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Original Research Paper

A Comparison of Different Patch Geometry Effects on Bandwidth

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Abstract: In this study, a new microstrip patch geometry, called Seljuk star, is proposed. The performance of the designed antenna is compared with the performances of square and circular microstrip antennas, which are two other popular patch geometries in literature. The design procedure consists of two phases: First, the patch dimensions of circular and square antennas are taken as the same with Seljuk star dimension. Then the patch surface areas of antennas are fixed to the area of Seljuk star patch and patch dimensions are calculated for the new designs. The effect of different patch types on bandwidth are investigated. Rogers Duroid 6010 (h= 3.175 mm, ε_r=10.2) is chosen as the substrate of the antennas which are expected to have a bandwidth center at 5800 MHz. All antenna designs are simulated in HFSS. Each individual antenna is intended to be working at a single frequency, but during the simulations multiple resonance are obtained in many designs. Therefore, the bandwidth and frequency comparisons are done for each resonant frequency among themselves. In comparison to the circular patch geometry with the same surface area, bandwidth is improved 10.57 times, as a result. The deviation between the theoretical calculations and simulations is % 1.38, which is the smallest deviation among all results. Based on this, it is observed that Seljuk star microstrip patch antenna has a better performance when its dimension or surface area is chosen as same with circular or square antennas. The proposed Seljuk star patch shape is believed to have a high potential to be used in future research.

Keywords: *Seljuk star, microstrip antenna, HFSS, bandwidth enhancement*

1. Introduction

Microstrip antennas are one of the most preferred types of antennas because of their small sizes, low power consumption and consumption for mobile applications today. However, the narrow bandwidth of the microstrip antennas is a major disadvantage. In order to overcome this negative side, many studies have been performed on bandwidth enhancement methods [1-3].

One of the common bandwidth enhancement methods in literature is choosing the optimal patch geometry; because, by choosing and adequate geometry, the desired resonant frequency and bandwidth can be obtained. In addition, the polarization and radiation characteristics can be adjusted by the geometry of the patch [1-3,6-8]. In this study, Seljuk star microstrip patch antenna, a new patch geometry in literature, is designed with using the traditional circular antenna expressions [1] then, their performances are compared with square and circular microstrip antennas. The study is performed in two phases. In the first phase, patch dimensions are taken equal to each other for all three patch geometries. In the second phase, the dimensions are chosen so that surface areas of the patches be equal. Other than patch dimension, all other antenna parameters are kept constant for aiming to investigate the effects of the patch shape on antenna performance. Study is described in detail below [2,4].

2. Antenna Design

Seljuk star is a special geometric shape which can be easily obtained by placing two equivalent squares with a 45° degree relative to one another. This geometry is often encountered in Islamic geography [9]. The reasons of choosing this geometry are the ease of mathematical calculation of dimensions and availability of the circular antenna expressions in literature. Seljuk star microstrip patch antenna (SSMSA) has advantages in many ways in comparison to other patch shapes and gives opportunities to reduce amtenna dimensions, so the new antenna design can be used widely in today's small sized mobile devices. Also, by appliying other bandwidth enhancement methods to this patch geometry, antenna performance can be improved [2,4,9]. In Figure 1, SSMSA designed on a square substrate is shown. Rogers Duroid 6010 is preffered as substrate material. It has a dielectric constant of 10.2 and a thickness of 3.175 mm. In all of the designs, antennas are fed by coaxial cables. The feed point of the antennas are determined by trial and error in simulations using HFSS [5]. Antenna parameters can be seen in Table 1.

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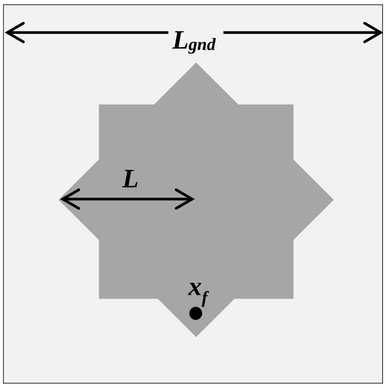


Figure 1. Seljuk Star Microstrip Patch Antenna

Table 1. Antenna Parameters

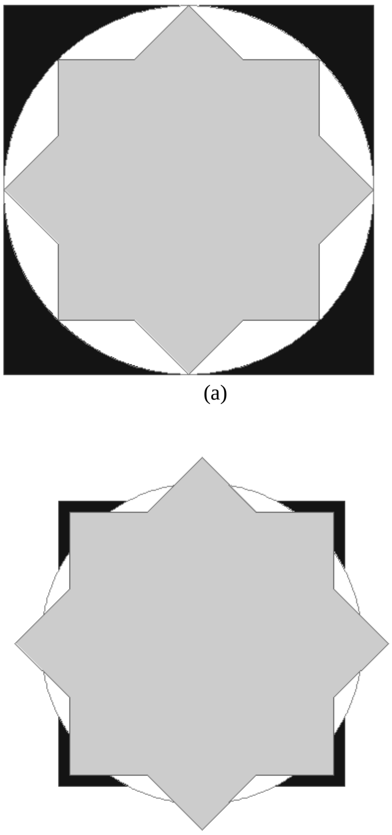
L (mm)	L_{gnd} (mm)	h (mm)	ε_r	x_f (mm)	f_{rTeo} (MHz)
47.46	127	3.175	10.2	36	5800

Where;
$2L$: The diagonal length of the square/ the distance between two corners of Seljuk star
L_{gnd}: The side length of the ground plane
h: Substrate thickness
ε_r: Dielectric constant of the substrate
x_f: Feed point
f_{rTeo}: The theoretical resonant frequency

In Figure 2, dimension equality and area equality designs for all three patch geometries are shown. At first phase, a Seljuk star microstrip antenna is designed by choosing the ground plane parameters and resonant frequency as 5800 MHz which are suitable for the available material. Simulations are completed for both dimension equality and area equality. After SSMSA is designed, the patch geometry is changed by adjusting square and circular dimensions, respectively. All other antenna parameters are kept constant. They are simulated using HFSS and their performances are compared.

3. Results

Simulation results are given in Table 2. From these results, it is obtained that with all patch designs, more than one resonant frequencies are occurred and the largest bandwidth is achieved with SSMSA design. This value of %1.48 is not enough for ISM 5800 MHz needs which is % 2.5, but it is quite larger than the square and circular antenna bandwidths. From simulation results, it is seen that a bandwidth is obtained 10.57 times larger as a result of Seljuk star design which has an equal area with the circular patch. For the same design, there is only a frequency deviation as % 1.38 between the simulation and the theoretical frequencies. Again, this is the smallest deviation among all results. Based on this, it is observed that Seljuk star microstrip patch antenna has a better performance than circular and square shape microstrip antennas with same dimensions or same surface areas. So, as a new patch geometry, Seljuk star has a potential in application and research areas in literature.



(a)

(b)

Figure 2. Antenna Designs a) equal dimension b) equal area

Table 2. Simulation Results of The Antennas

Geometry	f_{rTeo} (MHz)	f_{rSim} (MHz)	BW_{Sim} (%)
Seljuk Star	5800	5560	0.43
	5800	5630	1.48
	5800	5880	0.27
Square	5800	5550	0.13
	5800	5930	0.22
	5800	5980	0.17
Circle	5800	5570	0.16
	5800	5910	0.24
Square area	5800	5550	0.13
	5800	5930	0.22
	5800	5980	0.17
Circle area	5800	5880	0.14

4. Conclusion

A Seljuk star microstrip patch antenna is designed then its performance is compared with circular and square microstrip antennas that are the popular patch geometries in literature. There are two phases for the designs: First, the patch dimensions of circular and square are taken as the same with Seljuk star. Then the patch surface areas of antennas are fixed to the area of Seljuk star antenna and new patch dimensions are calculated for the designs. Antenna performances are compared in terms of bandwidth. As can be seen from simulation results, SSMSA design has superior performance compared with square and circular ones with a small deviation at each resonant frequency. However the % 2.5 bandwidth criteria nessecarry for WiFi applications could not be matched with % 1.48 bandwitdh result. Nevertheless, it's possible to improve the bandwidth further by applying additional bandwidth enhancement methods.

Acknowledgements

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