6-15 GHz wide scanning connected array

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6-15 GHz Wide Scanning Connected Array

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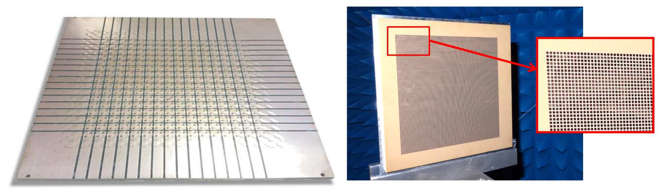
***Abstract*—In this work we report on the design, manufacturing and testing of a dual-polarized array of connected slots radiating in the presence of an artificial dielectric superstrate. The prototype array consists of 512 elements, i.e. 16×16 connected slots for each of the two polarizations. The antenna array is realized with a single multi-layer printed circuit board (PCB) and thus is low-cost compared to the typical configuration based on multiple vertically arranged PCBs. The performance is investigated in terms of simulated and measured matching characteristics and radiation patterns. The proposed structure achieves active voltage standing wave ratio (VSWR) lower than 3.1 over about an octave bandwidth (6 to 15 GHz), within a wide scan range (±60° in the H-plane and ±80° in the E-plane).**

I. Introduction

There has been a growing interest, in the last decade, in the development of phased arrays that can operate over wide bandwidths and wide scan ranges. Such characteristics are desired to support multifunction operation for both communication and radar applications and to reduce the number of antennas on complex platforms, where there is limited space available to accommodate an ever increasing number of sensors. To include communication services, these arrays should also provide polarization agility, to allow variable settings of radiation and higher information capacity.

Connected arrays have been proposed as one solution to realize wideband wide-scanning arrays [1]–[4]. However, most X- and Ku-band designs are based on array configurations where the radiating elements and the feed structure are printed on vertical printed circuit boards (PCBs) [4]. This arrangement can lead to costly assembly whose complexity increases when scaling down the array dimensions to operate at higher frequency.

The prototype array reported here (Fig. 1) is made with a single multi-layer planar structure, instead of vertical arrangement of the antenna PCBs, and it is based on the concept introduced in [5]. It consists of a dual-pol array of connected slots with artificial dielectric layers (ADLs) as a superstrate, with a 6-to-15 GHz bandwidth, with scan range to 60° or above. The artificial dielectric is used in place of a real dielectric because of its anisotropy, [6] which is a key property to avoid the excitation of surface waves and the occurrence of scan blindness. The ADLs also perform a wideband impedance transformation, as proposed in [7]. When the array is loaded with a single or multiple ADL slabs, the radiation from the slots is mainly directed upward, thus the distance from the ground plane can be greatly reduced without strongly degrading the impedance matching properties. This lower distance enables the realization of the feeding lines by means of standard via-hole technology, e.g. for X- or Ku-band designs. Consequently, a fully planar implementation of the array is enabled.



(a) (b)

Fig. 1. Photo of the array prototype: (a) connected array of slots and (b) same array with ADL superstrate.

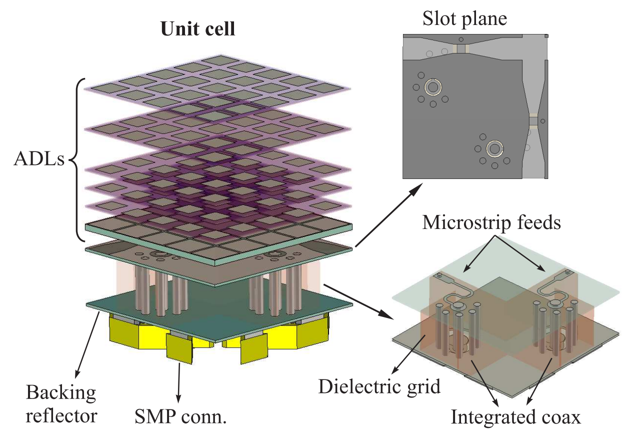


Fig. 2. Three-dimensional view of the final unit cell.

II. Array Prototype

The three-dimensional view of the unit cell with the details of the feeding structure is shown in Fig. 2. Based on the unit cell design, the prototype array in Fig. 1 has been manufactured, consisting of 512 elements, i.e. 16×16 connected slots for each polarization. Figure 1(a) displays the antenna board with connected slots before it is assembled with the ADL slab, whereas Fig. 1(b) represents a view of the entire array with the ADLs and the antenna bonded together.

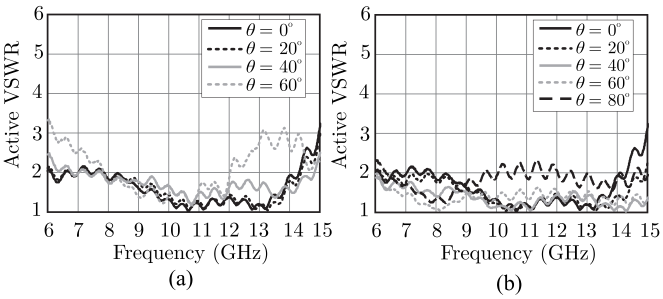


Fig. 3. Measured active VSWR of a central element of the array in the (a) H- and (b) E-plane for different scanning angles and in the presence of amplitude taper.

A. Measured Matching Properties of a Central Element

The measured active (VSWR) of a central element of the array is shown in Fig. 3, considering amplitude taper. The VSWR is lower than 2.6 from 6 to 14.5 GHz, scanning up to $40°$ in the H-plane and to $80°$ in the E-plane. The VSWR increases to 3.1 for $60°$ scan in the H-plane.

B. Measured Active Element Pattern

The active element pattern of central element of the array has been measured on the main planes and the two diagonal planes. The color maps in Fig. 4 show the element patterns as a function of angle and frequency, normalized to the maximum at each frequency. Small fluctuations of $2 \sim 3$ dB can be noted in the patterns, which are mainly due to reflection from the metal frame around the array and to edge effects [8], [9]. It can be observed that the X-pol levels are lower than 10 dB for the entire scan range and frequency bandwidth of operation, in both the main planes. However, higher X-pol levels ip to -5.5 dB are obtained in the diagonal plane ($\phi = 45°$), especially at the high end of the frequency range. Such result is consistent with what observed from simulations. The active element pattern is wider in beamwidth in the E-plane (Fig. 4(a)) as compared to the H-plane pattern. This is a consequence of the better matching performance of the array when scanning in the E-plane to wide angles.

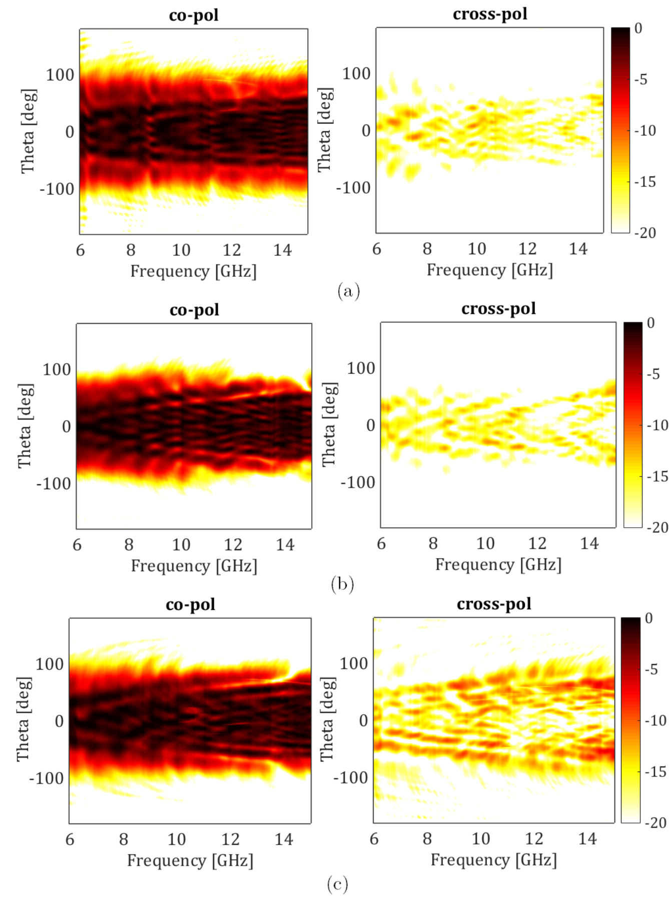


Fig. 4. Measured normalized co-polar and cross-polar active element patterns of a central element of the array for (a) $\phi = 0°$, (b) $\phi = 90°$, (c) $\phi = 45°$.

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