Miniaturization of Microstrip Patch Antenna obtained by Patch Meandering and Shorting Pin Loading Technique

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***Abstract* - Reduced size microstrip antennas with different slot and patch shapes are investigated .The ground plane size is 20 X 20 mm and substrate thickness taken to be is 1.6mm which is about the size of atypical wireless card. Detailed simulation and experimental investigations are conducted to understand their behavior and optimize for miniaturized operation. It is shown that the shorting pin makes the patch resonate at a much lower frequency compared with the conventional patch of same size and the narrow slot increases the effective electrical length of the patch thus reducing the required disk size for an antenna operated at a given frequency and helps providing more space on ground plane for electronics. The CST simulation software is employed for optimizing the design parameters and the simulation results in general agree with the measured data. Radiation patterns, S-parameter for circular and square shaped meandered patch antennas for frequency band of 1100MHz to 3000MHz are measured and shown.**

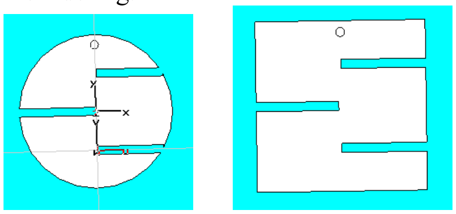
***Key words* – Mobile Communication , Microstrip patch antenna, circular patch , square patch , meandering , miniaturization.**

I. INTRODUCTION

Mobile communication have become an important part of telecommunications .Original applications- such as paging, mobile phones, GPS have shown a tremendous growth and new applications are emerging every day : tagging, wireless computer links, wireless microphones, remote control ,wireless multimedia links, satellite mobile phones, wireless internet just about everything “goes mobile”. Mobile means practical for the user and easily transportable .the mobile terminals of wireless applications networks must be light, small, have low energy consumption and have an appealing design. Technology has evolved very quickly to satisfy these needs in a rapidly growing market: chips are becoming smaller, they consume less current, they are more efficient and they perform more complex operations. Thus the sizes of the electronics needed for mobile application has decreased drastically during past few years, whereas there functionality has increased The antennas, however, have not experienced the same evolution, and marketing staff and designers are pressing engineers to develop smaller antennas. In opposition to electronic chips, the size of the antenna for a given application is not related mainly to the technology used, but is determined by the laws of physics: the antenna size with respect to the wavelength is the parameter that will have the preponderant influence on the radiation characteristics. This follows from the fact that an antenna is used to transform a guided wave into a radiated wave, and vice-versa, and one understands that to perform this transformation efficiently, the size should be of the order of half a wavelength or larger. Antennas can, of course, be made smaller, but at the expense of bandwidth, gain, and efficiency. The art of antenna miniaturization is an art of compromise: One has to design the smallest possible antenna that is still suitable for a given application with regard to its radiation characteristics. Or, in other words, one Looks for the best compromise between volume, bandwidth and efficiency and this best compromise is usually obtained when most of the allotted volume participates in the radiation. In order of antenna miniaturization several approaches have been proposed such as the length of a wall shorted rectangular patch antenna can be reduced from $\lambda_0/4$ to $\lambda_0/8$ by a simple folding operation [2], by slot loading technique [3], with the use of E-shaped parasitic shorting strips [4], by periodically loading the printed antennas with shunt capacitors to slow down the guided wave in the structures[5], miniaturization of rectangular microstrip patches based on genetic algorithms [6], antennas with different slot shapes—straight, L and inverted T, and placed on a small ground plane[7], by increasing the dielectric constant of the microwave substrate material, the addition of a shorting wall between the conducting patch and the ground plane, and the addition of a shorting pin between the conducting patch and the ground plane[8],using a shorted circular patch surrounded with non-planar rings[9]. In this paper, novel compact microstrip antennas with three different patch structures are presented. The first proposed design consists of a rectangular microstrip antenna with shorting pin and meandering narrow slots embedded in the antenna surface. The second proposed design consists of a square patch microstrip antenna with meandering slits and shorting pin.

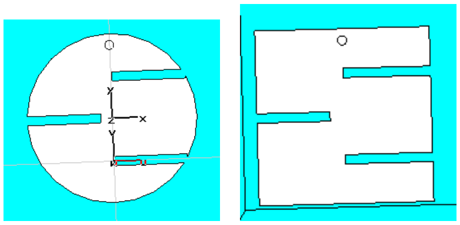
II. ANTENNA DESIGN

The design procedure for the proposed antenna is quite simple: fist of all, the total length of the meandered top patch and bottom patch is chosen to be about one-quarter wavelength of the resonant mode and then, by adjusting the length of the cut slot, the lowest resonant frequency is deduced. The geometry of the proposed antenna with a meandered circular patch is shown in Fig. 1(a) and square patch in Fig 1(b). The meandered patch is printed on the supporting dielectric substrate of dielectric constant 4.4, dimensions 20 mm X 20mm X 1.6 mm cylindrical pin of diameter 0.4 mm and length 1.6 mm is used for shorting the patch with the ground plane of PEC material having 20mm X 20mm, lowest possible thickness. The patch dimensions are taken to be 15mm X 15mm for the square patch and radius of 7.5 mm for the circular patch as shown in fig. 1(a) and fig. 1(b), the top patch is meandered by cutting three slits of width 0.8mm and length half the patch length in case of square patch, equal to radius in case of circular patch. Since these antennas are designed for analyzing the effect of meandering on the patch surface the slots of fixed width and variable length are as cut and the resultant effect on the resonant frequency as shown. A coaxial probe is used to feed the proposed antenna. Fig 2 and Fig 3 shows the variations performed on the slots in order to analyze the effect of meandering.



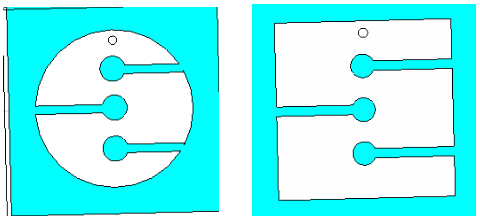
(a) (b)

Fig. 1 The geometry of the meandered circular patch and square patch antenna with all slots of equal length.



(a) (b)

Fig. 2 The geometry of the meandered circular patch and square patch antenna with center slot of decreased length.

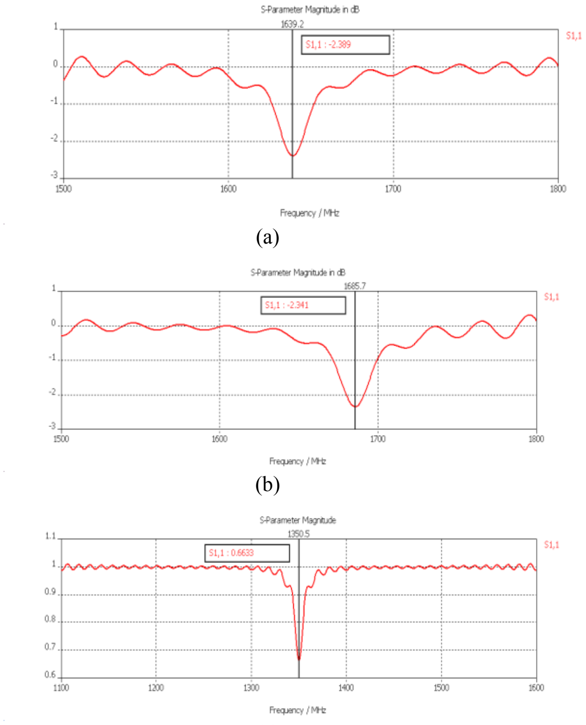


(a) (b)

Fig. 3 The geometry of the meandered circular patch and square patch antenna with all slots of equal length and countered edges.

III. RESULTS AND DISCUSSION

The simulation software released by Computer Simulation Technology (CST), however, due to the software limitations there might be some minor disagreements between the simulation and measured results. Fig. 4 shows the simulated S-parameter for the circular patch antenna with different slot length it can be seen that as the length of the central slot is equal to the radius the antenna resonates at 1639.2 MHz shown in fig.4(a) and as the length of the slot is decreased 2mm the resonant frequency increases to 1685.7MHz shown in fig.4(b) and further when the edges of the slots are contoured there length increases lowering the resonant frequency to 1350.5 MHz shown in fig.4(c) .Similarly fig.5 shows the S-parameter for the square patch antenna and it can be seen that as the length of the central slot is equal to half the length of the patch edge the antenna resonates at 1492.4 MHz shown in fig.5(a) and as the length of the slot is decreased 2mm the resonant frequency increases to 1528.1 MHz shown in fig.5(b) and further when the edges of the slots are contoured there length increases lowering the resonant frequency to 1290.9 MHz shown in fig.5(c). It is thus found that, by increasing the slot length the resonant frequency has reduced and is found to be lowest in the proposed antenna with countered slots.

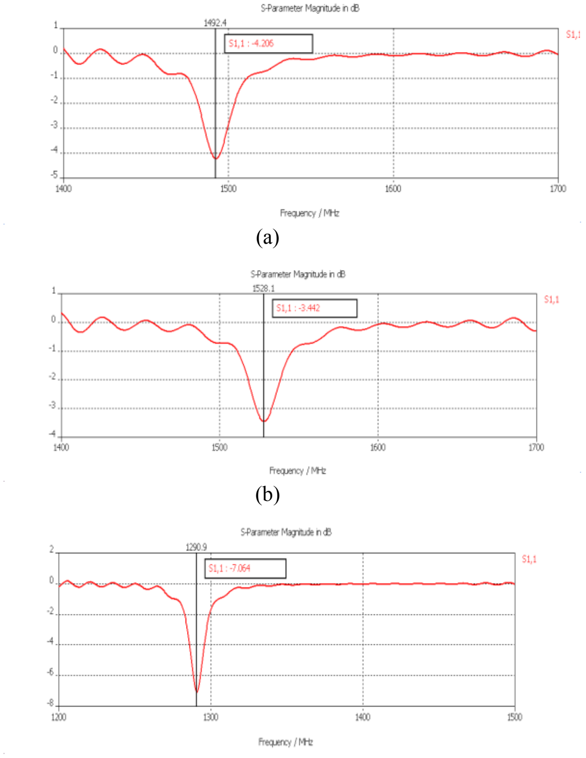


(a)

(b)

(c)

Fig .4 The simulated S-parameters results for the circular patch antenna with variable slot length.



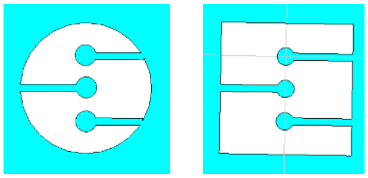
(a)

(b)

(c)

Fig.5 The simulated S-parameters results for the square patch antenna with variable slot length.

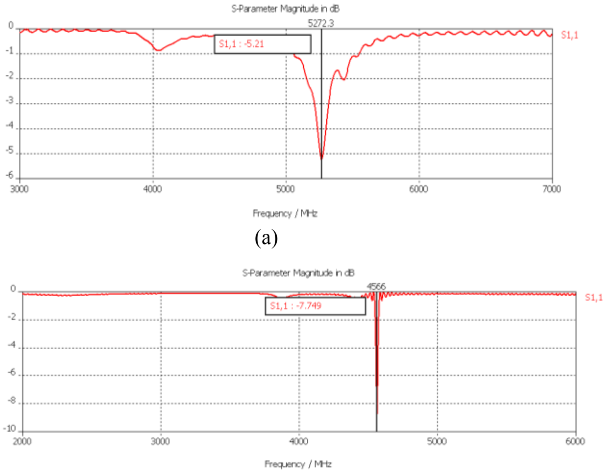
Further the effect of the shorting pin in reducing the resonant frequency is analyzed by removing the shorting pin fig 6 and obtaining the simulation result as shown in fig 7.



(a) (b)

Fig. 6 The geometry of the meandered circular patch and square patch antenna with all slots of equal length and countered edges without the shorting pins.

From Fig 7 it is shown that the resonant frequency of both the circular patch antenna and the square patch antenna has increased to 5272.3MHz in case of circular patch as shown in fig 7(a) and to 4566MHz in case of square patch antenna as shown in fig. 7(b). Thus from the simulation results as discussed it is found that shorting of patch with the ground plane also play an important role in miniaturization of the antenna.



(a)

(b)

Fig.7 The simulated S-parameters results for the circular patch antenna and square patch antenna without the shorting pin.

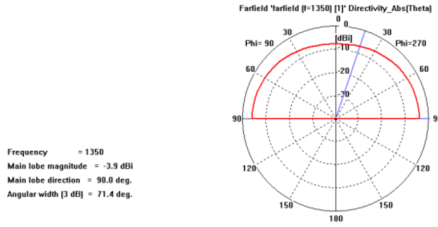


Fig. 8 The far field pattern of the proposed meandered square

patch antenna with all slots of equal length and countered slot edges.

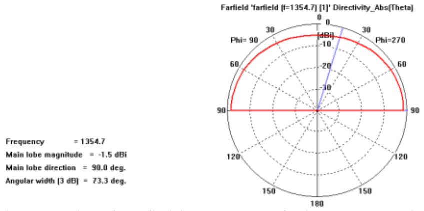


Fig. 9 The far field pattern of the proposed meandered circular patch antenna with all slots of equal length and countered slot edges.

IV CONCLUSION

In this paper, we present a novel method of miniaturization for designing the ultra low-profile patch antenna. Commercial software CST has been used to simulate the antenna characteristics. The designed results demonstrate that the compact structure properties are achieved by using shorting pin and meandered slots, A square and a circular shorted patch antenna with a meandered slots contoured at the end has been proposed and studied. It has been demonstrated that, with the radiating patch been meandered and shorted, the excitation of 1290.9 MHz (for square patch) and 1350.5 MHz (for circular patch) resonant frequency can be achieved. In addition, the proposed antenna occupies a small volume of 20 x 20 x 1.6 mm^3, which makes it very attractive for the application as an internal mobile phone antenna. Good radiation characteristics for the two operating frequencies have also been observed.

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