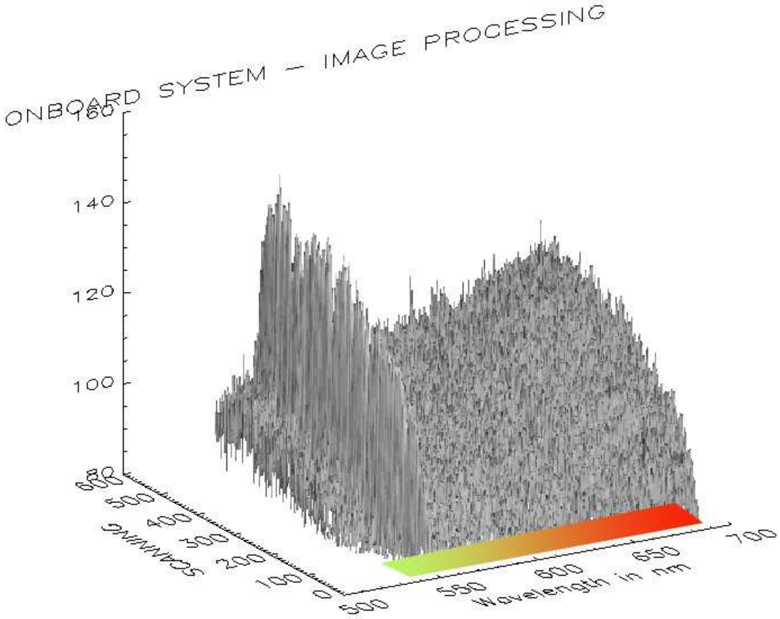

Figure 4: 2D Spectrum, Wavelength = 560 nm.

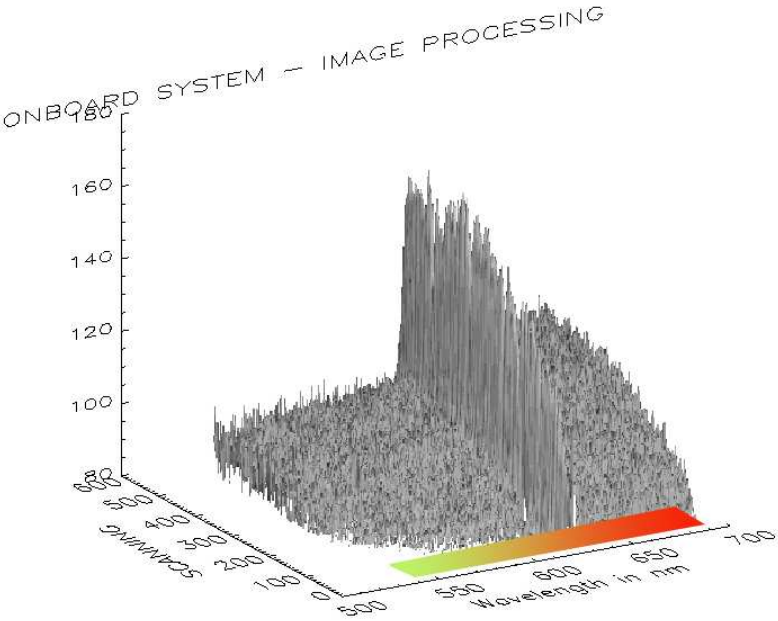

Figure 5: 2D spectrum, Wavelength = 630 nm.

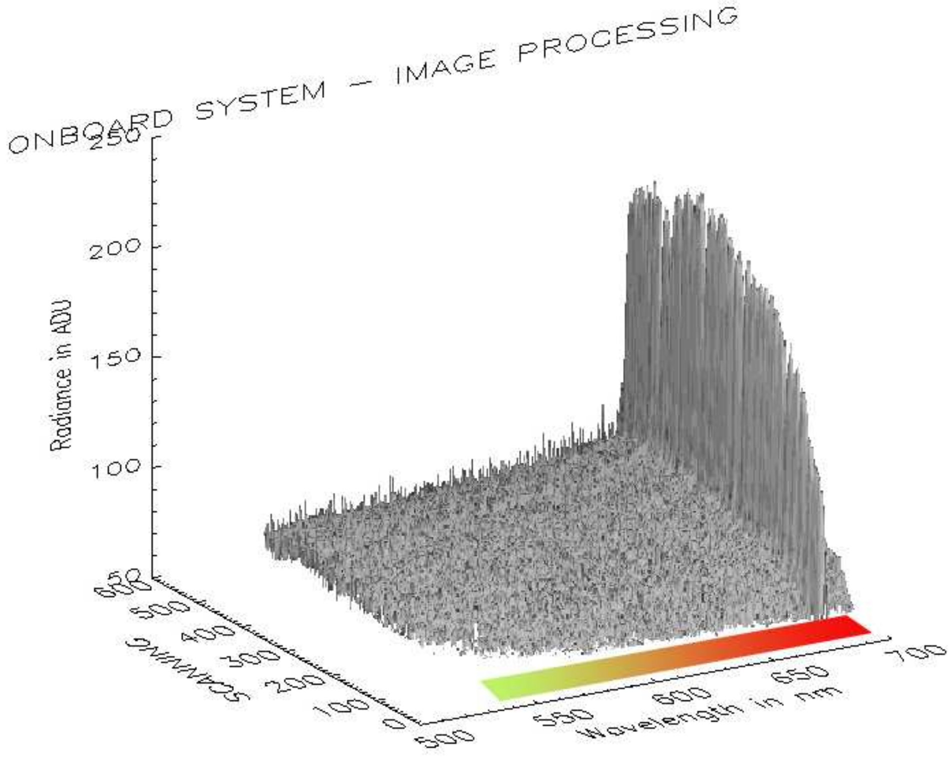

Figure 6: 2D Spectrum, Wavelength = 680 nm.

4. CONCLUSION

The worked out input-output controller is a part of an airborne-based video spectrometric system at the prototype level for remote sensing investigation of the land cover. The used newest technologies in the last years allow development of the portable devices with high-speed signal processing and low consumption. It is, therefore, recommended to design an industrial computer system that can accommodate the necessary boards for simultaneous navigation and image data acquisition. This would greatly improve system portability and cost

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