SUBSYSTEMS FOR SMALL SATELLITES UNDER DEVELOPEMENT IN THE INSTITUTE OF ATMOSPHERIC PHYSICS, PRAGUE, CZECH REPUBLIC

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ABSTRACT

Coming from the experience of the design and construction of the onboard-instruments of Czech satellites MAGION 1 to 5, (MAGION 5 is still working) the Institute of Atmospheric Physics is developing a new version of several sensors and electronic systems. The overview and main features of the following sensors and instruments are presented.

1. WIDE ANGLE DIGITAL SLIT SUN SENSOR USING CCD LINEAR ARRAY

1.0 INTRODUCTION

Our team manufactured simple analogue cosine law Sun sensors and made a good experience with them onboard of MAGION 4 and 5 satellites. However the new demands for the more accurate, wide angle sensor for the satellite on Low Earth Orbit let us feel their following drawbacks: The reflected light from the Earth disturbs the measurement. The degradation of the photosensitive elements caused by radiation drives down the accuracy of the sensor drastically and the re-calibration during the flight is problematic. A solution is a digital slit sun sensor. The common digital Sun sensors use photocell assemblies below a reticle slits pattern arranged usually in the Gray code. However those sensors about we have found information are robust, quite expensive and hence inappropriate to use on micro-satellites. That is the reason we decided to develop small, low mass sensor that would meet the above mentioned demands.

1.1 - MAIN FEATURES

- number of pixels:	2048
- wide angle:	FOV = 120 ° (± 60°)
- low mass:	0,11 kg
- small size:	65 x 55 x 25 mm
- typical accuracy:	0.2°
	0.1° for the FOV = 90 ° (± 45°), see discussion

- reflected light from the Earth does not affect the accuracy
- the gradual degradation of the sensitivity of the CCD does not influent the accuracy.
- serial communication to CPU

1.2 - TECHNICAL DESCRIPTION AND DISCUSSION

The sensor was described in more detail in [1]. The principle of the wide angle Digital Slit Sun Sensor DSSS is obvious from its functional scheme, which is presented in the figure 1. A thin opaque layer with a narrow slit made in a process of lithography, is placed above the CCD linear image sensor. The opaque layer has to be coated by anti-glare coat. To protect the CCD sensor against direct Sunbeams and radiation and to fit the appropriate exposure of the CCD a special attenuation-filter is used as a front window.

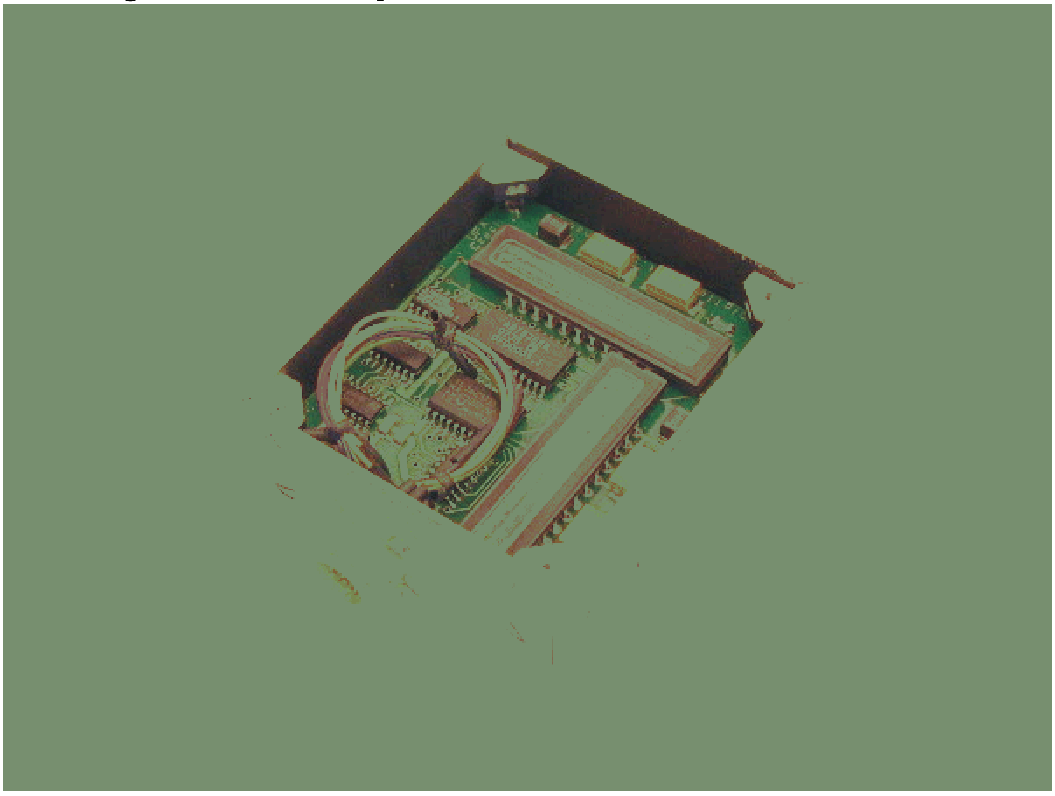
To be able to determine the Sun vector, two identical mutually perpendicular sensors are placed in one capsule.

The output signal from the CCD is digitised, read out serially by the microprocessor of the CPU that delivers also the proper timing and power supply for sensor. All the communication between the sensor and the CPU runs serially. The microprocessor, processes further the digitised signal from the CCD and calculates the angle - Sun vector. A photograph of the open sensor with electronics is in Figure 1.

The field of view greater then 90 ° (± 45°) reduces due to the tangent function the resolution (accuracy) of the sensor drastically. So the demands on very good antiglare and dark coating of the sensor inner parts arise. The authors consider that the maximum reasonable field of view is about 120 ° (± 60°).

The tests and calibration performed with an engineering model approved the function of the sensor. Further improvement of the dark antiglare coating is expected, other tests will be done.

Fig. 1: Photo of the open sensor with electronics



2. VLF/ELF MEASUREMENT SYSTEM

2.0 - INTRODUCTION

The VLF/ELF measurements are an important part of Earth's plasma-sphere and ionosphere study, including analysis of wave phenomena, wave-particle interactions and environment parameters.

Coming from the experience of the VLF/ELF measurement onboard of MAGION satellites, the Institute of Atmospheric Physics is developing a new version of VLF/ELF measurement 0.system. In contrary to the previous system, the data processing and transmission is fully digital.

2.1 - TECHNICAL DESCRIPTION

The embedded DSP processor allows to set the system into several modes of operation, allowing to fit the system to the available memory and telemetry volume. The choice of maximum frequency range or event (like whistlers etc.) recognition are the examples of the system options and the ways, how to reduce the data amount. The GPS system is the basis for time assignment.

The sensors determining the main physical characteristics are as follows:

a) 3-axis search coil magnetometer
Frequency range: 15 – 15000 Hz
Sensitivity (3 kHz): $4*10^{-6}$ nT/Hz$^{1/2}$
Dynamic range: 90 dB
b) 3-axis electric field measurement
Frequency range 0.1 – 15000 Hz
Sensitivity 50 nV/m/Hz$^{1/2}$ for frequencies higher then 10 Hz
Dynamic range: 90 dB

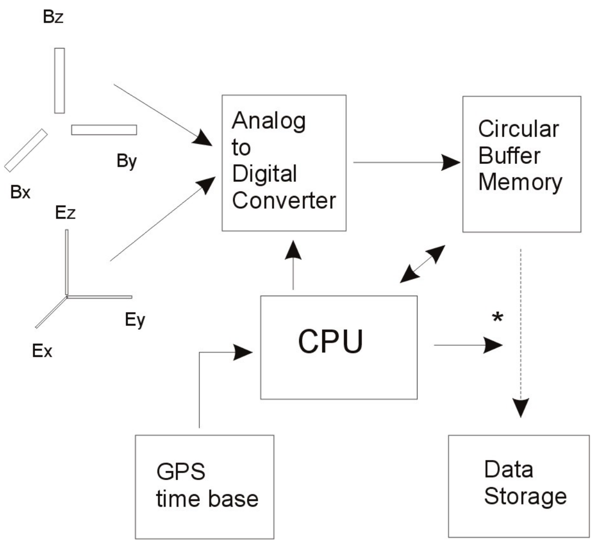


Fig. 2. Functional scheme of the VLF/ELF measurement system

3. TELEMETRY / TELECOMMAND SYSTEM

The new telemetry and telecommand system is under development, Fig.3. The system is based on the UHF up-link and S-band down-link scheme. The up-link data and modulation format is similar to that one, which was used on MAGION 4 and 5. Data rate was increased to 1.2 kbit/s. The down-link uses FM or BPSK modulation and data rate up to 2Mbit/s. The onboard-satellite systems are developed under stress of small size, low mass, low power consumption and low cost.
Simultaneously the ground station [3] is upgraded. The new 3m dish is installed, other antennas are reconstructed and equipped with new low-noise amplifiers and down-converters.

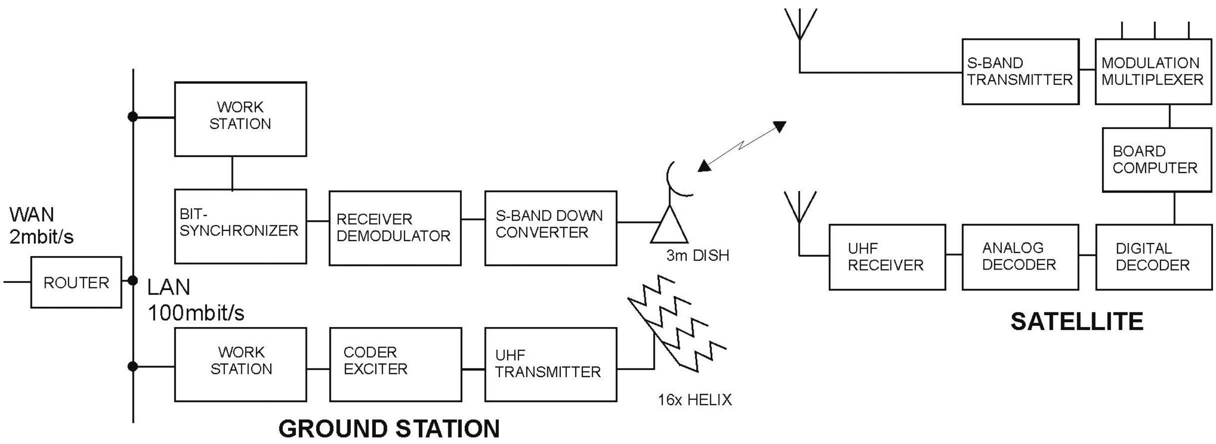


Fig. 3. Block diagram of the telemetry and telecommand system

4. CONCLUSION

The Institute of Atmospheric Physics (IAP), Prague continues in its activities in the field of small satellite development. New sensors, instruments and systems are ready for next scientific projects. The first one is MIMOSA [3] project, for which IAP provides some new sensors, housekeeping systems and ground station services. Other projects are proposed: M2S (Survey of Anthropogenic Electromagnetic Radiation), EMEC (Electromagnetic Monitoring of the European Continent), COLLISA-2 (Small Spacecraft for the Interstellar Atoms Composition Studies).

5. REFERENCES

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