PilsenCUBE-Strato – stratosférický test senzorů pro satelit PilsenCUBE-II

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PilsenCUBE-Strato – Stratosferic Test of the Sensors for PilsenCUBE-II Satellite

Abstract – **Small satellites are nowadays at least often equipped by large number of sensors for attitude determination. Due to small budget, which is quite often in small satellite project, it is necessary to use cheap sensors, that are not designed for space applications. There is no assurance of the proper function of such sensors in space conditions (low temperatures, low pressure, space radiation, etc.). In these reason it is necessary to test those sensors at least in high altitudes. High altitude tests of the sensors can be done by stratospheric balloons with relatively low costs.**

Keywords – Balloon Experiment; PilsenCUBE-II; PilsenCUBE-Strato; Stratospherical Balloon

I. Introduction

The PilsenCUBE-II satellite will be equipped by large number of the sensors for attitude determination. All of these sensors are not designed for use in space conditions. Even though the parameters seams satisfying, the space conditions may cause improper function of any sensors. This problem arises for example in case of the Panasonic AMG88 IR sensor during sounding rocket mission in last year.

The AMG88 sensor is very simple IR camera with resolution 8 by 8 pixels. In the PilsenCUBE-II satellite will be the AMG88 placed with another similar sensors Melexis MLX90621 for Earth's horizon detection. During souding rocket experiment some temperature values measured by the AMG88 sensor was overflowed. This improper function may disallow possibility of horizon detection.

The reason of this problem is not still known and additional information about sensor function were necessary. The opportunity to place this sensor into stratospheric balloon were welcomed because the condition in altitudes about 20 km or 30 km can be unfriendly enough to cause the improper function.

In reason to collect as much as possible number of informations about the attitude of the balloon capsule the additional sensors were placed in PilsenCUBE–Strato testing platform.

II. PilsenCUBE-Strato testing platform

The PilsenCUBE-Strato testing platform was launched during the Near Space Conference 2018 in Polish city Toruń as one of the balloon experiments in September 22.

A. *Mechanical design*

There was some mechanical design regulations that have to be followed to assure safety during the balloon flight and return to the ground on the parachute. The dimensions of the balloon have to be similar with 1U CubeSats ($10 \times 10 \times 10$ cm) and its weight must not exceed 0.5 kg.

B. *Measure equipment*

The block schema of the desired measure equipment is shown in the figure I. The balloon capsule was equipped by the following sensors: Infra-red cameras Panasonic AMG88, Melexis MLX90621 and MLX90640, motion tracker ICM20689 including accelerometers and gyroscopes and CMOS visible spectrum camera μCAM-III. All of these sensors were controlled by the Raspberry Pi Zero. There was an additional experiment including simple microcontroller board with connected simple dosimeter BG51. There was mentioned to use 2G/3G/4G modem for measured data backup during the parachute landing.

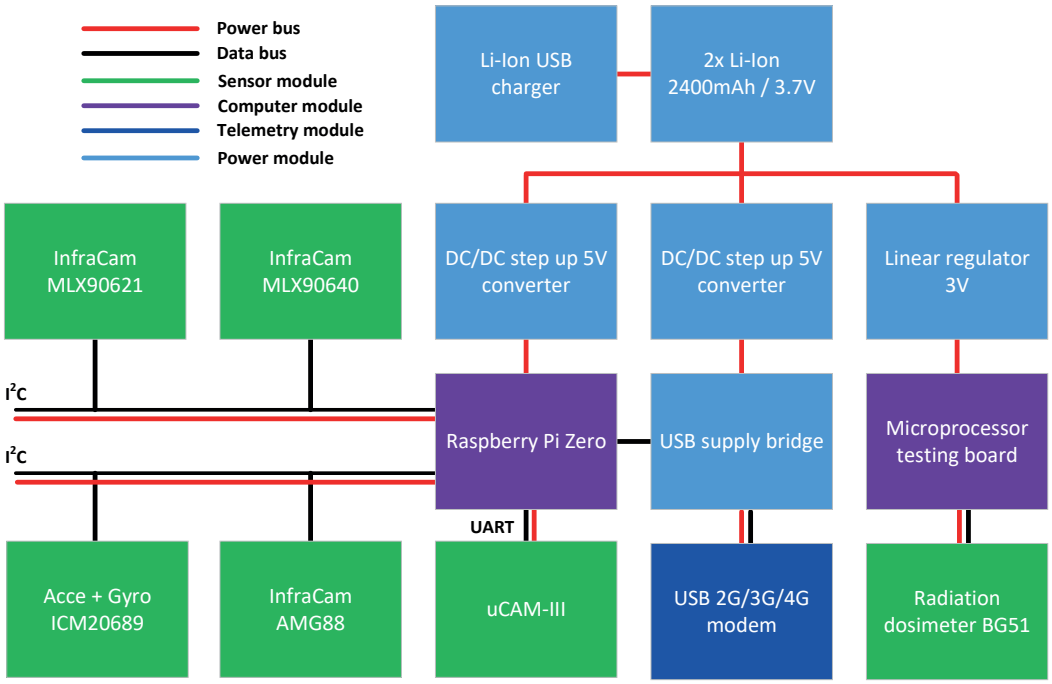

Figure I. Block schema of the balloon measure equipment

III. Measured results

The measurement was initiated before balloon start and switched off after its was picked up at landing location by recovery team and brought back to place of start. The values from the sensors were read out every two seconds and every five seconds was taken photo by μCAM-III.

The trajectory of the balloon flight is depending on many factors such as wind speed and direction in various layers of the stratosphere, weight of balloon payload and the pressure inside the balloon.

The typical stratospheric balloon flight follows the following scenario. After balloon is launched it is rising and freely carried by wind. At the altitude between 20 and 30 km it reach maximal altitude where the balloon is teared up by the inside helium pressure. Next occur free fall of the payload until the parachute is deployed by the around air and uncontrolled landing under the parachute. Whole balloon flight from launch to landing takes few hours depending on factors mentioned above.

The figure II shows the data from accelerometer. The figure III shows data measured by the AMG88.

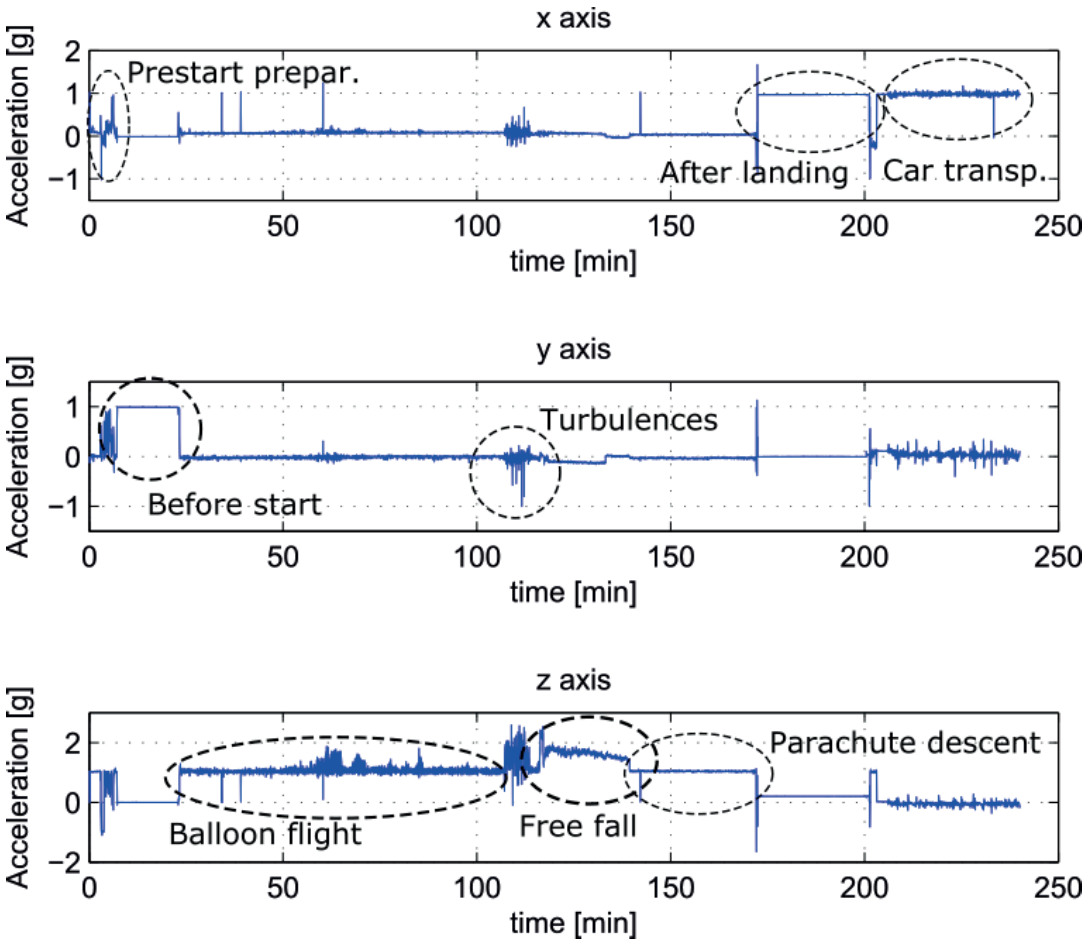

Figure II. Measured acceleration

IV. Conclusion

From the measured data can be clearly seen various phase of the balloon flight. These phases are marked in the figure II. Unfortunately there was problem with MLX sensors before balloon start. Because of this problem the IR measurements were done only by AMG88 sensor. The malfunction of the AMG88 sensor was present during some parts of the experiment. The data shown in the figure III are taken during proper function of the sensor. Now it is necessary to validate reasons of the malfunction of this sensor in

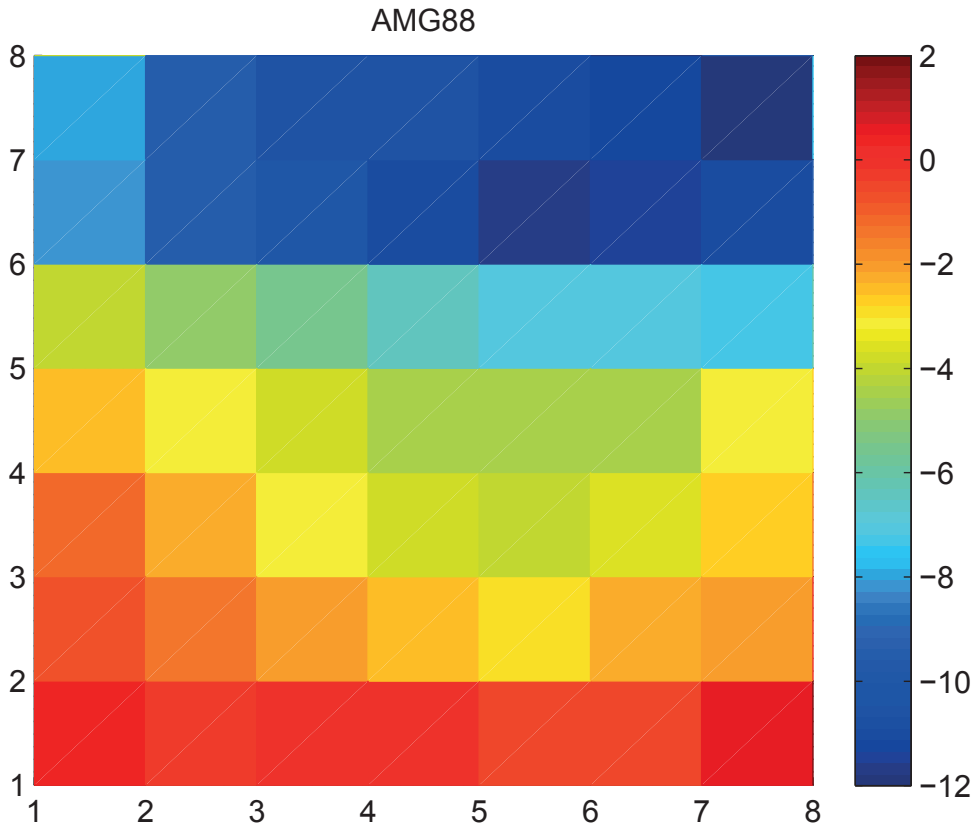

Figure III. Temperature image from AMG88 sensor

scope of another measured data. In time of writing of this paper we are waiting for some additional telemetry data provided by the balloon operating organization.

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