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Design of a monitoring platform for a Pico satellite with ground station using IoT technology

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Abstract. *This present paper proposes a design for a system for remotely monitoring the environment using a pico satellite sending data to a ground station. First, the telemetry technologies suitable for communication were identified, then the different types of internal structure for the adjustment of the PCB circuits in the pico satellite. Next, the other components were defined, respecting the project characteristics and constrains. Also, a structural analysis was realized to define the best model of pico satellite with its parachute. Finally, the ground station is integrated of a Raspberry Pi board and the LoRa communication protocol in other to have a graphical interface that allows the user to visualize in real time the data collect through plots.*

Keywords: Pico satellite, LoRa Protocol, Ground Station, Telemetry

1. Introduction

In the last 20 years, several new technological developments for the space sciences field have been developed in different institutions around the world. This has been fundamental for space science research due to the rapid progress in this area as well [Pelton and Madry, 2020]. In the present, many researches focus on the implementation of low earth orbit (LEO) constellations of satellites using smaller devices, which are classified as nano, pico and femto satellites [Davoli et al., 2019]. The difference of these devices from larger satellites resides in their lower costs, low power consumption and low latency in digital communication [Davoli et al., 2019].

Moreover, small satellites have enabled the generation of educational initiatives for children aimed at developing new competences in the scientific field, such as STEM skills. Consequently, nano and pico satellites are used as tools to teach, train, and attract young talent for engineering and science, from workshops where STEM skills are the most important [Pelton and Madry, 2019]. In addition, small satellites have a promising future for applications and, through the constellations of satellites in LEO and their associated low cost, they allow a great technological development for the space sciences. These developments can be beneficial for many tasks, such as predicting natural disasters, remote

M2M communications, monitoring the environment and internet of things [Davoli, 2019]. Therefore, this project presents the analysis and development of a proposal for a pico satellite as a monitoring platform, and a Ground station using Internet of Things (IoT) and free tools to carry out a complete environmental monitoring mission.

2. Methodology

This project used an applied analysis strategy in four phases.

Phase 1: Review and analysis of the state of the art of small satellite development

Phase 2: Identification of components, hardware devices and their respective software, for the development of the pico satellite and the ground station.

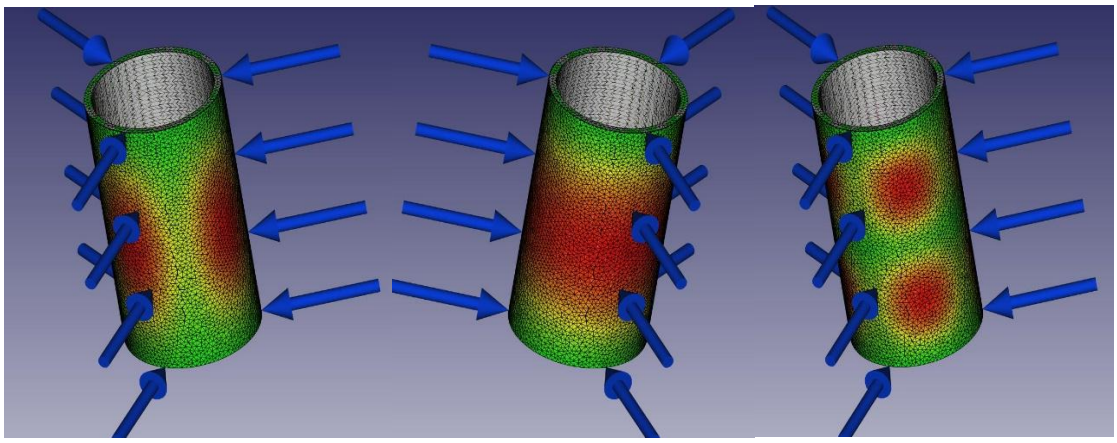
Phase 3: Study and testing of the sensors, and determination of the material for the structure material. Documentation of the method used was made.

Phase 4: Start the static tests. Final documentation of process.

The compilation of information was realized through databases and indexed journals in search engines. Next, the hardware technologies and software that are often used in pico satellites for university researchers were investigated, in order to make a proposal of low-cost technologies. After that, the programming tests of the different sensors and the LoRa protocol were established to communicate the data to the development board. Lastly, a proposal was created for the structure of the pico satellite and the ground station, from the performance of static tests. This allowed identification of an appropriate IoT design, flexible and with the least amount of communication failures between the pico satellite and the ground station.

3. Results and Discussion

The design of the pico satellite (as seen in Fig. 1) was made in the FreeCAD software, developing a 3D design of the body of the pico satellite resembling the shape of a drink can. Strength tests were also carried out satellite body, which was made of PLA (Polylactic acid) through an 3D printer, using Finite Element Method (FEM). In addition, a possible internal distribution of the sensors and the power system of the pico satellite was projected, thus obtaining the maximum use of the volume (as seen in Fig. 2).



(a) Mode 1. **(b) Mode 6.** **(b) Mode 10.**

Figure 1. Design on FreeCAD with frequency modes analysis applied to the structure of pico satellite.

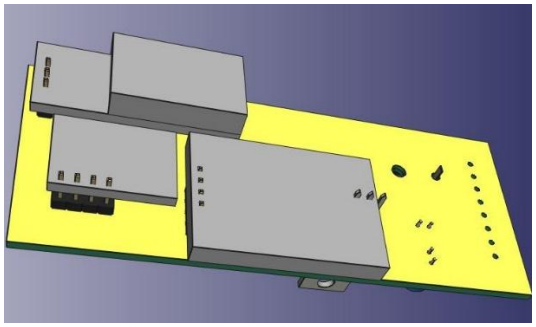


Figure 2. Distribution of sensors at PCB on FreeCAD.

This project includes sensors that allow obtaining atmospheric information and parameters for measuring the air, temperature, humidity, pressure and height of the CanSat, as well as data on the attitude of the CanSat, and the descent behavior, through gyroscopes, accelerometers and GPS.

All these data are transmitted from CanSat to the ground station implemented on a Raspberry Pi board (as seen in figure 3), by real-time telemetry through the LoRa communication protocol, in order to create databases and perform statistical analysis to interpret data and perform weather forecasts in adverse climates in the regions where these measurements are made.

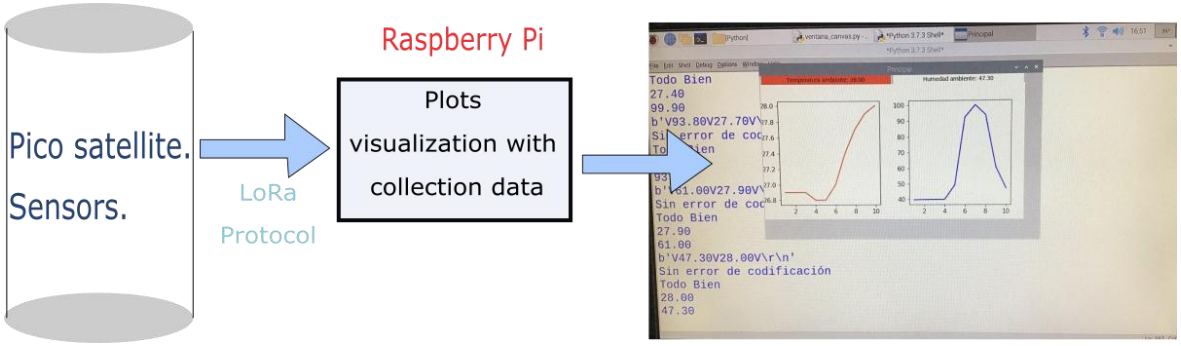


Figure 3. Propose of monitoring platform for ground station.

4. Conclusion

Through the analysis performed and the implementation of the pico satellite with its ground station, it had been evident that small satellites, can be helpful to perform different tasks in some areas of local and national interest, for instance agricultural, network and earth science applications.

Likewise, it was identifies the feasibility of a low cost model, that may interface with several satellite using IoT technology, in order to make a possible constellation of pico satellites within the atmosphere, making adequate use of LoRa protocol with small volumes of information.

Finally, it was proposed a ground station with Raspberry Pi board for showing information through a desktop application made using Python programming language, which makes the application a possible and viable development to be applied in different areas.

References

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