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Author: Dr. Raynell Inojosa
Philippine Space Agency, The Philippines

RADIO LINK ANALYSIS OF A CUBESAT-BASED IOT COMMUNICATIONS SYSTEM WITH AN INTEGRATED FRACTAL PATCH ANTENNA

Abstract

There is a rapid advancement in satellite-based Internet of Things (IoT) communications to employ a tiny cube-shaped small satellite, known as nanosatellite or cube satellite (CubeSat) to be deployed in low-earth orbit (LEO) mission due to its low cost, relatively fast development, and smaller space requirement for launching. Generally, the effectiveness of the CubeSat-based IoT communications system is determined by the link budget estimates, and one of the important components determining this is the performance of the antenna. Hence, the antenna should ensure a communication link between a CubeSat and a ground sensor terminal (GST) to support the required data rate.

In this work, an initial attempt to exploit the self-similarity features of the so-called fractals in the design of a patch antenna is discussed. Primarily, it intends to assess the performance of the designed fractal antenna mounted on a standard 1U CubeSat frame and compare its radiation characteristics with a commercial off-the-shelf (COTS) patch antenna resonating at the ultra-high frequency (UHF) band. A proposed antenna was optimized at a solution frequency, $f = 920$ MHz by adopting a commercial finite element method (FEM) solver for electromagnetic structures software, High Frequency Structure Simulator (HFSS).

A standard anechoic chamber test procedure was implemented at the Center for Nanosatellite Testing (CeNT) of Kyushu Institute of Technology (KyuTech) in Japan for measuring the radiation patterns of the fabricated fractal antenna. At $f = 920$ MHz, a reflection coefficient of -26.110 dB was determined. The minimum measured S11 was -30.364 dB at 906 MHz while -21.425 dB was obtained at 1 GHz. In addition, the integrated antenna achieved a measured peak gain of 3.148 dBi at $\phi = 0$ deg and 2.973 dBi at $\phi = 90$ deg.

The antenna was mounted on a standard 1U (10 cm x 10 cm x 10 cm) CubeSat, and its radio link performance was compared to the COTS antenna. Long-range test (LRT) campaigns were conducted and measurements indicated that the effective path loss was approximately -92 dBm. In comparison to the radio link performance of a CubeSat-based IoT communications system using a COTS patch antenna, the modified antenna has a greater link margin and the uplink packet success rate has become more stable. Both of these improvements were made possible by the fractal patch antenna's unique characteristics.