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The Data Handling Unit for the WSO-UV Field Camera Unit

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Abstract. The World Space Observatory (WSO) is a space telescope conceived to observe the universe in the UV. The instrument payload consists of three spectrographs and one Field Camera Unit (FCU) composed by three cameras for UV and visible light imaging. FCU instrument will produce a huge quantity of data to be transferred in a short time to the on board computer. Presently, the proposed satellite interface is the MIL1553B which represents a bottleneck due to its low data rate. In order to avoid very long images transfer time,we are designing a communication interface that uses an hybrid architecture which is capable o f high-speed and reliable data transfer.

1. Introduction

The World Space Observatory (WSO) is an international collaboration led by Russia and involving China, Germany, Spain, UK, Ukraine and Italy to build a UV space telescope. The telescope is planned to operate in a geosynchronous orbit observing the Universe in the UV band ($\lambda \geq 102nm$) providing completely new opportunities in extragalactic astronomy and cosmology. The instrument payload consists of three spectrographs and three imagers, the latter assembled in the Field Camera Unit (FCU) . The three branches of the FCU view adjacent fields to that sampled by the spectrographs, so the imagers can in principle be operated for parallel observations (survey mode) or for targeted projects. FCU represents the Italian contribution to WSO/UV. The FCU project is still in the phase A.The FCU cameras are a short focus Far UV camera, (FUV, operating in the spectral band 115-190 nm @ f/10), a long focus Near UV camera (NUV, 150-280 nm @ f/81) and an UV/Optical camera (UVO, that covers the wavelength range 200-700 nm). Both NUV and FUV detectors will be MCP with two different modes of observation:

- accumulation mode, accumulating counts in an array in which each element correspond to a pixel, producing a CCD-like image;
- time tag mode, where for each detected photon the device provides the position (x,y) and time information.

As detector for the UVO channel we selected a CCD 4kx4k with 15 microns pixel size. FCU instrument can acquire images with only one camera at the time and it produces, for each imager, a huge quantity of data. For example, assuming 16-bit as a typical CCD dynamic range, the image dimension will be 256 Mb. Actually, the expected data rate for FCU cameras depends on the detector and the observation mode. The MCPs in accumulation mode produce as data as a CCD with the same dimensions. If we assume to take exposures with integration time of 5 minutes, (which corresponds more or less to the time interval above which the CCD images will be split to reduce cosmic rays contamination) we expect to have a data rate respectively of 850kbps for the CCD and 200kbps for MCPs in accumulation mode.

The Time-Tag mode for MCPs preserves all the information about photons, but it produces an amount of data depending on the flux of the incoming photons, so that in this case the data rate is strongly dependent on the filters and on the sources in the field of view. Data are produced continuously during the exposure. Assuming a 2kx2k detector, we need at least 22 bits to codify spatial information, 1 bit for parity check, 1 bit for flag = 24 bit/photon. The time information can be coded or by adding additional bits to the photon word, or by using a reserved word sent every Δt, or a mix of both methods. The expected maximum count rate in time tag mode, however, was ~ 1.2 Mbps, (Scuderi et al., 2007). Since the data volume will be very huge it cannot be possible to store images on the computer mass storage for a long time.

2. The Data Handling Unit

At the XUVLab of the Department of Astronomy and Space Science of Florence University the Data Handling Unit (DHU) concept for FCU instrument is under development. DHU manages the data flow from the detectors to the Scientific Data Control Unit (SDCU) on the spacecraft. The link with SDCU is used to exchange commands and data. The data link between the DHU and the SDCU is through the MIL1553B interface. The MIL1553B interface bus is capable of nominal data rate of 800 kbps per channel. Actually, during normal operations, this data rate can decrease down to ~ 100 kbps for each channel, representing a real bottleneck for the downlink. For example, at such data rate the requested time to download, with the MIL1553 protocol, a CCD image in the UVO channel would be 43 minutes, that is a not acceptable time. Data have to be transferred to the on board control unit in an interval shorter than the typical exposure time. This avoids time losses between an exposure and the next one due to the image download. We are studying possible solutions to the data rate transfer problem. All of them are combinations of various elements: data compression, increase the number of downlink channels, selection of a faster interface.

Data Compression The first solution is to use a lossless compression algorithm that reduces the dimension of the image and so the data transfer time. The maximum compression factor that lossless algorithm can reach is 3 (like in HST), so the data transfer time for a CCD image would be reduced to about 14 minutes (@100 kbps) and for a MCP image (accumulation mode) to 4 minutes.

Increase the downlink channel Each camera would have two MIL1553B channels to transfer data to SDCU that can be all available when only one camera is used. With this kind of architecture we gain a factor 6 for the multi-channel transfer. This means that the total time to transfer a CCD image from FCU to SDCU turns into ~7 minutes instead of 43 minutes. This architecture presents some disadvantages: more complex design, increase of weight, space and power consumption, less reliability.

Change the communication protocol: The more direct solution could be change the bus interface. Just as an example the Spacewire standard, an ESA space protocol, is capable to reach a data rate of 200 Mb/s. This cancels all data rate problems (a CCD image would be transfer in < 2 seconds) but implies a radical change in the design of the SDCU communication network on the spacecraft and then a budget increase.

References

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