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Wideband Microstrip Patch Antenna for Sub 6 GHz and 5G Applications

***Abstract**. This paper investigates a new shape of microstrip patch antenna designed for the sub 6 GHz range, including a 5G application. The proposed antenna was designed and simulated for the frequencies from 3.5 GHz up to 5 GHz using CST Software. The Rogers RT5880 substrate is used in this study and comes with 0.254 mm thickness and a dielectric constant of 2.2. The proposed antenna feeds by a quarter metallic ground plane attached with a microstrip feed line to improve the antenna impedance mismatch. The effects of the design variation parameters such as the size of the substrate, size of patch and size of the ground plane were observed and analysed in this study. The best antenna parameter was selected based on the return loss antenna performance. Lately, the finalised antenna was successfully simulated in terms of antenna performance.*

Streszczenie.** W tym artykule zbadano nowy kształt anteny mikropaskowej zaprojektowanej dla zakresu poniżej 6 GHz, w tym aplikacji 5G. Proponowana antena została zaprojektowana i zasymulowana dla częstotliwości od 3,5 GHz do 5 GHz przy użyciu oprogramowania CST. W tym badaniu zastosowano podłoże Rogers RT5880 o grubości 0,254 mm i stałej dielektrycznej 2,2. Proponowana antena jest zasilana przez ćwierć metalową płaszczyznę uziemienia połączoną z mikropaskową linią zasilającą, aby poprawić niedopasowanie impedancji anteny. W niniejszym badaniu zaobserwowano i przeanalizowano wpływ parametrów zmienności projektu, takich jak wielkość podłoża, wielkość płata i wielkość płaszczyzny podłoża. Najlepszy parametr anteny został wybrany na podstawie wydajności anteny z tłumieniem odbiciowym. Ostatnio ukończona antena została pomyślnie zasymulowana pod względem wydajności anteny.* (Szerokopasmowa antena mikropaskowa dla aplikacji Sub 6 GHz i 5G***)

Keywords: Sub 6 GHz, Microstrip patch antenna, wideband antenna, 5G application
Słowa kluczowe: antena szerokopasmowa, komunikackja 5G.

Introduction

For more than two decades, the wireless communication industry has progressed tremendously, moving from analogue to digital systems known as 2G/GSM, multimedia transmission to high data rate cellular wireless communications 3G/WCDMA and eventually packet optimisation with 3.5G/HSPA and 4G/LTE [1]-[3]. The 5G refer as the fifth-generation mobile network. It allows for establishing a new type of network that connects virtually everyone and everything together, including machines, objects, and gadgets. It is also a new worldwide wireless standard after 1G- 4G networks. A transmission channel with a wider bandwidth than a single voice channel is known as a wideband [4]–[7]. A wideband is operating characteristics approximately the same over a very wide passband.

Many microstrip patch antennas were proposed to obtain a wide bandwidth to be able to cover a 5G spectrum [8]-[12]. However, this kind of antennas suffers from complicated design and bulkiness. It's very important to get a wide bandwidth while maintaining the antenna size as compact form as possible. Moreover, a few antenna types with different frequency responses were also proposed to obtain a wide bandwidth and attain an ultra-wideband response, such as those in helical antennas [13], [14] and monopole antennas [15]-[23].

In this paper, the design of a wideband antenna for a 6 GHz range for 5G application was proposed due to the current antenna not being suitable for the new technology in wireless service. In addition, due to its unique structure, the proposed antenna can be developed as a new design for a wideband antenna in the industry. For example, the structure of the antenna can be as a logo for specific products. Besides, the variety of the parameter has been observed and recorded in the result section. Lastly, a compact wideband antenna has been designed and presented with the primary objective in this research is to get a return loss below -10 dB within frequency range (3.5 GHz-5 GHz).

Antena design

Fig. 1. Shows the antenna design configuration for wideband antenna for sub 6 GHz range for 5G application. First, the antenna parameter was design based on the five circles with cutting the inner and outer radius (Rin, Rout). The antenna parameters with dimensions are presented in

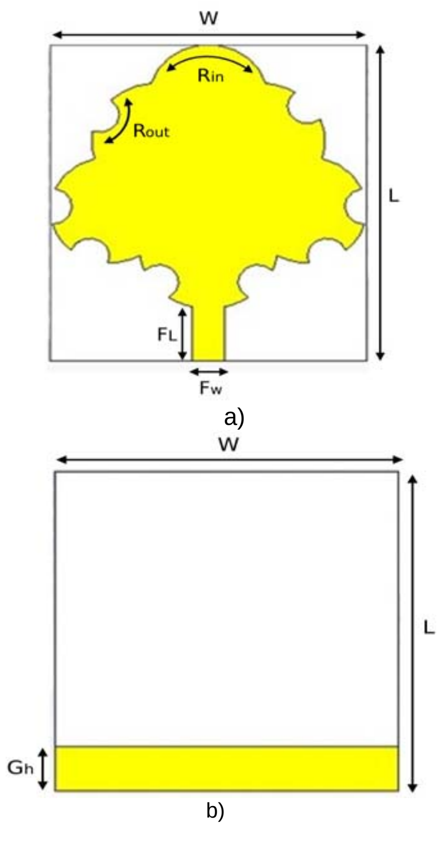


Fig. 1. Antenna parameters in both (a) Front view and (b) Back view.

Table 1. Then, the proposed antenna was designed with an operating frequency range of 3.5 GHz to 5 GHz. The Rogers RT 5880 substrate material uses a dielectric constant of 2.20 with a thickness of 0.254 mm. The total dimensions of the finalised antenna are 16mm x18mm x 0.254mm, with a thickness of copper that has been operating in this study is about 0.035 mm.

Table 1. Geometries of the proposed antenna

Parameters	Symbols	Dimensions (mm)
Substrate width	W	16
Substrate length	L	18
Ground height	Gh	2.5
Radius of the inner circle	Rin	1.5
Radius of the outer circle	Rout	0.7
Feedline width	Fw	1.4
Feedline length	FL	3.09

Results and discussion

Fig. 2. Shows the simulation results of the proposed antenna structure in the frequency range (3.5 -5GHz). The resonant frequency is enormously changed over a variety of the spectrum. For example, at resonant frequency 3.5 GHz with return loss -10.343 dB. Meanwhile, at 4.2 GHz, the return loss performance changed to -14.287 dB. Then, at 5 GHz, the return loss achievement is about -10.059 dB.

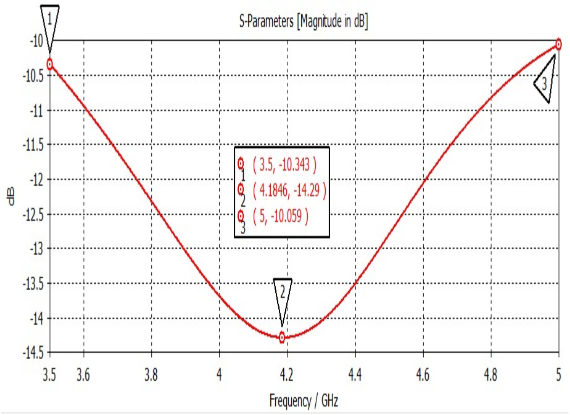


Fig. 2. Return loss performances of the proposed antenna.

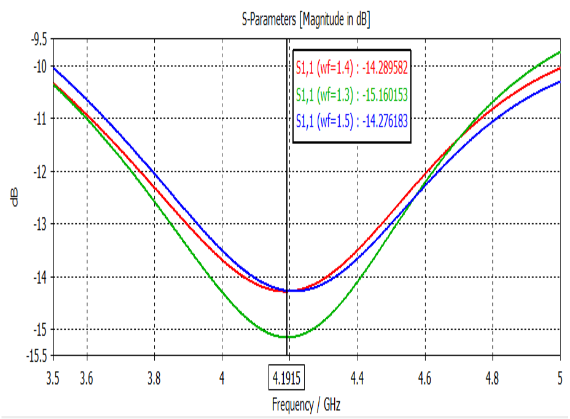


Fig. 3. Comparison of return loss performances based on the width of the feedline.

A parametric study regarding the feed line width is presented in Fig. 3. The feed line dimensions widths are 1.3 mm, 1.4 mm, and 1.5 mm. Respectively, when the width of the feedline changed, the feedline length also changed. For example, the red line indicates the size width of the feedline equal to 1.4mm, at the frequency response of 3.5 GHz with return loss -10.347 dB. Meanwhile, at frequency 4.1865 GHz, the return loss performance is about -14.289 dB, which is the minimum point and the highest point for this return loss with a value of -10.059 dB at resonant frequency 5 GHz. At the same time, the green line presents the width of the feedline at 1.3 mm, with a return loss of -10.367 dB at frequency response 3.5 GHz. However, the blue line exhibits the simulation outcome for the feedline width size at 1.5 mm. At the highest point, it shows the value of return loss designates -10.05 dB of return loss at 3.5 GHz of its resonant frequency, followed by -10.313 dB of return loss performance at 5 GHz.

Moreover, the proposed antenna gives a 2.07 dBi of directivity at 4.25 GHz. Meanwhile, the antenna gain is equal to -0.9762 dB. This is acceptable due to the small antenna size, as shown in Fig. 4.

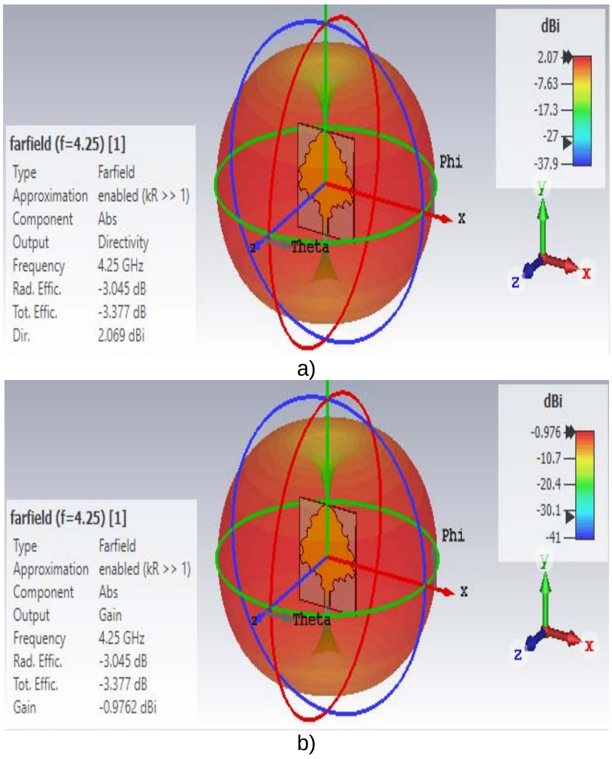


Fig. 4. Simulated results of the suggested antenna (a) Directivity and (b) Gain.

The surface current distribution is presented in Fig. 5. It shows how the flow of the current in the structure of the antenna. Especially at the curve area of the antenna, a lot of the radiation out of the design. As referred in Figure 5, when the different sizes of the curve are created, the frequency that would be different depends on the angle. Due to that reason, the antenna known as a wideband antenna. We can conclude that the result shows the maximum of the surface current at resonant frequency 4.25 GHz is 195.829 A/m.

The far-field radiation pattern of the finalised antenna is shown in Figure 6. it shows that the antenna's directivity is the same either from the front or back of the antenna, which means the signal transmitted through the front or back antenna is the same. It can be relevant that the antenna has omnidirectional radiation. The directivity of the antenna, at resonant frequency 4.25 GHz, the central lobe magnitude is 2.07 dBi at direction 178o, as presented in Fig. 6(a). Moreover, the antenna gain at resonant frequency 4.25 GHz with central lobe magnitude of -0.974 dBi at direction 178° with angular width 87° as shown in Fig. 6 (b). As for the E-field radiation pattern, Fig. 6(c) indicates at direction 178°, and the primary lobe magnitude is 13.5 dB (V/m) for frequency response 4.25 GHz. Finally, the H-field radiation pattern presented in Figure 6 (d) indicates that at a direction of 178°. The primary lobe magnitude is -38.1 dB (A/m) for frequency response 4.25 GHz.

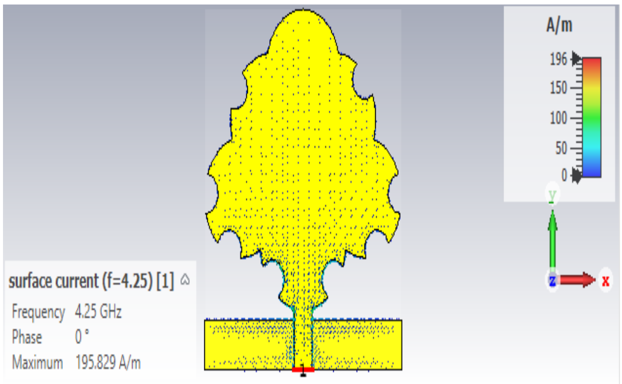
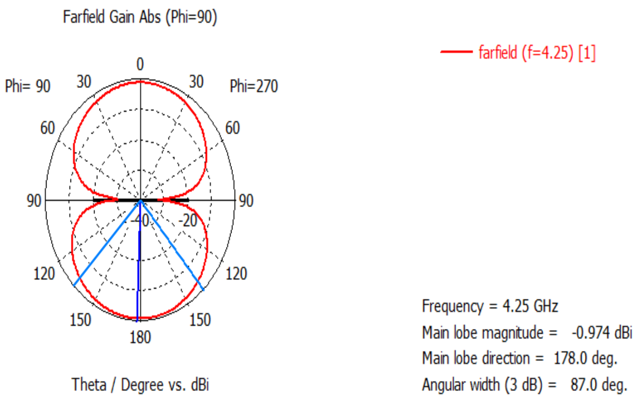
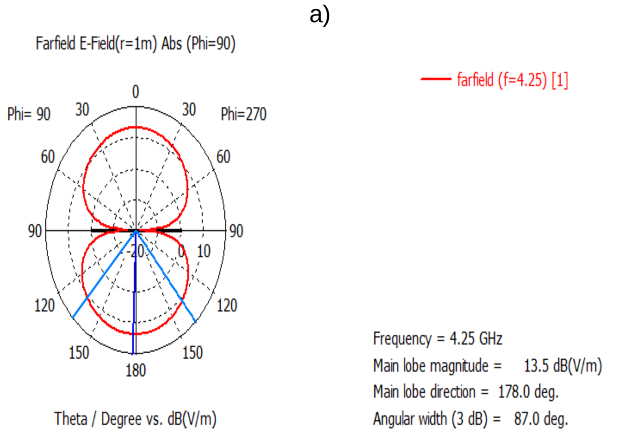


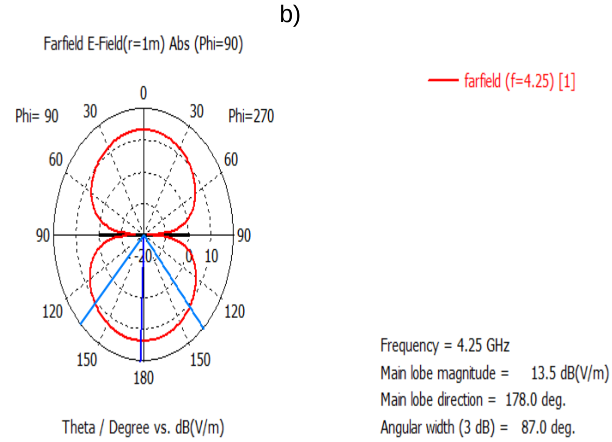
Fig. 5. Current distribution of the intended at 4.25 GHz.



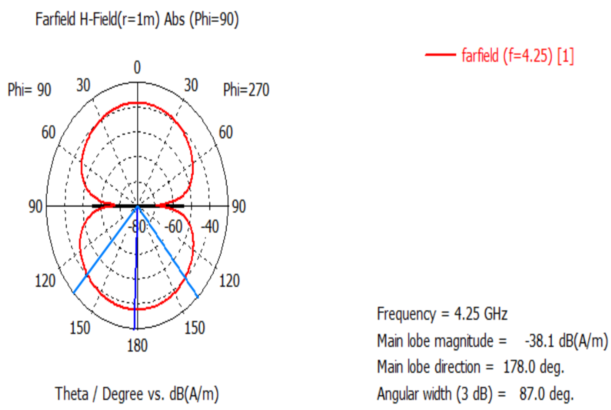
a)



b)



c)



d)

Fig. 6. The radiation pattern of the proposed antenna at 4.25 GHz (a) Directivity, (b) Gain, (c) H-field, and (d) E-field.

Conclusion

A wideband antenna for sub 6 GHz range and 5G application has been presented in this paper. The desired results of the antenna regarding the return loss, the structure of an antenna depends on the value of the parameter size of the antenna. It can be concluded that the more compact an antenna, it will affect return loss but depends on the type of antenna design. In addition, the width of the feedline also contributes a little bit different to the simulation result of return loss.

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