Frequency Tunable Monopole Patch Antenna Using Broadside Coupled Split Ring Resonator for Wireless Communication Applications

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Abstract – **This paper presents metamaterial based monopole patch antenna capable of tuning the radiating frequency over a wide bandwidth. The proposed novel antenna structure makes use of the metamaterial properties of Broadside Coupled Split Ring Resonator (BCSRR) for frequency tuning. The magnetic resonant frequency of the proposed antenna can be tuned by slightly adjusting the interplanar distance between the rings of the BCSRR so that the coupling due to effective capacitance and inductance between them can be changed. The desired range of frequency tuning for potential applications like Global System for Mobiles (GSM), Bluetooth, Wi-Fi, Wi-Max, WLAN etc. is achieved by proper designing of the geometrical parameters of BCSRR. The different antennas for different applications in a single device can be replaced with the proposed novel metamaterial based antenna structure.**

I. Introduction

Tremendous advancements in the field of electronic wireless communication industry pose the necessity of developing antennas capable of frequency tuning. Recent developments in multiband operation of antennas using a radiating patch with electromagnetic metamaterial components [1] have gained a great attention in the wireless communication field due to its capability of altering the radiation performance having negative values of permittivity and permeability [2]. Frequency reconfigurable antennas using various designs and techniques are also noticeable achievements in this field. Even though these antennas have properties like light weight, compactness, ease of fabrication and easy integration with other microwave components, the property of tuning the frequency continuously in a wide range is not achieved.

Broadside Coupled Split Ring Resonator (BCSRR) is a metamaterial component which exhibits negative permeability [3, 4, 5]. The proposed monopole patch antenna makes use of the BCSRR properties for frequency tuning. Since the magnetic resonant frequency of the BCSRR depends on its effective capacitance and inductance of the rings, the geometrical parameters of the BCSRR rings like inner and outer radii, split width and interplanar distance between them play important role in designing the frequency tuning range. The fabricated antenna exhibits high reflection coefficient magnitude in a 1.7 GHz tuning range which includes frequencies for potential applications like Global System for Mobiles (GSM), Bluetooth, Wi-Fi, Wi-Max etc.

II. BCSRR Loaded Monopole Patch Antenna

The layout of BCSRR loaded monopole patch antenna is given in Fig.1. The BCSRR is fabricated distinctly from the conventional manner where the two rings are separately etched photo chemically from thin sheets of copper with thickness 20 μm . One of the two rings of the BCSRR is fixed on the dieletric substrate of the antenna very near (0.3 mm) and side by side to the monopole patch as the slit faces the patch and the center of the ring is at a distance of 16 mm from the feed end. The second ring fixed on another piece of a dielectric substrate is arranged near the first ring co-axially such that the interplanar distance between the rings (d) can be varied continuously for frequency tuning. In this work a mechanically tunable antenna is designed since the mechanical realization of tunablity is comparatively easy to procure. The monopole radiating patch and the ground plane are also made

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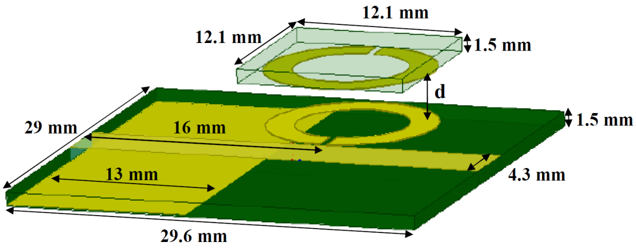

Fig. 1: The layout of BCSRR loaded monopole patch antenna.

from copper sheets of thickness 20 μm. The dielectric substrate used is a PVC foam sheet (thickness 1.5 mm) of relative permittivity 1.2 and dielectric loss tangent 0.001. The structural dimensions of the rings are inner radius 4 mm, outer radius 6 mm and split width 0.5 mm.

III. Results and Discussions

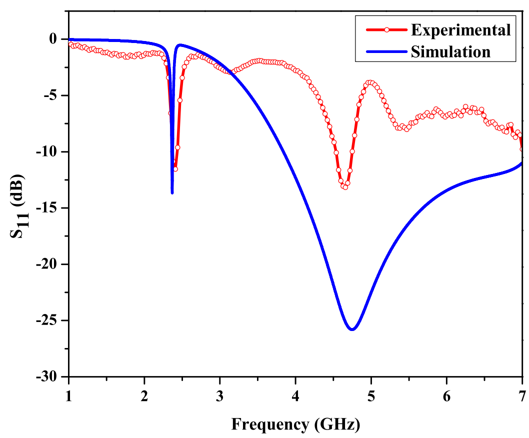

Fig. 2: S_{11} characteristics of the BCSRR loaded monopole for a typical spacing $d = 0.3$ mm.

The experimental and simulation S_{11} characteristics of the BCSRR loaded monopole antenna versus frequency at an interplanar distance of $d = 0.3$ mm is depicted in Fig.2. The notch at the vicinity of 5 GHz is due to the monopole which is not tunable while the additional notch near 2.5 GHz is due to the coupling between monopole and BCSRR which is tunable. The S_{11} characteristics versus frequency for different interplanar distances between the rings are plotted in Fig.3. The geometrical parameters of the rings are so selected that the range of frequency tuning includes the frequencies for applications like GSM, Wi-Fi, Bluetooth, Wi-Max, WLAN etc. It can be seen that a frequency tuning of range 1.7 GHz - 3.4 GHz is possible by adjusting the interplanar distance between the rings from 0.15 mm to 0.85 mm. The magnetic resonant frequency of the BCSRR depends on the self inductance of the rings, mutual inductance between the two rings, mutual capacitance between the rings and the capacitance of the two splits. The mutual inductance between the two rings is relatively small compared to the self inductance of the two rings and the capacitance of the splits is also small compared to the mutual capacitance between the rings. So the variation in magnetic resonant frequency of BCSRR is mainly due to the changes in the interplanar distance between the rings which in turn changes the self inductance of the rings as well as the mutual capacitance between the rings. Thus a tunable radiating frequency is achieved in the proposed antenna by coupling the BCSRR with the monopole patch.

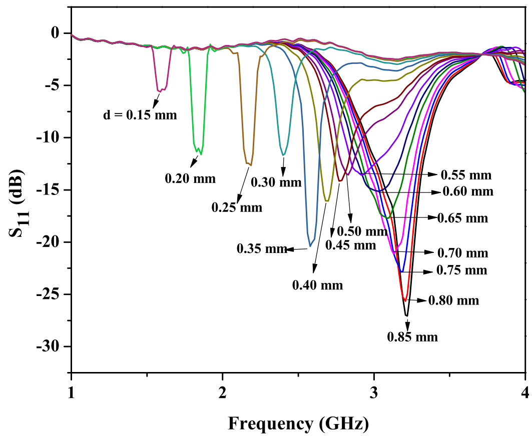

Fig. 3: The S_{11} characteristics of the BCSRR loaded monopole patch antenna at different interplanar distances, *d*.

The geometrical parameters of the monopole patch have been estimated to provide an additional resonant frequency in the vicinity of 5 GHz which is not tunable. It can be used in the upper Wi-Max band. The tunable frequency range (1.7 GHz to 3.4 GHz) may also be shifted to other frequency regions by changing the geometrical dimensions of the rings. This novel design may be useful for applications where more than one frequency radiation can be achieved using single antenna.

IV. Conclusion

It has been demonstrated that frequency tuning in monopole patch antenna is possible by a single unit of BCSRR coupled to the monopole. The fabricated prototype of the proposed antenna exhibits high reflection coefficient magnitude in a 1.7 GHz tuning range. This is the first time that the frequency tuning in antenna based on adjustable BCSRR is demonstrated. Owing to small dimensions and frequency tunability, the potential communication applications like Bluetooth, Wi-Fi, Wi-Max, WLAN etc. can be achieved by the single proposed antenna. The proposed antenna is compact, light weight and easy to design and fabricate when compared with the recently reported multiband monopole antennas. The experimental and simulated results are in good agreement which shows that the proposed antenna is a suitable candidate for potential wireless communication applications.

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