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Design of Different Micro Strip Antennas Used for Wi-Fi and IOT Applications

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Abstract
This research article presents the design and analysis of simple, low-cost microstrip antennas. The first antenna, referred to as Proposed Antenna 1, utilizes an affordable FR4 substrate and an inset feed transmission line network to excite the radiating patch. It operates as a single-band antenna with a resonant frequency of 5.34 GHz. To enhance performance, the dimensions of Proposed Antenna 1 were modified, incorporating cut slots on the radiating patch and employing a microstrip line feed technique for excitation. This modified version, named Proposed Antenna 2, features a unique comb-like structure and exhibits broadband characteristics, covering a frequency range of 3.44 – 6.86 GHz. The antennas were designed and simulated using the Ansoft High-Frequency Structure Simulator (HFSS). The study discusses the simulated reflection coefficient, gain, and radiation patterns in detail. Both Proposed Antenna 1 and Proposed Antenna 2 are well-suited for Wi-Fi and IoT-based applications.

Keywords: *microstrip antenna, broadband, reflection co-efficient, gain, radiation pattern*

1. Introduction

Microstrip antennas play a vital role in wireless communication systems**,** particularly in Wi-Fi and IoT-based applications**,** due to their low profile, cost-effective fabrication, ease of integration, and compact design**.** A basic microstrip antenna consists of a radiating patch made of conductive material on one side of a dielectric substrate, with a ground plane on the opposite side By introducing strategically engineered slits and slots on the radiating patch or modifying the excitation technique, microstrip antennas can achieve broadband characteristics, enabling high data rate communication. Over the years, extensive research has been conducted to enhance the bandwidth of microstrip antennas. An microstrip antenna uses a curved slot on the metal patch to achieve 109% bandwidth is proposed in [1]. A patch antenna uses parasitic mushroom-like geometry for wideband application has been reported in [2]. A wideband slot antenna was designed for ground-penetrating radar in [3]. A broadband antenna has broad bandwidth which provides a high data rate with a low level of power consumption reported in [4]. A circular ring-like antenna with a curved ground plane was proposed for operating in the frequency range of 1.99 GHz to 10.8 GHz was published in [5]. A novel geometry was done on a circular patch for the attainment of ultrawideband (UWB) in [6]. Fractal geometry was done on a patch for the attainment of wideband application informed in [7][8]. UWB was achieved by using resonant elements in [9]. A half-circular microstrip antenna and a hexagonal shaped antenna used co-planar feed line for achievement of Ultra-Wide Band (UWB) were reported in [10] and [11] respectively. The defective star-like patch provides (1.6638-6.652) GHz in [12]. This article proposes two microstrip antennas. Proposed antenna1 provides single band of frequency and proposed antenna2 uses wideband. Two antennas are simple in geometry and they are useful in various wireless applications. [6]

2. Antenna Design of Proposed Antenna1

At first a microstrip antenna with 5.2 GHz resonant frequency has been designed and it is named as proposed antenna1. It uses low-cost FR4 substrate material which has relative permittivity (ε_r) of 4.4, height of 1.6 mm and loss tangent tan δ=0.023. An

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inset feed transmission line feed network is used to model the proposed antenna structure. To design, width and length of microstrip antenna have been calculated by using-by-using following formulas [7] formula (1-5) [13]

Width of the patch, $W=\frac{c}{2f_0\sqrt{(\mathcal{E}_r+\frac{1}{2})}}$...................... (1)

$W=\frac{3\times10^8}{2\times5.2\sqrt{(\frac{4.4+1}{2})}}$ [$c=3\times\frac{10^8 m}{sec}$ $\mathcal{E}_r = 4.4$, $f_r = 5.2$ GHz], we use FR4 substrate & height of it, h=1.6 mm]

= 17.55 mm

Effective dielectric constant of patch is

$\mathcal{E}_{reff} = \frac{\mathcal{E}_r+1}{2} + \frac{\mathcal{E}_r-1}{2}\left(1+\frac{12h}{w}\right)^{(-\frac{1}{2})}$............. (2)

$=\frac{4.4+1}{2} + \frac{4.4-1}{2}\left(1+\frac{12\times1.6}{17.55}\right)^{(-\frac{1}{2})} = 3.87$

Extended incremental length of the patch, $\triangle L = 0.412h\frac{(\mathcal{E}_{reff}+0.3)(\frac{w}{h}+0.264)}{(\mathcal{E}_{reff}-0.258)(\frac{w}{h}+0.8)}$...............(3)

$= 0.412\times1.6\frac{(3.87+0.3)(\frac{17.55}{1.6}+0.264)}{(3.87-0.258)(\frac{17.55}{1.6}+0.8)} = 0.726mm$

Effective length of patch, $L_{eff} =$

$\frac{c}{2f_r\sqrt{(\mathcal{E}_{reff})}}$..(4)

$=\frac{3\times10^8}{2\times5.2\times10^9\sqrt{(3.87)}}$=0.0146m = 14.6mm

Actual length of patch, $L= L_{eff}-2\Delta L$.................. (5)

$=14.6-(2\times 0.726)= 13.14$ mm

After calculating optimized considered length and width are, L= 13.2 mm, W=17.55 mm The proposed antenna is designed by ansoft HFSS simulation software which is shown in Figure 1. The width and length of patch are respectively W=17.55 mm, L=13.20 mm. Length of the inset feed line is 30 mm and its width W_0=3mm. The overall dimension is $60\times60\times1.6mm^3$. extensive research has been conducted to enhance the bandwidth of microstrip antennas. An microstrip antenna uses a curved slot on the metal patch to achieve 109% bandwidth is proposed in [1]. A patch antenna uses parasitic mushroom-like geometry for wideband application has been reported in [2]. A wideband slot antenna was designed for ground-penetrating radar in [3]. A broadband antenna has broad bandwidth reported [9]

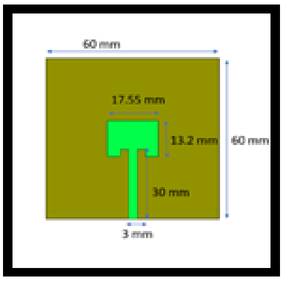

Figure 1 **Geometry and Dimensions of the Rectangular Microstrip Antenna**

3. Result and Discussion of Proposed Antenna1

In this section simulated reflection co-efficient, gain and radiation patterns of the proposed antenna have been discussed. Figure 2 shows that the antenna provides single band of frequency of 5.24– 5.44 GHz. The simulated reflection coefficient is -21.92 dBi at resonant frequency of 5.34 GHz. The bandwidth of simulated microstrip antenna is (5.44-5.24) GHz = 0.20 GHz and percentage bandwidth are 3.74%. Gain of the antenna is shown in Figure 3. Peak gain is 6 db has been achieved at the resonant frequency of 5.34 GHz. The radiation patterns at 5.34 GHz of the microstrip antenna is shown in Figure 4. The red line indicates the E-plane radiation pattern and the green line indicates H-plane radiation pattern. [8]

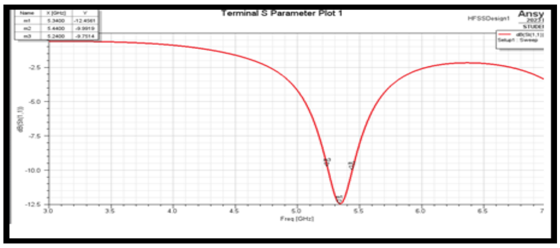

Figure 2 **Reflection Coefficient (Db) Versus Frequency (GHz) Plot**

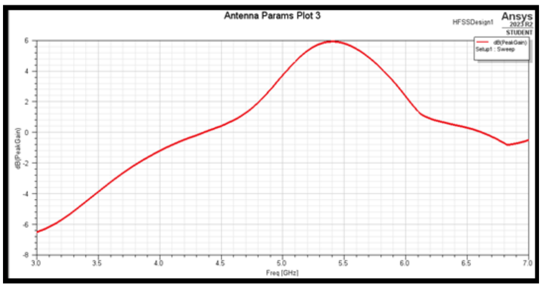

Figure 3 **Reflection Coefficient(dB) Versus Frequency (GHz) Plot**

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4. Antenna Design of Proposed Antenna2

To achieve broadband, slots on the radiating patch and partial ground structure of dimension (12 ×40) mm^2 has been designed on proposed antenna1 and this modified version is named as proposed antenna2. Proposed antenna2 is shown in Figure 5. FR4 substrate of height, h=1.6mm, relative dielectric constant 4.4, and loss tangent 0.023 is used to design the proposed antenna2. The width and length of patch are respectively W=17.55 mm and L=13.2 mm respectively. Length of the feed line is 14 mm and its width W0=3 mm. The overall dimension of the substrate is (40×40×1.6) mm^3. [10]

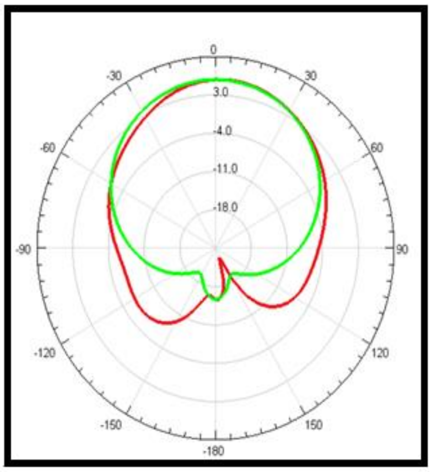

Figure 4 Radiation Pattern at 5.34 GHz

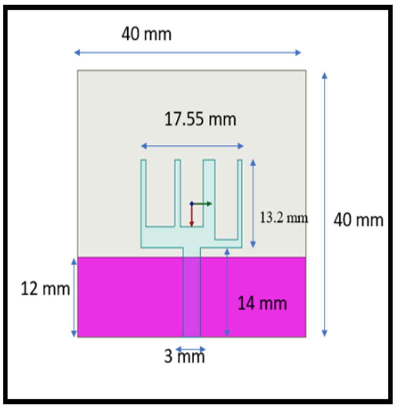

Figure 5 Geometry of the Proposed Antenna2

5. Simulation result discussion of proposed antenna2

In this section simulated reflection co-efficient, gain and radiation patterns of the proposed antenna have been discussed. The reflection co-efficient (dB) versus frequency (GHz) of the proposed antenna is shown in Figure 6. It shows that the antenna provides single broadband of frequency is (3.44 – 6.86) GHz. The bandwidth of simulated microstrip antenna is (6.86-3.44) =3.42 GHz and percentage bandwidth are 66.40 %. The peak gain of the proposed antenna is shown in Figure 7. 3.48 dBi at 3.82 GHz and 0.836dBi at 5.89 GHz frequency have been obtained from the proposed antenna2. The radiation patterns of the proposed antenna2 at 3.82 GHz and 5.89 GHz are shown in Figure 8 and Figure 9 respectively. The red line indicates the E-plane radiation pattern and the green line indicates H-plane radiation pattern. [11]

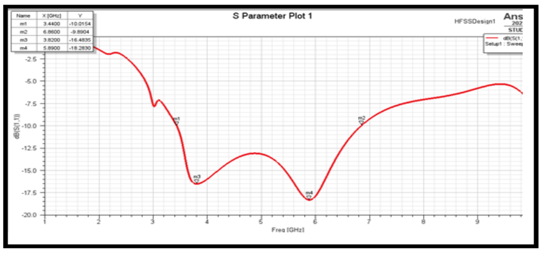

Figure 6 Reflection Coefficient Vs Frequency Plot for Broadband Monopole

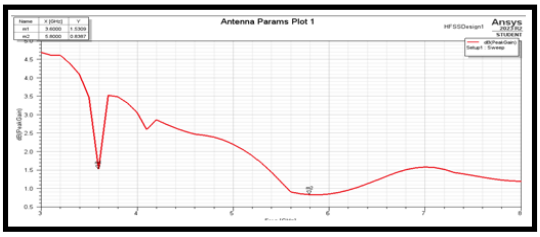

Figure 7 Peak Gain (dBi) Versus Frequency (GHz) of Antenna

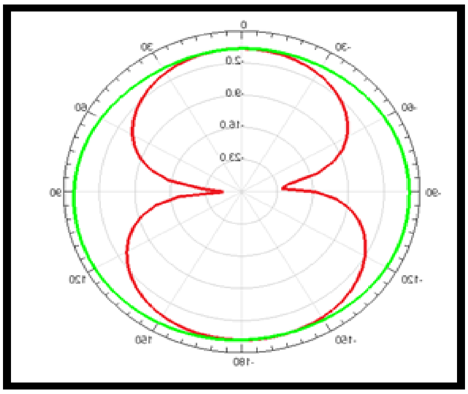

Figure 8 Radiation Pattern at 3.82 GHz

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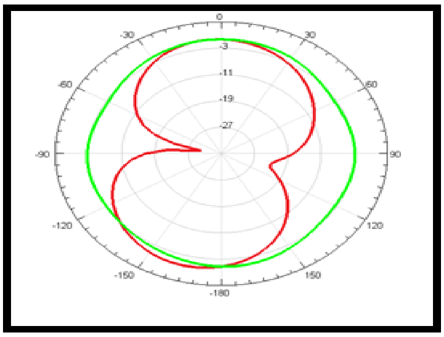

Figure 9 Radiation pattern at 5.89 GHz

Conclusion

Micro strip antennas have a promising future in various applications due to their compact size, lightweight nature, and compatibility with modern electronics. In this article two antennas have been proposed. Proposed antenna1 provides single band of frequencies and proposed antenna2 provides broadband. Both antennas are very simple in construct and they are low profile. They are modelled by HFSS software. Both antennas are useful for IOT applications. [12]

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