Wideband Dual Circularly Polarized Radiating Element Based on a Semi-Corrugated Waveguide

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In modern communication systems, particularly in satellite links, dual-polarized integrated systems are crucial to maximize link capacity while minimizing space and weight. Additionally, circular polarization is desirable for its effectiveness in reducing polarization mismatch losses, especially at higher frequencies, such as Ku or Ka bands. However, traditional PCB-based solutions encounter significant challenges in space environments due to harsh conditions, high power handling requirements, and increased losses associated with higher frequencies.

To address these challenges, research has been directed towards circularly polarized, low-loss waveguide antennas. Innovative designs, such as horns with hexagonal sections or septum-loaded horns, have been proposed to meet the demanding requirements of satellite systems. Recent advances propose fully metallic radiating elements that enable low-profile implementations of highly directive circularly polarized array antennas fed by corporate networks. Among the proposed solutions, those based on polarizers can achieve bandwidths of up to approximately 10%. Other proposed elements can increase the bandwidth up to 25%, but they lose the dual polarization capability.

This paper describes a fully metallic radiating element based on a waveguide that can produce dual circular polarization over a wide bandwidth. To achieve this, a quasi-square waveguide section with a pair of corrugated walls is used, which converts ±45º linear polarization into dual circular polarization. The addition of periodic corrugations slows the propagation of one of the fundamental modes and results in the appearance of a stopband. Both effects result in a phase difference between the waveguide modes that exhibits a parabolic behavior rather than a linear one. This considerably increases the bandwidth in which a very pure circular polarization of less than 1 dB of axial ratio can be achieved.

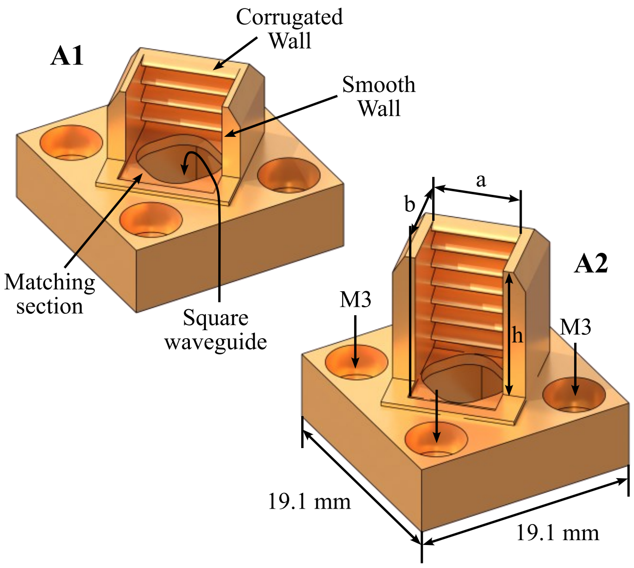

Fig. 1. Radiating elements based on a semi-corrugated waveguide.

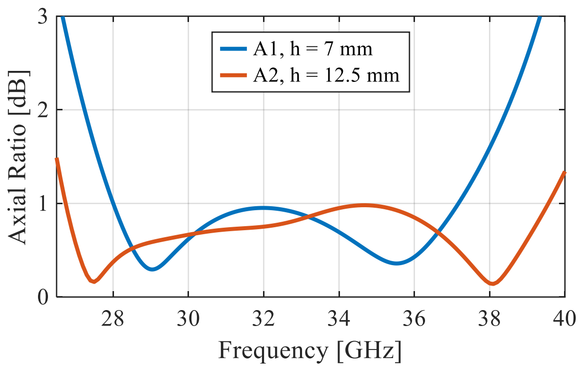

Fig. 2. Axial ratio of the designed radiating elements.

After studying the behavior of the semi-corrugated waveguide and analyzing its dimensions as a function of bandwidth and required length, two versions of the radiating element, shown in Fig. 1, are designed to demonstrate its versatility. The first, A1, is designed with the aim of obtaining a reasonably flat element, and with a profile of 7 mm (0.75 λ) consisting of four corrugations, a bandwidth with an axial ratio of less than 1 dB of 27.7% is obtained from 28 to 37 GHz. In the second prototype, A2, using a slightly larger 12.5 mm (1.4 λ) profile, the entire Ka band (26.5 - 40 GHz) can be covered with a very pure dual circular polarization, as can be seen in Fig. 2. Both prototypes are fed with a square waveguide to achieve dual circular polarization and the reflection coefficient is less than -15 dB over the whole band.

The radiating element is intended for integration into a planar waveguide array. Therefore, the axial ratio, bandwidth, and radiation patterns of a 4x4 array, as shown in Fig. 3, are presented last.

The proposed fully metallic radiating element has small dimensions, allowing for integration into an array with a low profile, while its versatile design enables the attainment of large bandwidths with very pure dual circular polarization.

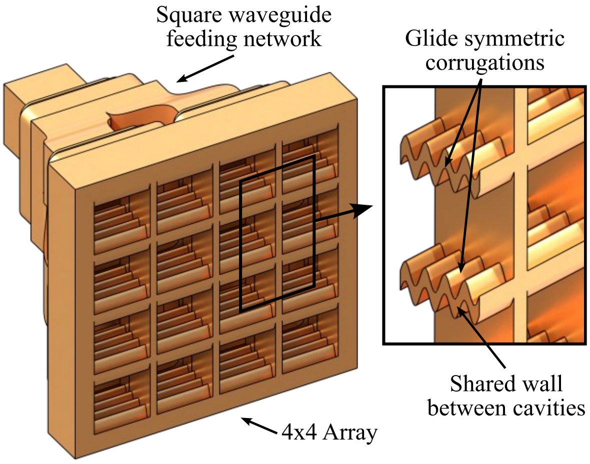

Fig. 3. 4x4 array based on the proposed radiating element.