Recent Results in Antenna Pattern Measurement with UAVs

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***Abstract* – A novel antenna measurement strategy has been developed to characterize both the embedded-element and the array patterns in the real installation conditions at low frequencies (50 MHz – 650 MHz) [1]. It exploits a micro Unmanned Aerial Vehicle (UAV) as a far-field test source.**

The system demonstrated good performance on the co-polarization radiation pattern of VHF and UHF antennas. Several results with reference antennas have been published [2, 3]. Further experiments have been performed on the Aperture Array Verification System (AAVS0) array and the Medicina Array Demonstrator (MAD), which also focus on the calibration of a small array and the beam forming.

This paper presents two recent experiments performed on a log-periodic antenna at 250 MHz and 350 MHz. Significant results have been achieved for both co- and cross-polarization patterns. Moreover, the symmetry of the test-source pattern has also been demonstrated.

1 INTRODUCTION

An important task in the development of new-generation radio telescopes which are based on large arrays, such as the low-frequency instrument of the Square Kilometre Array (SKA), is the characterization of the elements and the array radiation patterns, as well as the array calibration.

In the framework of the SKA, the authors developed an innovative antenna characterization system based on the Unmanned Aerial Vehicle (UAV) technology. The UAV is able to perform GPS-guided, constant-height flights above the Antenna Under Test (AUT), operating as a flying far-field test source to characterize the AUT in its installation conditions (over the soil, as array element, etc.). For this purpose, the vehicle has been equipped with a continuous-wave RF transmitter and a dipole antenna, as shown Fig. 1. The UAV position is determined by a GNSS dual-frequency receiver using a PPK positioning.

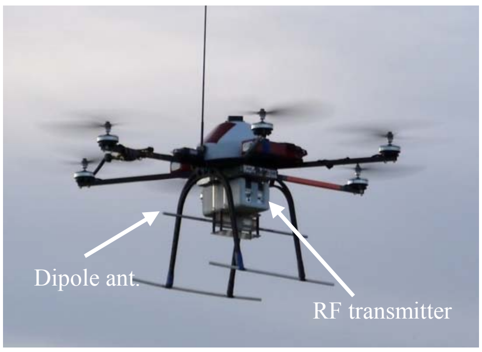

Figure 1: the UAV with dipole and RF transmitter.

The system has been successfully used to measure both embedded-elements and array patterns of a 3x3 array of Vivaldi antennas. Furthermore, the UAV has been used as a calibration source for the digital beam-forming system [4, 5].

This paper presents two recent experimental results obtained on a log-periodic antenna at 250 MHz and 350 MHz, which are focused on the evaluation of the symmetry of the test-source radiation pattern and the cross-polarization performance of the system.

2 TEST-SOURCE SYMMETRY

To investigate the symmetry of the test-source pattern, which depends on both the balun performance and the mechanical symmetry of the UAV structure, two experiments have been performed. At two different frequencies, the AUT has been measured performing two flights with opposite test-source orientations (compass angle 0° and 180°), which in principle should provide identical results.

Fig. 2 shows the measured E-plane co-polar patterns at 250 MHz. A good repeatability with both orientations has been obtained. The discrepancy between the two measurements is within 0.1 dB, and no asymmetry can be observed.

The agreement is satisfactory also in the 350-MHz case, shown in Fig. 3. The asymmetry of the measured data with respect to zenith is the same for both curves. For this reason, it is only related to the

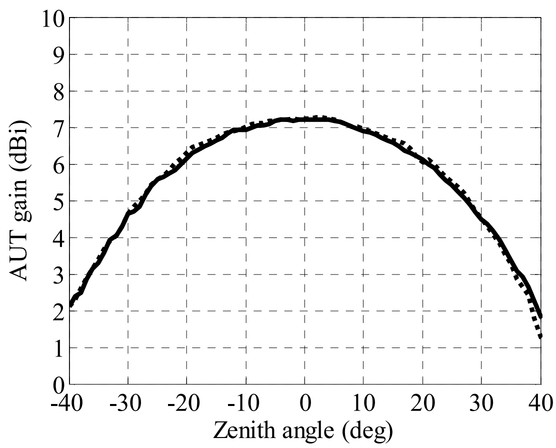

Figure 2: measured E-plane co-polar patterns at 250 MHz. Measurement with 0° test-source orientation (dotted), measurement with 180° test-source orientation (solid).

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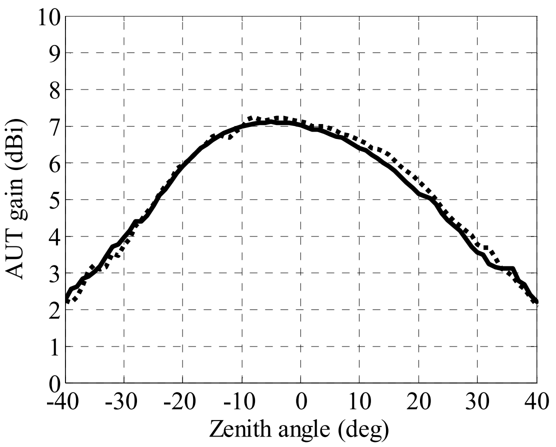

Figure 3: measured E-plane co-polar pattern at 350 MHz. Measurement with 0° test-source orientation (dotted), measurement with 180° test-source orientation (solid).

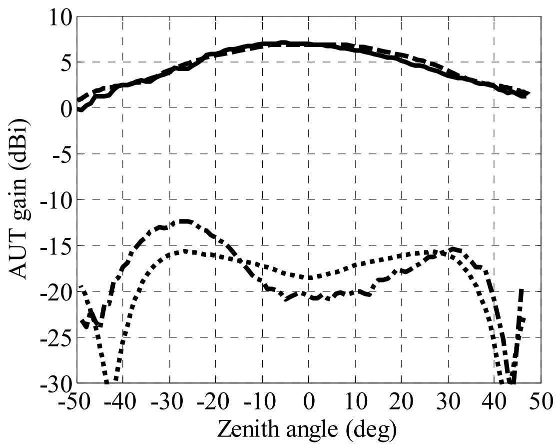

Figure 4: E-plane radiation pattern at 350 MHz. Co-polar measurement (solid), co-polar simulation (dashed), cross-polar measurement (dash-dotted), cross-polar simulation (dotted).

AUT, since an asymmetry of the test-source pattern would have instead shown a mirrored behaviour with respect to zenith. The discrepancy between the two measurements is within 0.3 dB, which is slightly higher than the case in Fig. 2, owing to slightly different path and wind conditions.

3 CROSS-POLARIZATION PATTERN

Fig. 4 shows the measured E-plane co-polar and cross-polar patterns of a log-periodic antenna at 350 MHz. Both measurements are compared with the simulations since no measured reference data are available at these low-frequencies. The antenna is placed on the soil and oriented at zenith.

For the co-polar pattern, the discrepancy between measurement and simulation is within 0.5 dB. A higher discrepancy can be observed for the cross-polar measurement. However, the consistency is good and an overall 25-dB cross-polarization level has been observed. These discrepancies are due to a) uncertainties of the test-source orientation with respect to the AUT (compass angle), which depend on the accuracy of both the Inertial Measurement Unit and the Flight Control Unit of the vehicle, b) mechanical uncertainties and alignment of the dipole on the UAV, c) mechanical uncertainties of the AUT and d) simulation accuracy (EM model and soil parameters).

4 CONCLUSION

Recent results obtained with the UAV-based antenna measurement system have been presented. The experiments highlighted both the symmetry of the test-source radiation pattern and the good cross-polarization performance of the system.

The measurements with opposite test-source orientations (0° and 180°) demonstrated a symmetrical behavior within 0.1-0.3 dB.

The cross-polar measurement, which is about 25 dB below the co-polar, showed a maximum deviation of 3 dB from the simulations.

References

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