Paper ID: 8179

SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advanced Systems (1)

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ON THE USE OF GROUND ANTENNA ARRAYS FOR SATELLITE TRACKING: ARCHITECTURE, BEAMFORMING, CALIBRATION AND MEASUREMENTS

Abstract

Nowadays, ground stations which integrate the control segment of a satellite mission have as a common feature, the use of large reflector antennas for space communication. Apart from many advantages, large dishes pose a number of impairments regarding their mechanical complexity, low flexibility, and high cost. In the user segment, the use of planar arrays to substitute domestic reflectors will provide a more compact and easy to install antenna system and is an interesting solution e.g. for Satellite-On-The-Move (SOTM) systems.

Antenna arrays have several advantages over large dishes: the capability to track several satellites simultaneously, higher flexibility, lower production and maintenance cost, modularity and a more efficient use of the spectrum. In an antenna array, the computation of a close approach of the direction of arrival (DoA) and the correct performance of the beamformer depends on the calibration procedure implemented.

However, some issues must be considered during the design and implementation of a ground station antenna array: first of all, the architecture (geometry, number of antenna elements) and the beamforming process (optimization criteria, algorithm) must be selected according to the specifications of the system: gain requirements, interference cancellation capabilities, reference signal, complexity, etc. During implementation, deviations will appear as compared to the paper design due to the manufacturing process: sensor location deviations, and sensor gain and phase errors.

In the particular case of an active antenna array, due to the ageing of electronic components and temperature conditions, their gain and phase response will have a time-varying characteristic. Finally, mutual coupling between antenna elements will modify the theoretical antenna pattern that depends on the position of the elements. Because of that, a calibration procedure must be defined in order to track these changes and compute an adequate beamforming solution. In case of very large arrays, it is also very important to select a calibration procedure with low complexity in order to compute the array parameters in real-time.

In this paper, we present the above issues applied on the design of a conformal active antenna array for tracking LEO satellites named GEODA (Geodesic Dome Array). It is formed by 30+30 triangular arrays of 1 m side. Its structure is based on the use of triangular subarrays of 45 double stacked circular patches with their own LNA and phase shifter. Special emphasis will be done in the calibration techniques and the associated measurements and also results from field trials will be presented.