VOL. 10, NO. 8, MAY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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DESIGN AND ANALYSIS OF S-SHAPED MICROSTRIP PATCH ANTENNA FOR GPS APPLICATION

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ABSTRACT

Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2D (2-Dimentional) physical geometry. They are usually designed to operate at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at resonance frequency. In this paper, a S-shaped patch antenna array is designed for GPS application. The antenna array is designed to enhance the overall performance characteristics of a radiating system at 1.6 GHz. Simulation models are developed for S-patch antenna and S-patch antenna array using High Frequency Structure Simulator (HFSS). Finally, a comparison among the developed simulation models is performed and conclusions are extracted.

Keywords: s-patch antenna, GPS, radiation, feed.

1. INTRODUCTION

Low profile antennas are essential for many wireless and telecommunication systems and hand held mobile devices, where size, weight, cost, performance are constrained. They commonly consist of a rectangular or square metal patch on a thin layer of dielectric or substrate on a ground plane. The bandwidth specification of antennas should be satisfied for VSWR, radiation pattern and polarization properties.

Dielectric substrate plays an important role in the design of microstrip patch antennas. There are different types of substrates used for the design of antennas. The dielectric constants range from $2.2 \leq \varepsilon r \leq 12$. In this paper, the dielectric substrate is chosen as FR-4 whose dielectric constant is 4.4. FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic with good strength to weight ratios. FR-4 is most commonly used as an electrical insulator having considerable mechanical strength. It has a wide variety of applications.

The main advantages of the microstip patch antenna are planar profile, ease of fabrication, compatibility with PCB and integrated circuit technology. An added feature of microsrip antenna is that they can be easily integrated with RF devices.

A single patch antenna provides a maximum directive gain of around 6-9dBi. The input impedance of a resonant micro strip antenna is from 150 to 400Ω and the desired impedance is 50Ω [1].A s-patch antenna is designed for Bluetooth application. The antenna width is changed and the antenna parameters are obtained [2]. A high-gain multilayer 2 × 2 antenna array for the application of WLAN (wireless local area network) AP (access point) is presented. The antenna array consists of four square patch antenna elements fabricated on FR4 substrate [3].

The detailed analysis on the design and implementation of 4×1 and 8×1 microstrip patch antenna (array) of given specifications using IE3D software with dielectric material FR4 is performed. The microstrip patch antenna array is designed for WLAN applications; at an operating frequency of 2.4 GHz [4]. A corner-truncated square microstrip patch antenna on a relatively thick substrate of high dielectric constant is used for global positioning system (GPS) applications at the frequency of 1.575 GHz [5].

The design and analysis of linear array of two S-shaped Microstrip patch antenna is performed using IE3D software Ver. 15.2. This antenna is designed for wireless applications [6]. A single-patch broadband microstrip S-shaped patch antenna fed by a coaxial feeding is designed using IE3D software. This antenna is operating at centre frequency of 4.3GHz [7]. An antenna is the most important element of any wireless communication. The S - shaped Multib and Microstrip Patch antenna is simulated and analyzed using HFSS (High Frequency Structure Simulator). This antenna is designed for various multiple applications such as Bluetooth, Medical Application and ISM Application, in the operating range 1-5 GHz [8]. A compact analysis and design of S-shaped Microstrip patch antenna suited for Wi-max application is simulated over IE3D software Ver. 15.2. The obtained gain and bandwidth is best suited for Wi-max application [9].

A wideband S-shape microstrip patch antenna is designed. The bandwidth is further increased by introducing PBG structure. The antenna designed by this method has low volume and low profile configuration, easily mounted, low fabrication cost and light weight. This antenna is best suited for C-band communication [10].

The study of microstrip patch antennas has made great progress nowadays. The microstrip patch antennas have more advantages. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. The microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feed line flexibility, beam scanning omnidirectional patterning. In this paper the microstrip antenna, types of microstrip antenna, feeding techniques and application of microstrip patch antenna are discussed and compared with other conventional antennas [11].

To maximize the gain of microstrip patch antenna, we use microstrip circular patch antenna at 5.8 GHz frequency for ISM Band application. Coaxial feeding technique is used as it is easier to implement [12].

A dual-band circularly polarized microstrip patch antenna for GPS and Beidou applications is proposed and simulated. The measured results confirm the validity of this design that can meet the requirement of GPS and Beidou application [13]. In this paper, a S-shaped patch antenna array is designed for GPS application. The proposed antenna has two notches. The antenna array is designed to enhance the overall performance characteristics of a radiating system at 1.6 GHz. Simulation models are developed for S-patch antenna and S-patch antenna array using High Frequency Structure Simulator (HFSS).

2. FEEDING METHODS

The feeding techniques used in the microstrip antenna are broadly divided into two forms contacting feed and non-contacting feed. In contacting feed method, the patch is directly fed with RF power by the connecting element such as microstrip line or co-axial line. On other hand, the patch is not directly fed with the RF power but instead power is transferred to the path from the feed line through electromagnetic coupling in non-contacting feed. Apart from these two we have more feed system like aperture coupled feed and proximity coupled feed which is also called as indirect feed.

Many good designs have been discarded because of their bad feeding. The designer can build an antenna with good characteristics and good radiation parameter and high efficiency. If the feeding is bad, the total efficiency reduces and the whole system gets rejected.

In this paper, microstrip feed is used. The main advantage is impedance matching is done and additional impedance matching circuitry is not required. This method of feeding is very widely used because it is very simple to design and analyze, and very easy to manufacture.

3. METHOD OF ANALYSIS

There are many methods of microstrip antenna analysis. The most popular are transmission line model, cavity model and moment method. In the transmission line model, the patch is a transmission line or part of a transmission line. This is the easiest way to analyze microstrip patch antennas. Transmission line model does not produce accurate results compared with other models. In the cavity model, the patch is a dielectric - loaded cavity. The cavity model is based on the assumption that the region between the microstrip patch and ground plane is a resonance cavity. The moment model is very accurate but very complex. In our proposed paper, we use cavity model for the method of analysis.

4. ANTENNA DESIGN

The operating frequency fr is known.

The width of the patch is calculated using the formula:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

The thickness of the patch is calculated using the formula:

$$h \leq 0.3 \times \frac{c}{2\pi\sqrt{\varepsilon_r}f_r}$$

The effective dielectric constant is given by the formula:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left\{\left[1+12\frac{h}{w}\right]^{\frac{-1}{2}} + 0.04\left[1-\frac{w}{h}\right]^2\right\}, \frac{w}{h} < 1$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left\{\left[1+12\frac{h}{w}\right]^{\frac{-1}{2}}\right\}, \frac{w}{h} \geq 1$$

The actual length, L of the patch is using the following formula:

$$L = \frac{\lambda_g}{2} - 2\Delta L$$

To determine the length extension, we use this formula:

$$\Delta L = 0.412h\left[\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}\right]$$

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_{reff}}} = \frac{1}{\sqrt{\varepsilon_{reff}}}\cdot\frac{c}{f_r}$$

where c is the velocity of light [14].

5. RESULTS AND DISCUSSIONS

The s-microstrip patch antenna was first designed and simulated using HFSS. The antenna parameters return loss, VSWR and radiation pattern are obtained.

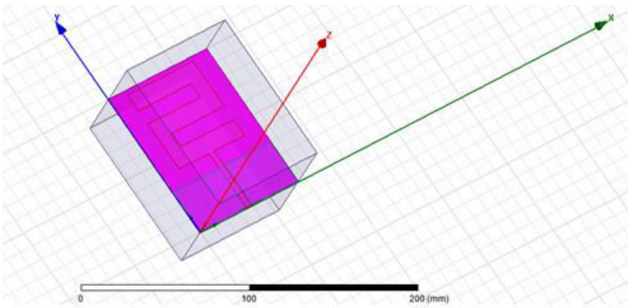

Figure-1. S-patch antenna.

VOL. 10, NO. 8, MAY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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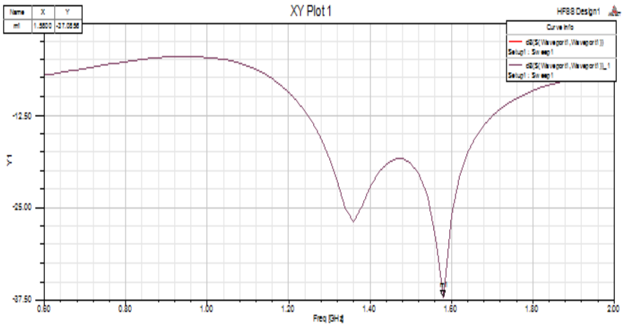

Figure-2. Return loss of S-patch antenna.

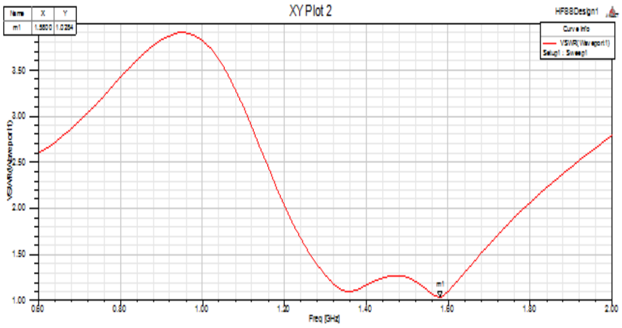

Figure-3. VSWR of S-patch antenna.

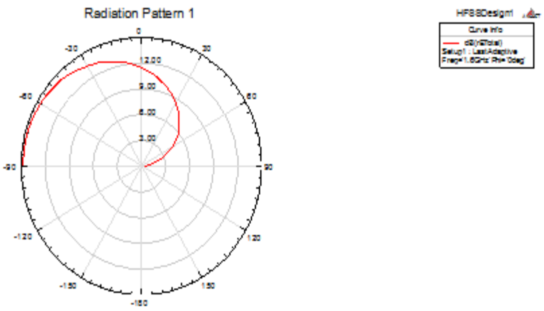

Figure-4. Radiation pattern of S-patch antenna.

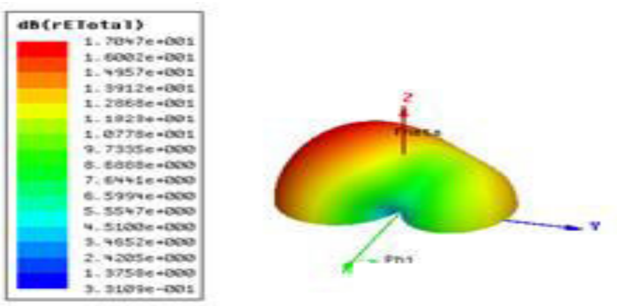

Figure-5. 3-D Radiation pattern of S-patch antenna.

Microstrip antennas are used in arrays as well as single elements. By using array in communication systems we improve the performance of the antenna like increasing gain, directivity, radiation pattern, VSWR and other antenna parameters that are difficult to perform with the single element antenna. We designed a 2 element s-shaped patch antenna array and the parameters return loss, VSWR and radiation pattern are obtained.

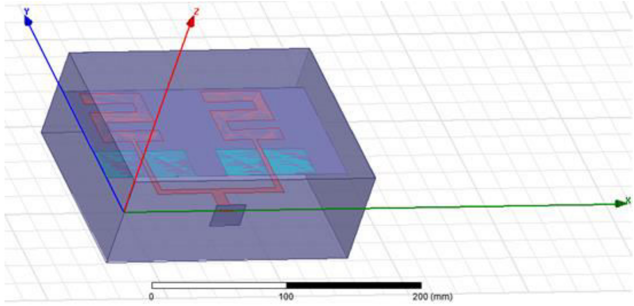

Figure-6. S-patch antenna array.

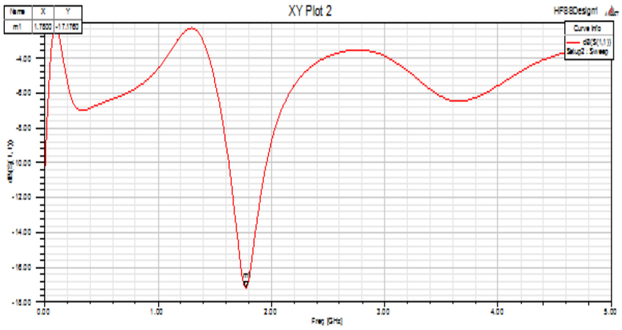

Figure-7. Return loss of S-patch antenna array.

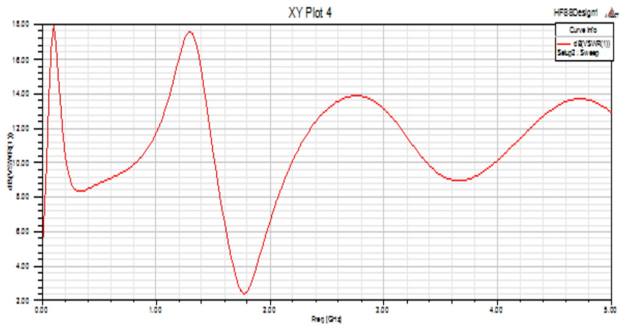

Figure-8. VSWR of S-patch antenna array.

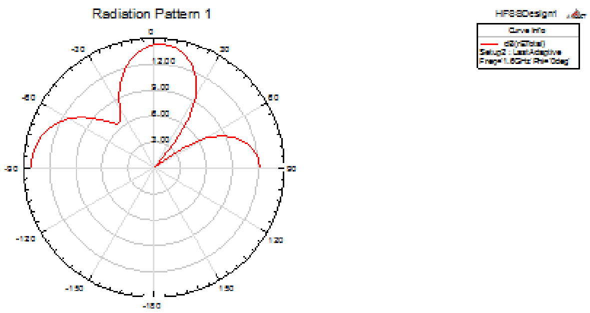

Figure-9. Radiation pattern of S-patch antenna array.

VOL. 10, NO. 8, MAY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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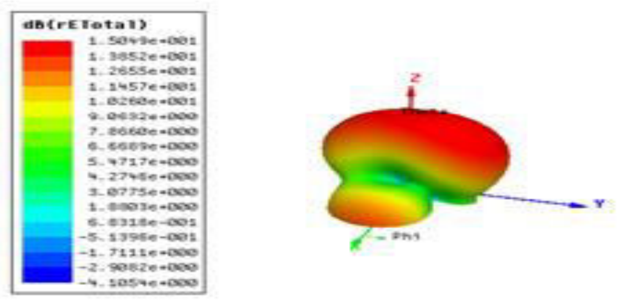

Figure-10. 3-D radiation pattern of S-patch antenna array.

The figures show the comparison between simulated results for S-shaped antenna and S-shaped antenna array. On increasing the length of notch lower and higher resonance frequencies shift towards lower side. On increasing the width from, wideband is obtained and frequencies are shifted to lower resonance side. On increasing the height of the substrate lower frequencies shifted towards lower side and higher resonance frequencies shifted towards higher side.

6. CONCLUSIONS

An analysis of S-shaped antenna and antenna arrays has been carried out at 1.6 GHz. Simulation models are developed for S-patch antenna and S-patch antenna array using High Frequency Structure Simulator (HFSS). Finally, a comparison among the developed simulation models is performed and conclusions are extracted. From the simulated results, it is observed that S-patch array has better radiation pattern and characteristics compared to s-patch antenna. This proposed antenna can be used for GPS applications.

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