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ANALYSIS AND VERIFICATION OF COMMUNICATION LINK BUDGETS FOR SMALL SATELLITES

Abstract

This paper presents an in-depth analysis and verification method of communication link budgets for small satellites by comparing theoretical calculations with experiment results. This can be used to assess and improve link budgets throughout the development of future satellites. As case study, the VHF, UHF and S-Band links of the Delfi nanosatellite missions, developed by the Delft University of Technology, are investigated.

The theoretical background of the parameters involved in a link budget is studied in depth. Experimental results on the communication links of the completed Delfi-n3Xt satellite, as well as the operational satellite-ground link Delfi-C3, are provided. These results come from accurate measurements carried out on the satellite and the ground station in 2012 and early 2013. Among these measurements are the output power of all the radios, the attenuation introduced by connectors and cables and a comparison of power consumption and bandwidth with different modulation schemes and different data rates.

Special attention is given to one of the parameters, the receiver noise figure, whose theoretical calculations are complex due to the multiple factors affecting it. Both dynamic and steady noise is analyzed by measurements of the background noise at different times and under different antenna angles. This allows the set up of more accurate link budgets, which take dynamical behavior of this background noise into account. The results of the final link budgets of Delfi-C3 and Delfi-n3Xt are compared with the phase-A link budgets that were based on assumptions. It is shown that the difference is in the order of a few Decibel, which can have a major impact in the link quality and/or allowed data rate.

The results presented can be used by small satellite developers when making and analyzing the communication link budget. Recommendations are provided for measurements to be performed at the satellite and the ground station and the contingencies that should be applied at preliminary link budgets.