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Analysis of cavity back antennas with characteristic modes

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The objective of the communication is to present the latest advances made by the authors in the design of cavity-back directive antennas in the sub-6 GHz band, with Ultra-Wide Band characteristics [1, 2]. A thorough study of several open cavity geometries was conducted, resulting in the determination of the characteristic modes, including currents, radiated fields, and frequency response. The theory of characteristic modes has had a great impact, due to its rigor [3] and applicability to antennas in the microwave band [4].

The studied open cavity geometries included square, circular, and coaxial cavities, as well as square coaxial cavities with different shapes of the inner conductor. The fundamental modes (TE_z, TM_z,) and the response of the cavity to the incidence of a plane wave were obtained. This allowed for the selection of most suitable characteristic modes for radiating in the broadside direction, which was determined to be a combination of TE and TM modes. Once the fundamental modes were known, the feed points were located, and a full-wave optimization was performed. The cavities were fed at multiple ports with capacitive monopoles with designs ranging from 2 to 10 ports.

As a design method we have used software developed by the Universitat Politècnica de València (UPV), together with the electromagnetic simulators Feko and CST. The prototypes have been built in metal, with numerical control milling machines. The measurements have been made in the anechoic chamber of the Antennas and Propagation Laboratory (APL).

Designs have been made with orthogonal polarizations with bandwidths greater than 100%. Circularly polarized antennas with similar bandwidth and MIMO antennas with up to 10 ports, were also designed, with isolation greater than 15 dB and return loss better than 10 dB over the entire bandwidth. The simulated and measured results showed unidirectional radiation pattern, a total efficiency higher than 85% and low envelope correlation coefficient (ECC).

This study demonstrates the successful application of the theory of characteristic modes to the design of cavity-back directive antennas with Ultra-Wide Band capabilities, offering promising results for future development in this field.

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References

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