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SWARM TO EARTH COMMUNICATION IN OLFAR

Abstract

New science drivers have recently emerged in radio astronomy for observation of low frequency radio waves (below 30 MHz). Exploring this frequency band will provide better understanding of known cosmic phenomena and also reveal part of the so-called astronomical dark ages. However, man-made radio interference and ionospheric properties (scattering or opacity) make it difficult to observe these ultra-long wavelengths from Earth.

The Orbiting Low Frequency Antennas for Radio Astronomy (OLFAR) project aims to develop a distributed radio telescope in space sensitive to EM waves in the 0.3–30 MHz band using a swarm of 50 or more nano-satellites. The satellites will form a 100 km diameter cloud that will be placed either on a lunar or a dynamic solar orbit. They will observe the celestial radiation of interest, process the data in a collective manner and transmit the result to a base station on Earth. The peculiar positioning of the swarm results in harsh requirements for the communication layer. The downlink will have to support data rates of hundreds of kbps transmitted over a very large distance. Furthermore, attempting to realize all the aforementioned tasks with very small spacecraft adds complexity to the problem.

This paper describes the design of a reliable communication system capable of exchanging data with the OLFAR cloud. The main obstacle to overcome is the high path loss due to the large distance between the base station and the swarm. This can be partly compensated at the ground station. Highly directive parabolic antennas will be used to provide more than 50 dBi of gain. On the other hand, the limited size of the satellites will not be able to accommodate high-gain antennas. Patches are preferred as they can be integrated with the solar arrays and require no additional deployment mechanism. Power is also an important factor as it is a scarce resource for nano-satellites. The available power will be around tens of watts and will be shared by all subsystems (propulsion, processing, inter-satellite links, etcetera).

We present the design consideration of the downlink system for the OLFAR swarm. The communication between individual satellites and the base station is analyzed, and antenna system requirements are extracted from the link budget. We propose a communication scheme that exploits the spatial diversity of the swarm, in order to minimize the number of antennas and avoid the use of attitude control.