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Author: Mr. Sebastian Tepper
Chile

Prof. Cristian Chavez
Pontifical Catholic University of Chile, Chile
Dr. Holger Drass
Pontifical Catholic University of Chile, Chile

EDUCATIONAL PICOSATELLITE TELEMETRY AND DATA DOWNLOAD STATION

Abstract

This paper presents the design and implementation of an automated full-motion antenna for downloading telemetry and low-bitrate data from picosatellites operating in the UHF frequency band. The project provides a great opportunity to motivate undergraduate engineering students by involving them in the design and construction of an electromechanical system that integrates several engineering disciplines to produce a functional device. In addition, real-world design practices and constraints are enforced, such as using readily available materials, managing costs, and adding mechanical and personnel safety features.

An antenna designed for operation in the UHF amateur satellite band is placed in an XY mechanical mount that incorporates X- and Y-axis position feedback, mechanical end of travel signalling microswitches, and an interlock chain that disables power to the servomotors whenever a safety condition is broken.

In order to keep costs low and design complexity within undergraduate student level, the system only has download capability, so it is assumed that the satellite operator will command its picosatellite in advance in order to activate data transmission to Earth at the appropriate time, and no communication handshake needs to take place while data is being downloaded.

A helical antenna was chosen for its ease of design and construction, and because it provides adequate gain (around 14 dBi) with reasonable beamwidth (around 30 degrees). Automotive windshield wiper motors and gear reducers were selected to drive the XY mount due to low-cost, ease of availability, and low voltage operation. A simple frequency converter translates the UHF band of interest into the audio band, and this signal is sent to the Audio Card input of a PC computer for further processing and demodulation of telemetry and mission data.

The same PC computer runs an orbital prediction software to calculate in advance the necessary antenna pointing angles. An Arduino Microcontroller provides closed-loop control of the antenna position based on a preloaded Tracking Table containing Time, X-angle and Y-angle triplets every second for the entire duration of the satellite pass, typically between 120 and 720 seconds.

The design and implementation of this satellite station involves several disciplines of mechanical and electrical engineering areas, such as: mechanical design, proper material selection, automatic control, antenna design, RF amplification and downconversion, digital signal processing, and low-orbit satellite operation, giving a complete and balanced learning experience to students involved in aerospace and ground stations topics.