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Study of an Inverted Rectangular Patch Printed on Anisotropic Substrates

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ABSTRACT
The resonant frequencies and bandwidths of the inverted rectangular patch over anisotropic substrates are investigated in this paper. A rigorous analysis is performed using dyadic Green's function formulation in the vector Fourier transform domain. The Galerkin's technic is then used in the resolution of the integral equation; the complex resonance frequencies for the TM_{01} mode are studied with sinusoidal basis functions. The numerical results obtained are compared with previously published numerical results computed by means of the electromagnetic simulator "IE3D software". Good agreement is found in all cases among all sets of results. For an isotropic substrate, it is confirmed that the bandwidth decreases with increasing of air-gap layer for high permittivity and low thickness of the substrate. Also, we show that the resonant frequencies and bandwidths are highly dependent on the permittivity variations alongside the optical axis. Other theoretical results attained display that the resonant frequencies downtrend monotonically with increasing substrate thickness, the diminution being larger for the uniaxial anisotropy of the substrate. Finally, numerical results for the effects of uniaxial anisotropy in the substrate on the radiation of the inverted rectangular microstrip structure are also presented.

KEYWORDS
Air-gap layer; Anisotropic optical materials; Galerkin approach; Inverted microstrip antenna

1. INTRODUCTION

Microstrip patch antennas are very popular among the other antennas for the researchers due to their attractive features, such as low weight, simplicity of manufacture, and compatibility with Monolithic Microwave Integrated Circuits (MMIC), low fabrication cost, feeding is easy [1–3]. These qualities have resulted in wide applications of microstrip patch antennas in radar, satellite and mobile communications, multi-standard handheld devices supporting many standards such as GPS, Bluetooth, WiMAX, WiFi, etc. [4,5]. The main drawback of the microstrip antenna is its narrow bandwidth, low gain, and surface wave excitation [1]. There are various methods to enhance the bandwidth of the antenna like by using a thicker substrate with low dielectric constant [1], by using electromagnetic feeding method [6], or the use of multilayered dielectric substrates [7], employing stacked configuration [8], and use of slot antenna geometry [5]. It has been verified that multilayered dielectric substrates can be used to reduce the radiation losses by surface waves to enhance efficiency [7]. On the other hand, placement of such a dielectric cover over a microstrip antenna can provide protection against environmental hazards and, appropriately located, can increase the gain and the bandwidth of the antenna by changing the effective permittivity of the microstrip structure [7,9,10]. In the case, when the patch is deposited on the underside, hence, it is called "inverted patch". The main benefit of using an inverted microstrip structure is primarily affected by the air dielectric layer surviving in between the reversed patch and the ground plane [11]. Therefore, optimal integration of external components is very easy as only the air dielectric is present under the patch and the ground plane [12]. Thus, bandwidth should be enhanced without modifying radiation pattern and efficiency as the patch suffers no surface wave hazards due to air dielectric [11,12]. The anisotropy is either intrinsic of the material or artificially caused by the substrate fabricating process [12,13]. In the conception of MMIC and printed antennas, anisotropic substrates have been more and more popular [12]. Moreover, crystalline substrates are preferable in some applications because they have certain advantages over ceramics, such as higher homogeneity, lower losses, and lower variations from sample to sample [13]. Thus, the use of the anisotropic substrates has the possibility to improve the frequencies range of these devices/components, and offers more exactitude and litheness in the conception procedure [12–15].

The inverted antenna is a particular type of superstrate antenna geometry [11]. Various researches have deliberated the influence of the substrates on the resonant