

Study of Superconducting Equilateral Triangular Patch printed on Anisotropic Dielectric Substrates

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Abstract—The aim of this manuscript is the analysis of an equilateral triangular patch antenna (ETPA) based on superconducting patches using the cavity model and the electromagnetic knowledge in conjunction with the boundary conditions of the complex resistivity. The present method is chosen for the reason that, in contrast to precise techniques, it affords an improved qualitative thoughtful besides it requiring straightforward mathematical formulas. The obtained numerical results are presented for the dominant mode as well as the higher-order modes. A parametric study is carried out in order to study the influence of some physical and electrical parameters on the antenna performance taking in consideration the uniaxial anisotropy in the dielectric substrates. The obtained data of all the structures are evaluated with the calculated and measurement data mentioned in the literature.

Keywords- equilateral triangular antenna; superconducting patches antennas; cavity model; uniaxial anisotropy.

I. INTRODUCTION

Recently, the superconducting thin films use is increasingly spread over in the microwave components industry, like resonators and filters for the communication applications [1-2]. Due to the superiority they have been showing over their normal metal counterpart in performance at high frequencies such as: 1) resistance in surface is very lower in high T_c thin films contrasted to copper and gold, which correspond to high Q [3-5] and enhanced performance in passive microwave components. In additional the fewer losses in superconductors allows the implement low-dispersion compact designs [6]; 2) the frequency independent penetration depth, which means that the particle dispersion introduced into superconducting components become insignificant in frequencies of hundreds of gigahertz [5]; 3) Due to the small size and shorter interfaces, the propagation time can be greatly reduced [3-5], [7]. Microstrip patch antennas contribute to an essential task in wireless communication systems. Due to its compact appearance, low cost and flexible reshaping, it has become popular in microwave transmission. Thus, they have a wide set of applications in various systems like wireless equipment, wireless terrestrial and spatial communications [8-10]. Therefore, a several works have been done to characterize the different geometries of the patch. Though, the microstrip antennas have some limitations such as considerable feed radiation; low bandwidth and superior cross polarization which can be overcome by the use of an efficient technique and/or

design [11]. In recent years some studies have been done on how the microstrip antennas perform when the anisotropic dielectrics are used as substrates and they have shown that a good choice of uniaxial type anisotropic substrate is more expedient than the isotropic substrate, which makes the characteristics clear of wider bandwidth with various resonant frequencies [12-14]. The triangle patch antenna is among the shapes that have been attracting a lot of attention lately [15]. Having the same radiation properties as the rectangular antenna, the triangular patch geometry finds extensive use for the realization of microstrip antennas. Specifically, the equilateral triangle patch antenna In general, the equilateral type is the most commonly used as triangular shape since it has the advantage that the quality factor is high, as well as the advantage of filling less space compared to other shapes, such as rectangular and circular patches [16-18].

The objective of this work is to design and model, equilateral triangular patch antenna (ETPA) made from superconducting patches printed on anisotropic type substrates, using the cavity model based on electromagnetic knowledge in conjunction with the boundary conditions of the complex resistivity.

II. MATHEMATICAL FORMULATION

The figure 1 shows the geometry of an ETPA whose radiating element (patch) made by a superconducting material, of thickness t , and lateral length s . This patch is printed on a monolayer dielectric substrate of thickness h , Featured by the vacuum permeability μ_0 , and a permittivity ϵ_r .

A. Antenna Resonance Frequency

In order to calculate the resonance frequency of ETA, the triangular patch has been replaced by the rectangular patch (width W and length L) that has the same equivalent surface. Based on our equivalence relation, we have:

$$W \cdot L = \left(\frac{\sqrt{3}}{4}\right) \cdot s^2 \quad (1)$$

such as:
$$L = \left(\frac{3}{4}\right) \cdot s \quad (2)$$

The width W of the rectangular patch was obtained from equations (1) and (2) as follows:

$$W = \left(\frac{1}{\sqrt{3}}\right) \cdot s \quad (3)$$