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A Wide Coverage S-Band Array with Dual Polarized Connected Bowtie Antenna Elements

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Abstract—A low profile dual polarized bowtie antenna element is studied for an S-band (3 GHz) wide-scan application in a large-scale (nearly an infinitely large) uniformly excited phased array. The study shows that the array with such elements, when connected, is capable of scanning up to ±75° at E-plane and ±15° at H-plane for horizontal and vertical polarizations respectively. The bandwidth of the infinite array with such elements across these scan angles is 10% and 25% for the active reflection coefficient of −10 dB and −5 dB respectively.

Keywords— A wide scan array, connected array, bowtie array, phased array, dual polarization.

I. INTRODUCTION

One of the main development trends in the aerospace industry is to improve the aerodynamic characteristics of an aircraft using lightweight structures to reduce fuel consumption and impact on the environment. Multifunctional structures with integrated systems like fuselage integrated antenna systems may provide, and improve sensor performance due to the great flexibility in the mounting position [1], [2]. The integrated solutions could be used for applications like air surveillance, satellite communication, electronics warfare, etc.

This paper presents a new antenna element which can potentially be used in such fuselage integrated antenna systems. The element is a dual polarized bowtie, and it is studied in an infinite connected array environment. In a connected array, the adjacent antenna elements are physically or electrically connected to each other, and hence are strongly mutually coupled in order to operate over a wide frequency band [3], [4]. In arrays, this connected element approach is considered as a suitable solution for wide-band, wide-scan applications [5]. This concept has been used for the dipole [5], Vivaldi [6] and slot [7] antenna elements. In this paper, the concept of connected array is implemented with a dual polarized bowtie element to achieve a relatively low profile (∼0.35λmax), wide scan (±75° at E-plane and ±15° at H-plane) antenna array.

II. ANTENNA CHALLENGES

The studied antenna structure is required to endure very tough environmental conditions. For example, wind pressure on the fuselage can reach up to around 4,000 Pa, static loads to 2g, and bending moment to 30,000 Nm. The operating temperature has a wide range from −65° C to +55° C. The array is targeted to have a high gain and wide beam scan angles with 20 × 200 (vertical × horizontal) antenna elements operating at S-band (3 GHz), while enabling the integration with a low profile conformal radome to the fuselage. The required active reflection coefficients (Γact) and the relative bandwidth at different operating conditions are given in Table I.

TABLE I: Electrical specifications of the antenna array

<table>
<thead>
<tr>
<th>Operating conditions</th>
<th>Bandwidth</th>
<th>Γact</th>
<th>Scan angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>10%</td>
<td>-10 dB</td>
<td>±75° at E-plane</td>
</tr>
<tr>
<td>Function</td>
<td>25%</td>
<td>-5 dB</td>
<td>±15° at H-plane</td>
</tr>
</tbody>
</table>

III. ANTENNA DESIGN

Fig. 1 shows the antenna element, antenna ports, cross-section view of the element and the array with the elements in the connected infinite boundary condition. The dual polarized element is realized by two orthogonal bowties which are above the ground plane supported by two pairs of pillars, each pair for each bowtie. One pillar in each pair is a coaxial feed line whose outer conductor is connected to the ground plane at the one end and to one arm of a bowtie at the other end, and whose inner connector is connected to the other arm of the same bowtie via a metal microstrip line on a small piece of PCB. The bowtie arm connected with the inner conductor is also connected to the ground via the second pillar (solid) in the same pair of the pillars. As in Fig. 1c, one of these two strips (for each bowtie) is in the top layer and the other one is in the middle layer of the PCB. These pillars functions as baluns that transform the single-ended antenna ports to the differential ports of the bowties.

This antenna element has a wide bandwidth and a broad embedded radiation beam pattern, which are essential for large scanning antenna array. The element is defined by several geometric and electric parameters, which introduces a few parametric freedoms for optimizing the scan reflection coefficients, especially at wide scan angles. The connected array structure is mainly used to improve wide scan capabilities. Furthermore, it also makes the array mechanically strong and resilient to strong vibrations because the elements support each other, and hence make a more stable structure.
The cross bowtie antenna element has promising simulation results in terms of a wide scan range for infinitely large arrays. In the same time, it exhibits possibility for the fuselage integrated antenna array design.

**REFERENCES**


