Microstrip Posts and Dielectric Resonators Showing a Steep Slope at Lower and Upper Stopbands for Bandpass Properties

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***Abstract*—In this letter, two types of novel microstrip structures providing a steep slope at lower and upper stopbands for bandpass characteristics will be proposed. The structures have been formed by means of TEM mode dielectric resonators and capacitive or inductive shunt posts in microstrip line. Equivalent circuits of various combined structures have been formulated. S-parameters of the structures have been obtained from a series of experiments and equivalent circuit calculation, and have been compared with each other. The result has also been compared with the measurement and the equivalent circuit calculation for the inductive block.**

***Index Terms*—Bandpass property, microstrip post, TEM mode dielectric resonator.**

I. Introduction

Vertical shunt posts in microstrip line [1] are found in relatively few microwave circuit applications. They could be compared to inductive posts in rectangular waveguide [2]–[5]. At present, such shunt posts cannot provide narrow band pass characteristics in microstrip filters.

When designing a bandpass filter based on coupled parallel resonators, attenuation poles providing a steep slope at lower and upper stopbands are desirable characteristics [6]. Such poles can be found in elliptical filters. These characteristics can be obtained by inserting a capacitor or inductor in series with a parallel resonator, as shown in Fig. 1.

It is not obvious how one could insert a capacitor and/or inductor in series with a microstrip resonator, even though some techniques providing capacitive or inductive effects have been studied in order to reduce the filter size and the number of resonators required in designing bandpass filters [7]–[9].

In this letter, the two problems of directly inserting a capacitor and/or inductor and of obtaining narrow bandwidth have been studied by introducing two novel structures. The first structure with an attenuation pole at the upper stopband is realized by means of an inductive post in microstrip line. The second structure with the pole at the lower stopband is realized by means of a capacitive post. Equivalent circuits of the structures have been formulated. The equivalent circuit simulation agrees well with experimental results. The FDTD simulation [10] with PML absorbing boundary conditions [11] has been used for the inductive block.

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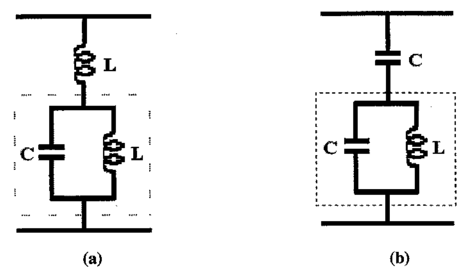


Fig. 1. Equivalent circuits of a parallel resonator with attenuation poles (a) at the upper stopband and (b) at the lower stopband.

II. Structures and Equivalent Circuits

Two types of structures, namely, inductive and capacitive blocks, have been implemented in the 50 Ω microstrip environment using RT-Duroid substrate with relative permittivity 2.33 and 0.78 mm thickness. The dielectric resonator mounted on the microstrip has an input impedance of 18 Ω in a square coaxial structure, consists of material with $\varepsilon_r = 38$, has the $\lambda/4$ length at the resonant frequency of 1950 MHz, and a Q value of approximately 500.

Fig. 2 shows an inductive block and its equivalent circuit. This structure is composed of an inductive post placed below the center conductor of the 50 Ω microstrip and a square coaxial dielectric resonator mounted below the ground plane of the microstrip line.

A capacitive block and its equivalent circuit are shown in Fig. 3. This structure is composed of a mainly capacitive post in the center of the microstrip gap, the dielectric resonator mounted on the center of the microstrip gap, and a thin dielectric sheet placed between the dielectric resonator and the center conductor.

Inductive blocks consisting of one and two resonators are shown in Figs. 2(c) and (d), respectively. In the latter case, two inductive posts are connected at the edge of the center conductor, as shown in Fig. 2(d), resulting in a narrower bandwidth. Both types of structures have been analyzed by FDTD with PML absorbing boundaries. In Fig. 4, $|S11|$ and $|S21|$ of the twin inductive blocks obtained by FDTD calculation, equivalent circuit calculation, and experiments are compared, and attenuation poles due to inductive posts are shown at the upper stopband at around 3 GHz.

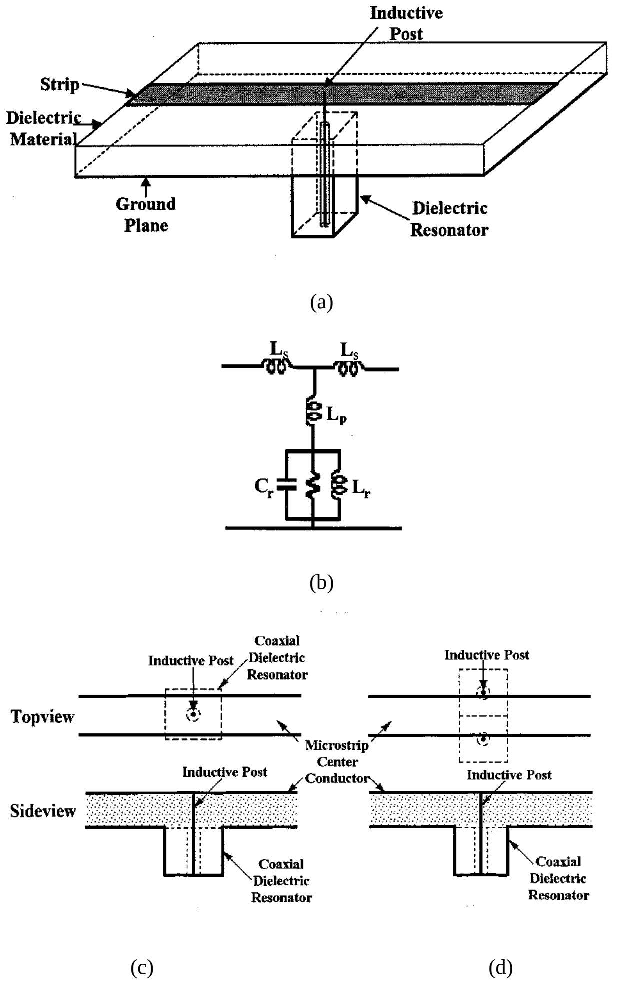


Fig. 2. Inductive block having an attenuation pole at the upper stopband. A dielectric resonator is placed the microstrip. Connection between the center conductor and the resonator has been done with an inductive post. (a) 3-D geometry of the inductive block; (b) its equivalent circuit; (c) geometry showing one resonator mounted; and (d) geometry showing two resonators mounted.

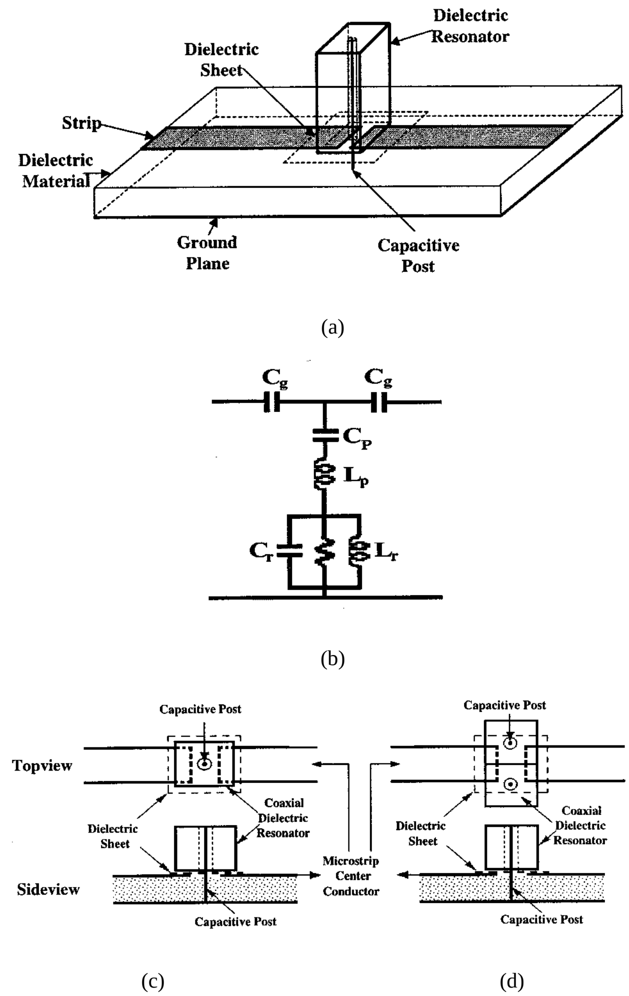


Fig. 3. Capacitive block having an attenuation pole at the lower stopband. A dielectric resonator is placed on the microstrip. Connection is done by using a capacitive post through the microstrip gap. A thin dielectric sheet between the center conductor and the resonator is used. (a) 3-D geometry of the capacitive block; (b) its equivalent circuit; (c) geometry showing one resonator mounted; and (d) geometry showing two resonators mounted.

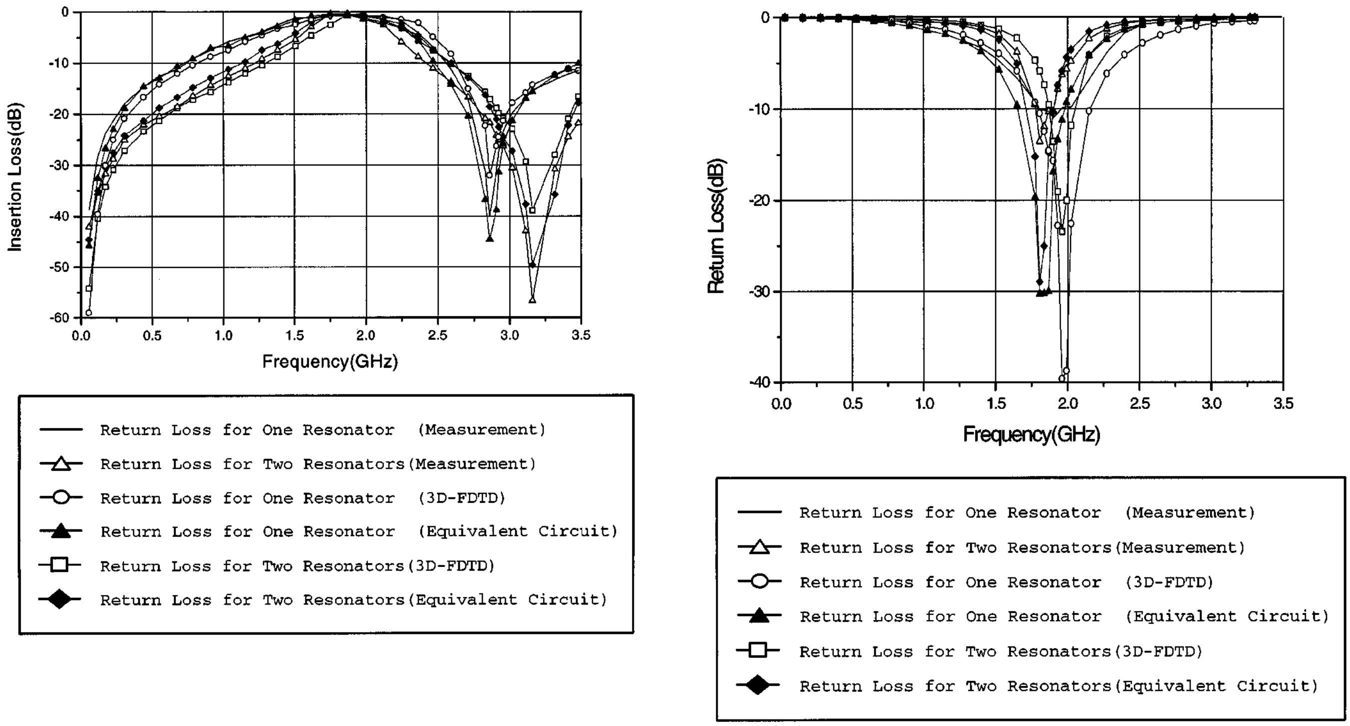
The capacitive block has been realized with a 1 mm gap in the 50 Ω microstrip line and a post of 0.57 mm diameter, as shown in Fig. 3. Fig. 5 shows the comparison between experimental and equivalent circuit calculation results for the cases of one and two mounted resonators. Even though in this figure attenuation poles are shown at both of the lower and upper stopbands, capacitive effect is deeper than the inductive one. The reason why the attenuation poles are at both of the stopbands is that inductive component is in series with capacitive one, as shown Fig. 3(b). Fig. 5 also shows that the bandwidth becomes narrower as one more resonator is added on the same transverse plane. In order to mount two resonators, two capacitive posts have been placed at the edge of the gap, located differently than the single post in the center of the gap.

The equivalent circuits of Figs. 2(d) and 3(d) are the same as Fig. 2(b) and Fig. 3(b), respectively, but they should have different values for the circuit elements.

The $|S21|$ comparisons for one resonator show the worst differences between the measurement and the equivalent circuit calculation are 1.2 dB for the inductive and 0.3 dB for the capacitive blocks for the frequency range approximately from 0.5 to 3.5 GHz.

III. Conclusion

In this letter, two novel microstrip structures showing bandpass characteristics have been introduced. The first type consists of square coaxial dielectric resonators coupled to microstrip using an inductive post running under the microstrip ground plane. The second type consists of square coaxial dielectric resonators coupled to the microstrip center conductor using a gap in the microstrip line and a capacitive post. The two resonators on a microstrip transverse plane transfer more RF input energy to the output at the resonant frequency due to parallel resonance. Therefore, for narrower bandwidth, two resonators have been mounted in parallel. The equivalent circuits of the basic blocks have been ex-



(a) (b)

Fig. 4. (a) $|S21|$ comparison for experiment, equivalent circuit calculation, and 3-D FDTD simulation for the inductive blocks with one and two resonators. (b) $|S11|$ comparison for experiment, equivalent circuit calculation, and 3-D FDTD simulation for the inductive blocks with one and two resonators.

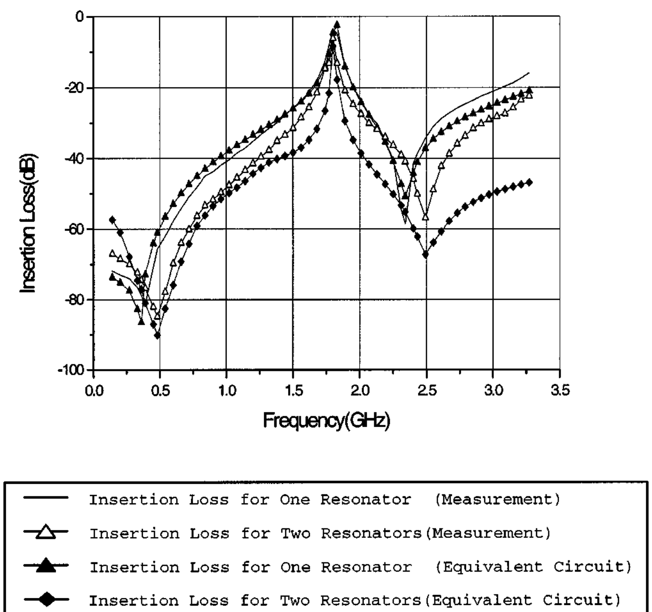


Fig. 5. Insertion loss characteristic comparison for experiment and equivalent circuit calculation for the capacitive blocks with one and two resonators.

tracted. The capacitive structure, shown in Fig. 3, exhibits narrower bandwidth than the inductive type in Fig. 2.

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