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Design, Manufacturing, and Testing of a Broadband Microstrip Array Antenna System for a 6U CubeSat X-Band Sensor

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The small-satellite antenna system reported here consists of 4 antenna units with individual receivers and it satisfies three challenging requirements. First, the antenna system can have a maximum protrusion of 7.5 mm from the surface of the 100 x 200 x 300 mm^3 satellite in order to fit into the launch vehicle. Second, each antenna unit must operate from 9 to 11 GHz, thus a bandwidth of 20%, with a gain of minimum 10 dB. Third, the phase radiation patterns of the 4 units must be similar within a few degrees of phase; since the units are located in different positions on the satellite this means that their radiation patterns must be insensitive to any scattering by the satellite structure. It is noted that at 10 GHz a phase change of 1 deg. corresponds to a free-space length change of 0.08 mm.

The first requirement is satisfied by low-profile microstrip technology. The bandwidth of the second requirement is met by a U-slot patch and a thick substrate, while the gain requirement is met by a 4-element array. This is turn requires a feed network, also in microstrip technology and located below the ground plane of the antenna to reduce spurious radiation, using Wilkinson power dividers due to the bandwidth requirement. The patches are probe fed by vias to the feed network. The thick substrate and the feed network, as well as the support structure of the antenna unit, necessitates the maximum protrusion. The third requirement is met by arranging the E-plane distance between antenna elements of the antenna unit so that the diffractions of their radiated fields at the edge of the satellite tend to interfere destructively.

The antenna system is designed by use of the integral equation / method of moment programme WIPL-D. The simulations include small- as well as large-scale features from the feed network connector land to the satellite surface. Space-qualified components, materials, and production techniques are employed for the manufacturing of the antenna system. The gain and radiation pattern are measured at the DTU-ESA Spherical Near-Field Antenna Test Facility.

This presentation will overview the complete development of the antenna system and it will address specific challenges and choices in the course of the design, manufacturing, and testing.

Below: The Antenna Layer with 4 U-slot patches and the Feed Network Layer with 3 Wilkinson power dividers of one Antenna Unit.

Right: Satellite model with 4 Antenna Units in the DTU-ESA Facility for testing of radiation patterns and gains.