A microstrip resonator filter using sandwich structure

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1 Introduction

Recently, for stopping the propagation of certain frequency bands of electromagnetic waves, the transmission characteristics of microwaves, a photonic band gap (PBG) microstrip filter has become more noticeable. Due to the volume of this filter being very large, the PBG microstrip filter expands very slowly. The planar compact PBG [1] and frequency-selective surface (FSS) [2] structures, which are characterized by the pass and stop bands for electromagnetic waves, are more and more interesting because of their smaller volume, easier integration, and lower cost [3–7]. In this paper, a microstrip resonator filter, which is based on a sandwich structure substrate with a fractal pattern, is designed and investigated.

2 Design of the resonator filter

The architecture of the microstrip resonator filter with the sandwich structure substrate is shown in Fig. 1. It shows the cross section of the sandwich structure of the microstrip resonator filter. The first layer is the microstrip, the second layer is the substrate, the third layer is the fractal pattern, the fourth layer is the substrate, and the bottom layer is the ground plane.

The fractal pattern [8, 9] (see Fig. 2) is generated from a golden line of length \( L = 8 \text{ mm} \), which is between the ground plane and the microstrip. This golden line is defined as the first level of the fractal structure, and is placed parallel to the \( x \) axis in the \( xy \) plane. The \((k+1)\)th-level structure contains \( 2^k \) lines, with the midpoint of each perpendicularly connected to the ends of the \( k \)th-level lines being scaled from that of the \( k \)th-level line by a factor of two if \( k \) is an even (odd) number. In the experiments, four sets of metallic fractal patterns are studied, while the thickness of the metal lines in the patterns is 0.1 mm and the line width is 0.2 mm.

The microstrip resonator filter (see Fig. 3) is fabricated by the shadowing/masking/etching technology of a multilayer, which has been printed on circuit boards. The microstrip is based on the first substrate, the thickness of the microstrip is 0.1 mm, and the line width is 1.8 mm, so that the characteristic impedance of the microstrip is 50 \( \Omega \). The metallic fractal pattern is between the first substrate and the second substrate, and the substrate of the microstrip resonator filter is made of the microwave material FR4. The dielectric constant of FR4 is 4.3, and the thickness of the substrate is 0.6 mm. The ground plane is made of Au and the thickness is 0.1 mm.
discontinuities is of great importance, since many complicated circuits can be realized by interconnecting microstrip lines with these discontinuities and using transmission line and network theory. In this simulation, the background material of the microstrip filter is air, the boundary conditions of the microstrip filter are free space beside the ground plane, and it is assumed that the electric field is zero. The excited signal is the normal Gaussian signal and the frequency range is from 0 GHz to 10 GHz. By the simulation of FDTD, we obtain results in the time domain and then obtain results in the frequency domain from a fast Fourier transform (FFT) algorithm.

The attenuation center frequency for the proposed microstrip filter is about 1.3 GHz, 4.1 GHz, 6.5 GHz, and 8.3 GHz, and the attenuated magnitude of the attenuation center frequency exceeds 7 dB. It is believed that almost no electromagnetic waves propagate at those center frequencies. There are some pass bands at other frequency ranges, and then the microstrip resonator filter shows the transmission characteristics of multiple gaps. The excellent agreement between the measured and simulated results in the overall frequency range shows the appearance of the properties of the PBG and FSS in the above microstrip resonator filter. From Fig. 5, we find that the physics of multiple pass and stop bands is dictated by a series of ‘magnetic resonances’ inside the multiple-layer substrate.

by the vector network analyzer. Before the measurements are conducted, the equipment was calibrated by using a coaxial matching method. It is seen from Fig. 4 that the simulated spectra of reflected (S11) and transmitted (S21) microwaves show multiple gaps from 40 MHz to 10 GHz.

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