UAV-based pattern measurement of the SKALA

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***Abstract*— A novel antenna pattern measurement technique has been recently developed exploiting the capabilities of a micro Unmanned Aerial Vehicle (UAV) as a far-field test-source. This technique is suitable for characterizing VHF antennas such as those for low-frequency radio astronomy. This paper presents some of the measurements recently performed on the Square Kilometer Array Log-periodic Antenna (SKALA), which has been selected as the receiving element for the Low Frequency Aperture Array (LFAA).**

I. Introduction

One of the new frontiers in Radio Astronomy is the observation of the Universe in the lower frequency band of the radio spectrum (between tens of MHz and few hundreds of MHz) using aperture array telescopes. Some astronomical instruments addressing this new area have already been commissioned, such as LOFAR (Low-Frequency Array) and MWA (Murchison Widefield Array). They consist of arrays of detectors which electronically form the beam in virtually all directions of the sky by properly tuning the phase of each element. In this context, the SKA (Square Kilometer Array), the largest radio astronomical facility currently along the preliminary design phase, will also include an instrument based on this technology. Indeed, the SKA low instrument will observe the sky from 50 MHz to 350 MHz with more than 250,000 dual-polarized log-periodic antennas called SKALA (Square Kilometer Array Log-periodic Antenna). In this paper we show some SKALA radiation patterns obtained with an innovative UAV (Unmanned Aerial Vehicle) system that allows a full antenna characterization including also the effects of the ground.

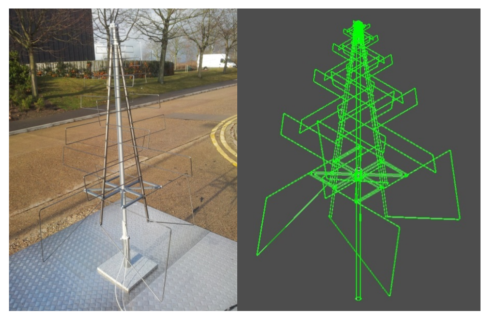

Fig. 1. The SKALA antenna outside the Cavendish Laboratory, Cambridge (left) and a computer model of the antenna used for the EM simulations (right).

A. SKALA

In order to achieve the demanding requirements of SKA [1], a log-periodic antenna has been designed and developed at Cambridge University [2]. The 3 main design targets were the maximization of the instrument's sensitivity across band (in m^2/K), the minimization of the cross-polarization ratios and low cost. The antenna consists of 9 wide dipoles capable of delivering excellent performance from 50 MHz to 650 MHz. The antenna is fed with a pseudo-differential amplifier directly connected to the terminals of the antenna in order to minimize the receiver noise temperature.

Fig. 1 shows a view of the antenna. The antenna was designed to be part of a disconnected array (the SKA-low 1 will have 1024 stations of 256 antennas each). The field of view of each antenna must be ±45 degrees from zenith. These fairly wide beam patterns, together with the close proximity to the ground and the long wavelengths at which we work, makes the characterization of these elements very complicated without

Fig. 2. The UAV during a measurement.

an innovative measuring system such as the one described in here.

B. *The Measurement System*

The *UAV antenna measurement system* is an outdoor far-field technique for the validation of the radiation pattern of VHF antennas and arrays [3]. The Antenna Under Test (AUT) operates in receive mode, whereas a small UAV, properly equipped with a transmitter and a dipole antenna (Fig. 2), is used as the test-source with linear polarization. The source, which can fly higher than 60 m over the AUT, following quasi-rectilinear paths, is used to scan the principal planes of the AUT.

The received RF signal at the two AUT ports (the antenna is dual-polarized) are measured using two spectrum analyzers in zero-span mode, both synchronized with the GPS timescale. These data are post-processed, together with the hexacopter position (GNSS) and orientation (inertial measurement unit) data, in order to extract the AUT pattern [4] [5]. The system is completely portable and does not require any particular infrastructure.

II. Experimental Results

The SKALA has been characterized at several frequencies from 50 to 650 MHz. The E-plane and H-plane patterns at 350 MHz are shown in Figs. 3a and 3b, respectively. Fig. 4 shows instead a H-plane pattern at 650 MHz. Both figures include co- and cross-polarization data. The measured patterns are compared to full-wave simulations showing good agreement. The discrepancy between measurements and simulations is generally within 1 dB in all the co-polar patterns. The cross-polar ones show an higher discrepancy but the overall shape is consistent. The difference can be probably attributed to the presence of the coaxial cables, small variations of the bearing angle during the flight and manufacturing uncertainties of both AUT and test-source. More results will be presented at the conference.

(a)

(b)

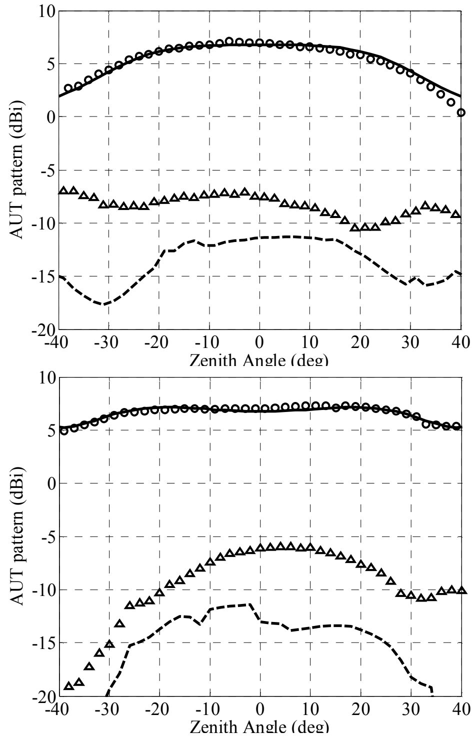

Fig. 3. Co-polar and cross-polar patterns at 350 MHz. (a) E-plane; (b) H-plane. Co-polar meas. (circles); co-polar sim. (solid line); cross-polar meas. (triangles); cross-polar sim. (dashed line).

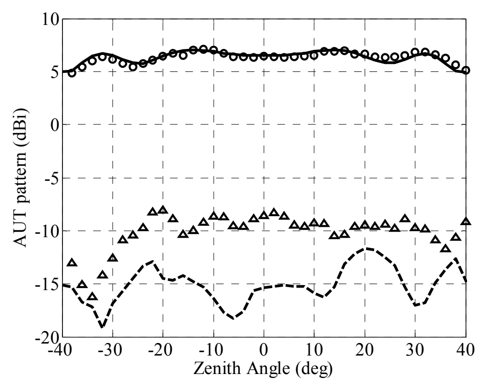

Fig. 4. H-plane, co-polar and cross-polar patterns at 650 MHz. Co-polar meas. (circles); co-polar sim. (solid line); cross-polar meas. (triangles); cross-polar sim. (dashed line).

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