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Design and Analysis of Microstrip Photonic Band Gap Filter without Etching Ground Plane

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Abstract—A design of microstrip photonic band gap (PBG) filter is presented in this paper. The band reject filter is compact in structure and provides accurate band gap. The proposed filter has a periodic configuration; the impedance distribution over the length of each period is varied according to a designated sinusoidal function. Both theoretical and experimental results indicate that a bandstop filter with an extremely wide bandwidth can be achieved. Detailed analysis of the frequency response of the PBG filter is carried out in this paper.

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1. INTRODUCTION

Recently filters design has become an active research area since filtering is important when used in close proximity to other circuit components like power amplifiers in the transmitter part and low noise amplifiers in the receiver part in various RF applications. Filters can be implemented using shunt stubs [1] or stepped impedance lines in microstrip circuits [2], but these techniques require large circuitry and provide narrow band operation, along with spurious pass-band in stopband [3]. PBG structures provide an alternate solution of these problems in microwave applications.

Microstrip lines incorporating photonic band gap structures exhibit slow wave characteristics which can be exploited to control the size of circuit layouts and periodicity. PBG structures are periodic in nature, where the propagation of waves is not allowed for some frequency bands or directions, according to the Bragg phenomenon [3]. This is quite similar to the energy band gap concept in solid-state materials, photonic crystals, etc., which provides a mean to control propagation of electromagnetic wave.

Earlier a wide range of filters based on photonic band rejection concept were reported [4–6]. The majority of them have holes in substrate or periodic patterns etched in the ground plane. Such structures have a packaging problem when being implemented as MMICs [7]. The present work considers the design of a photonic band gap filter with optimum design parameters and without ground plane etching. The conducting strip is a periodic structure varied sinusoidally along the microstrip line with the characteristic impedance being a function of its length. Rigorous analysis is required to synthesize such a circuit, particularly for the sinusoidally varying periodic pattern on the top of substrate, which is very difficult to calculate. Hence, the moments method IE3D simulation software [8] has been used for the complete analysis. Subsequently the obtained result is analyzed and discussed.

2. FILTER DESIGN AND ANALYSIS

The concept of microstrips with sinusoidal variation of the microstrip line's width and without etching in the ground plane was presented early in 1984 by Nair and Mallick [9]. In the present work a microstrip structure with six periods of a fundamental element, called "cell," is suggested. The layout of the band stop filter is shown in Fig. 1. The characteristic impedance of the fundamental element has a sinusoidal variation along its length, as given by the following equations, reported by [10],

$$Z_0 = 50 - (50 - Z_{\min})\sin(2\pi x / L) \quad \text{for} \quad 0 \le x \le L/2, \tag{1}$$

$$Z_0 = 50 + (Z_{\max} - 50)\sin(2\pi x / L) \quad \text{for} \quad L/2 \le x \le L, \tag{2}$$