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Compact Chip Inductor Loaded multiband Antenna

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ABSTRACT

A compact chip inductor loaded microstrip patch antenna for multiband application is proposed. The antenna is fabricated on a substrate of dielectric constant 4.4 and thickness 1.6mm. The proposed antenna is of circular geometry with a circular patch of radius 7mm surrounded by four different inductors which are connected to small rectangular metal patches. The obtained resonant frequencies are 2.28GHz, 2.82GHz, 3.96GHz and 5GHz. Optimization of the proposed antenna along with simulation and experimental results are presented.

Key words: Microstrip antenna, chip inductor, multiband antenna

INTRODUCTION

Multiband antennas are highly demanded as services operating in multiple bands are widely used in today's communication. Microstrip antennas are commonly used for this purpose because of their planar structure, low profile, light weight, moderate efficiency and ease of integration with other active and passive devices. Many multiband radiators in planar arrangement have been proposed for mobile communication devices [1-5].

Standard multiband techniques are stacking, addition of parasitic elements, modification of patch by introducing suitably shaped perturbing elements such as slots and notches etc. In [6], a floral shaped patch antenna is designed to resonate at multiple bands by introducing slits on a rectangular patch. The parasitic elements in the design provide a simple and efficient method for obtaining low profile, broadband and high gain antennas. [7] Presents a comparative study of four different multiband planar antennas and the multiband operation is achieved by etching perturbation slots on the patch. Other techniques such as the use of pin diodes, switches and varactor diodes are also used for multiband operation [8-10]. A new reconfigurable multiband microstrip antenna is proposed in [11]. Slots were cut on a hexagonal to provide the shape of a 6 armed star and further rectangular slots were inserted for achieving multiband operation. The antenna was made reconfigurable by the use of switches. But the use of active components increases complexity in the design and needs extra biasing circuits. A compact printed monopole antenna with a chip inductor embedded on radiating element is presented in [12-13]. The antenna has one resonant element and the dual band operation is achieved by embedding one chip inductor to bring down the resonant modes of original antenna. Here it is demonstrated that with chip inductor, the resonant frequency and hence electrical length of the antenna can be reduced considerably.

In this paper, we are proposing a compact multiband antenna in which the multi band operation is achieved by loading chip inductors in between the central circular patch and surrounding outer rectangular patches. The flower shaped antenna shows four bands of operation. 44% of size reduction is obtained in the lowest resonant frequency of the antenna. The performance of the antenna such as return loss, radiation pattern and gain are presented. Parametric optimization method for obtaining desired frequency bands are also addressed in this paper.

ANTENNA GEOMETRY

The antenna is fabricated on FR4 substrate of relative permittivity 4.4, loss tangent 0.02 and height 1.6mm. As shown in Fig.1, when a single outer patch is connected to the central circular patch through chip inductor (ind=1.8nH) a lower resonance is generated at 4.48GHz. The designed frequency band can be easily generated by choosing an appropriate inductor value. Parametric study of the above mentioned structure with different inductor values is shown in Fig. 2. The dimensions of rectangular patch can also be used to tune the resonant frequency of the antenna. Resonant frequency variation due to rectangular patch width (W) and length (L) are plotted in Fig. 3.

An additional frequency tuning of 1GHz can be achieved by changing the dimensions (L&W) of the rectangular patch. This yields the antenna to operate at any frequency by changing the above parameters.

The proposed quad band antenna geometry is shown in Fig.4. The antenna is fed centrally with a coaxial connector to a circular patch of radius 7mm. The four surrounding outer rectangular patches are of different dimensions. Between the outer rectangular patches and the inner circular patch different chip inductors are loaded to establish different resonant frequencies. The outer rectangular patch dimensions are also shown in Fig. 4. Chip inductors from Coil craft are used in the fabrication of the antenna and the inductor values are 4.7nH, 3.3nH, 2.2nH, 1.8nH as shown as IND1, IND2, IND3, IND4 respectively in Fig.4.

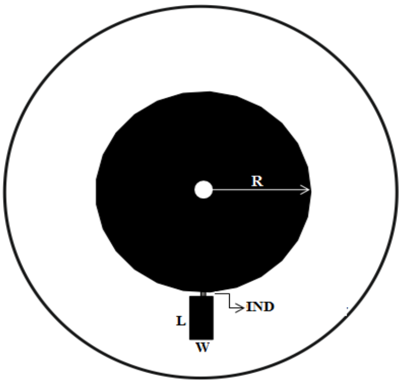

Fig. 1 Coaxial fed antenna with single rectangular patch connected to circular patch through chip inductor (IND) R=7mm, L=3mm, W=1.5mm

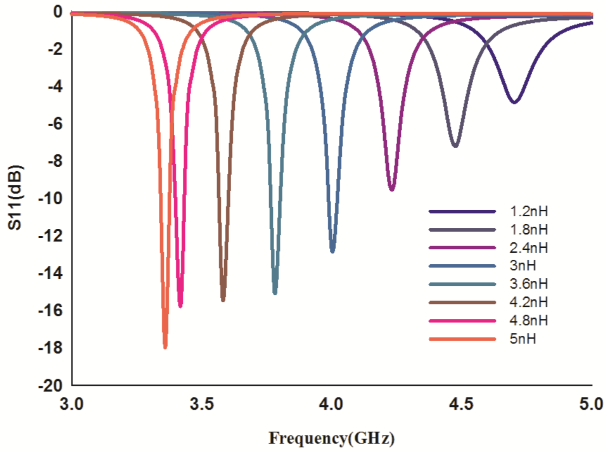

Fig.2 Different S11 characteristics for different inductor values

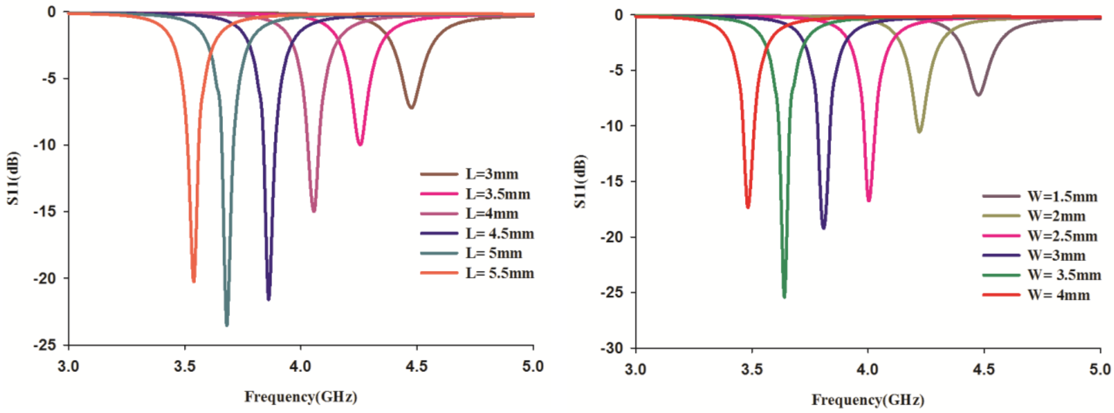

Fig.3 Effect of different length (left) and width (right) on reflection coefficient

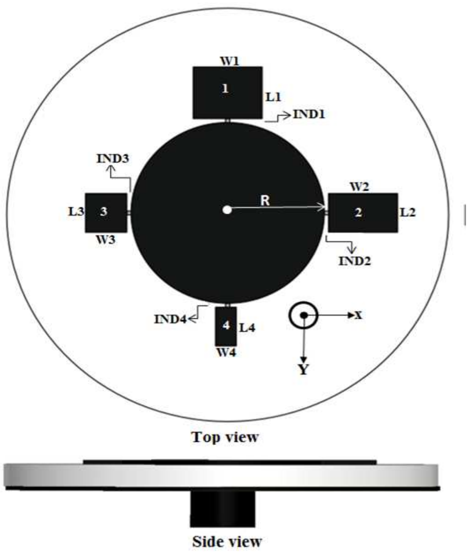

Fig.4 Geometry of the proposed multiband antenna. R=7mm, W1=5mm, L1=4mm, W2=5mm, L2=3mm, W3=3mm, L3=3mm

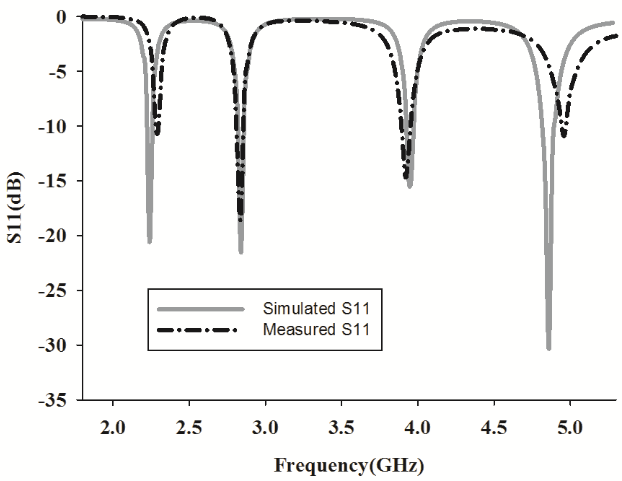

Fig.5 Simulated and measured reflection coefficient

RESULTS AND DISCUSSIONS

Parameters of the antenna are optimized using Ansoft HFSS (High frequency structure simulator). Based on the design parameters and the optimization mentioned above, the prototype of the proposed antenna is fabricated and tested. The antenna is analysed on RFS ZVB20 network analyser.

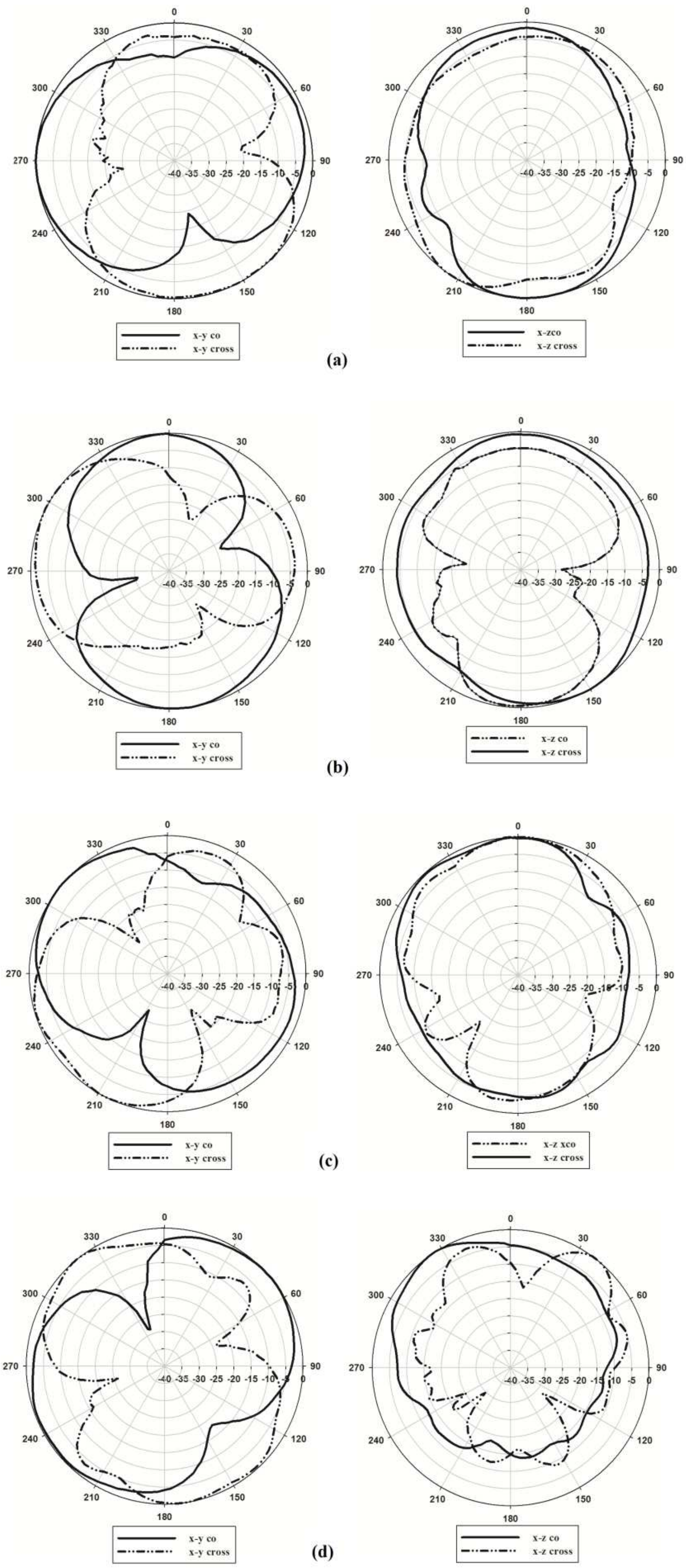

Fig.6 Measured radiation pattern (a) 2.28 GHz (b) 2.82GHz(c) 3.96 GHz (d) 5GHz

The proposed geometry has 4 outer rectangular patches. Each rectangular patch and the associated chip inductor correspond to individual resonances. The dimensions of rectangular strips and inductor values are adjusted to get optimum results. Rectangular patch1 dimensions are adjusted as 5mmx4mm to get the lower resonant frequency. Similarly patch 2, patch 3 and patch 4 dimensions are set as 5mmx3mm, 3mmx3mm, and 1.5mmx3mm, respectively to get the second, third and fourth resonant frequencies.

Measured and simulated reflection coefficient is shown in Fig.5. The obtained resonances are 2.28GHz, 2.82GHz, 3.96GHz and 5GHz. The lowest resonance is due to the highest chip inductor value and its associated rectangular patch, i.e., here it is due to IND1 and the rectangular patch connected. Similarly, resonance at 2.82GHz is the result of current path provided by IND2 to its associated rectangular patch. 3.96GHz and 5GHz resonances correspond to IND3 & IND4 and their associated patches, respectively. The measured radiation patterns at the four obtained frequencies are shown in Fig.6. The gain of the antenna is calculated using two antenna method and is found as 3 dB at the higher frequency. A size reduction of 44% is obtained compared to the standard circular patch antenna resonating at the same frequency.

CONCLUSION

A compact chip inductor loaded quad band flower shaped antenna for microwave applications is presented in this paper. The obtained resonances are 2.28GHz, 2.82GHz, 3.96GHz and 5GHz. The VSWR of the proposed antenna is ≤ 2. The maximum gain of the antenna is observed as 3dB at the highest resonant frequency. A size reduction of 44% is also obtained.

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