

# An efficient study of circular microstrip antenna on suspended and composite substrates

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**Abstract** In this paper, an efficient full-wave analysis of a circular microstrip patch printed on suspended and composite substrates is performed using a dyadic Green's function formulation. Galerkin's technique is used in the resolution of the integral equation of the electric field. The TM set of modes issued, from the magnetic wall cavity model, are used to expand the unknown currents on the circular patch. The radiation patterns are expressed regarding the transforms of the currents. The convergence of the method is proven by calculating the resonant frequencies, half-power bandwidths, and quality factors for several configurations. The computed results are found to be in excellent agreement with those observed in the literature. The numerical results obtained show that the bandwidth increases with the increase in the thickness of the suspended or composite substrates, especially for low permittivity of the second layer. Also, it is demonstrated that the resonant frequencies of the circular microstrip patch on suspended and composite substrates can be adjusted to obtain the maximum operating frequency of the antenna. Finally, the effect of the presence of the second layer under the circular patch on the radiation patterns is also investigated.

**Keywords** Vector Hankel domain transforms · Galerkin method · Circular patch · Radiation pattern · Suspended and composite layers

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## 1 Introduction

Microstrip antennas have found pronounced acceptance in the electromagnetic and microwave theory practitioners due to their numerous advantages [1]. The interest in designing such microstrip antennas has increased because of lightweight, smooth production, conformability, flexibility in shapes and integration with solid-state devices [2–7]. Therefore, a considerable amount of research have been devoted to the characterization of different geometries of these structures. Particularly, a circular microstrip resonator can be used both as a separate antenna, or as a component of oscillators and filters in multilayered microwave and millimeter wave integrated circuits (MWICs) [1, 8, 9]. Regarding the inherent narrow bandwidth of this type of antenna around their operating resonant frequencies, it is important to develop accurate algorithms for the computation of those resonant frequencies [9]. To achieve enhanced operating bandwidths, the use of an air gap layer having an adjustable thickness between the substrate and the ground plane is also found to be useful in obtaining the wide band operation [10–12]. Therefore, a new structure having tunable properties is obtained for which a new resonant frequency formulation is required. Furthermore, the suspended substrate patch antenna is a particular type of a patch antenna on the composite substrate [12]. The advances on suspended and composite substrates have been encouraged, in the realization of microstrip transmission lines and antennas, and many works dealing with microstrip structures with suspended and composite substrates have been proposed [10–14]. This latter configuration presents some advantages, the most common benefits of using the suspended and composite substrates configurations are improving bandwidth and radiation characteristics, and a patch antenna made on a multilayered microwave and millimeter wave integrated circuits (MMIC) [10], and an