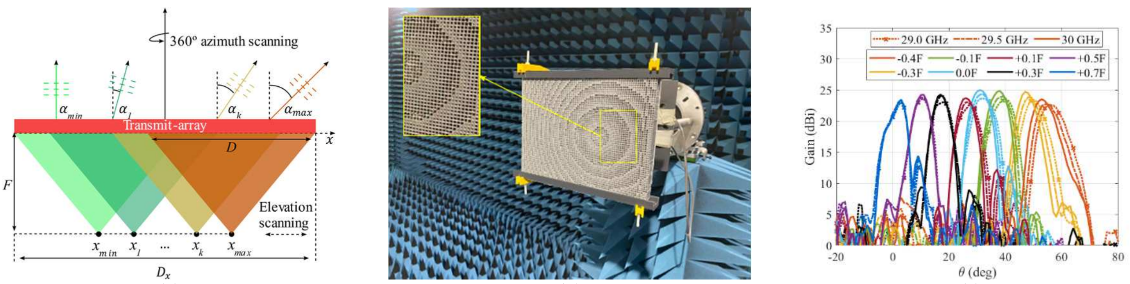
Low-Profile 3D Printed Transmit-array for Wide-Angle Beam Scanning at Ka-Band

Álvaro. F. Vaquero*(1,2), Sérgio Matos (2,3), Manuel Arrebola (1), Jorge R. Costa (2,3), João Felício (2,4), Carlos Fernandes (2,5), and Nelson J. G. Fonseca (6)
(1) Dept. Electrical Engineering, Universidad de Oviedo, Gijón, Spain, e-mail: fernandezvalvaro@uniovi.es.
(2) Instituto de Telecomunicações (IT), Lisbon, Portugal.
(3) Dept. Information Science and Technology, University Institute of Lisbon (ISCTE-IUL), Lisbon, Portugal.
(4) Centro de Investigação Naval (CINAV), Escola Naval, 1400-203 Almada, Portugal.
(5) Dept. Electrical and Computer Engineering, Instituto Superior Técnico (IST), Univ. of Lisbon, Portugal.
(6) European Space Agency, Antenna and Sub-Millimeter Waves Section, Noordwijk, The Netherlands.

Low-cost and compact antennas for wide-angle beam scanning in the mm-Wave band play a key role in the development of the next generation of terrestrial and satellite communication systems. Phased array antennas are currently getting a lot of attention for their excellent scanning with a low profile and mature manufacturing process [1]. However, the power consumption and losses due to their complex feeding network and large count of active components are still their main drawbacks. Both issues are overcome using spatially fed antennas (SFA) such as reconfigurable reflectarray (RA) or transmitarray (TA) antennas. These solutions avoid the feeding network, and the beam scanning is obtained using power-efficient controlling elements (PIN, MEMs, Liquid Crystal, etc.) [2]. However, they are still more costly and complex than solutions based on passive periodic structures combined with mechanical scanning (mainly reflector-based antennas, RA, or TA).

Passive TA antennas provide several advantages over the aforementioned solutions: low-cost compared with phased-array; more compact than reflector-based solutions, avoiding off-set-feed configurations, as well as feed blockage; and decrease the ratio F/D over RA- and reflector-based solutions [3]. In this sense, the F/D is usually around 1 in mechanical scanning alternatives, to achieve a good trade-off between the spillover and the illumination tapering. This F/D rapidly increases the profile of the antenna when using larger surfaces. However, to be competitive with phased arrays, much more compact terminals (F/D<0.4) are still needed to consider SFA systems as a realistic alternative.

In this work, we propose a general technique to address the design of low-profile (F/D<0.4) TA antennas with wide-angle beam scanning performance. This approach is based on an iteratively modified phase distribution that allows to average the phase aberrations as a result of the feed displacement among the different outgoing beams. To validate the design process, a prototype based on dielectric unit cells is fabricated and measured, allowing us to take advantage of additive manufacturing (AM) to reach a cost-effective solution in Ka-band. For this, the antenna is composed of a perforated dielectric slab of PLA fed by an open-ended waveguide (WR28) placed at a distance of 47.5 mm, reaching an F/D near to 0.34. The result is an ultra-compact antenna and easy to manufacture. The prototype scan performance goes up to ±50°, preserving the SLL below −10 dB, and scanning loss better than 1.5 dB at the central frequency of 29.5 GHz. Moreover, the dielectric implementation of the TA provides broadband operation demonstrating that the design technique is still effective for large operational bandwidth, in this case from 29 to 31 GHz.



(a) (b) (c)

Figure 1. (a) Sketch of the proposed technique (b) Prototype at the anecoich chamber (c) Measurements.

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