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A MECHATRONIC ENGINEERING APPROACH ON THE DESIGN OF A TELEMETRY, TRACKING, AND COMMAND SYSTEM FOR THE MONITORING OF A 3U CUBESAT NANOSATELLITE

Abstract

The design of a Communications system in Cubesat-type missions is a task commonly accomplished in a methodical and traditional procedure by a telecommunications engineer. In this work, a different approach is implemented to design and develop a reliable Telemetry, Tracking, and Command (TTC) system for a 3-Unit Cubesat, taking advantage of the scope of mechatronic engineering, including: the ability to integrate electromechanical hardware components and software, as well as control and automation in the processing of analog and digital information, contributing to the improvement of performance and efficiency in the transmission and monitoring of a satellite. The design is based on theoretical models such as the link budget calculation using the Normalized Signal to Noise Ratio Method (E_B/N_0), considering a ground station located in Aguascalientes, Mexico and the nanosatellite orbiting at an approximate altitude of 450 km (LEO orbit). Technical and theoretical study is automated with simulations executed in Matlab and STK (Systems Tool Kit) software, whose data obtained are processed using C++ and Python, so that through machine learning techniques transmission window times are optimized considering the analysis of the proposed orbits and their implications for data transmission and reception, including the use of frequencies, bandwidth, coding, automatic encapsulation of information, and transmission protocols for amateur missions. The results are implemented, tested, and validated on physical transmission devices using RF (radiofrequency) modules controlled by Raspberry Pi 3 Model B and Arduino Uno R3. Ultimately, this TTC system will be part of the first 3-Unit CubeSat nanosatellite developed by students from the *Universidad Panamericana* (Located in Mexico), in collaboration with Massachusetts Institute of Technology (MIT) and NASA Jet Propulsion Laboratory (JPL), this implies that the design is compatible with a proposed Concept of Operations (CONOPS), taking into account budget constraints, regarding mass, volume, price, data budget, and all possible interactions between other systems such as Avionics, Payload, or Software.