المؤتمر العلمي الدولي الثالث للعلوم و الهندسة
The 3rd Scientific International Conference in Science & Engineering

http://bwu.edu.ly/icse2024
Received 25/07/2024 Revised 25/08/2024 Published 10/09/2024
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Metamaterial Based Microstrip Patch Antenna Design for 5G/WiFi Wireless Technology applications.

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Abstract: To increase the antenna performance (gain and directivity), metamaterial surfaces are essential for achieving in-phase reflection and surface wave suppression. A compact metamaterial antenna for 5G WiFi wireless applications is presented in this study. The proposed antenna operates at 5.5 GHz the bandwidth is greater than 160MHz. One composite right/left handed unit cell is used in the construction of the suggested antenna. The suggested antenna has a smaller dimension (it measures just 18 x 17.2 x 5 mm) and achieves return loss of better than 10dB. Approximately 32% less area is covered by the design than by traditional patch antennas using the same frequency.
Keywords: Fifth generation(5G), Wireless Fidelity) (WiFi), VSWR (Voltage Standing Wave Ratio).

Introduction

WiFi is a trademark of the WiFi Alliance Manufacturers as a product brand certification and is a wireless local area network device based on the IEEE 802.11 standard. IEEE 802.11 devices have been installed in many products on the market, such as home computers, smartphones, wireless sharers, notebook computers, video game consoles and other peripheral devices. IEEE 802.11ac, also known as 5G WiFi (5th Generation of Wi-Fi), is an 802.11 Wireless Area Network (WLAN) communication standard. The frequency band for communication is in the 5GHz band. It can provide at least 1Gbps bandwidth for multiple stations. Wireless zone network, or a single connection transmission bandwidth of at least 500Mbps, establishes a standard for improving the speed of wireless network transmission, so that wireless networks can provide transmission performance comparable to wired networks. [1] The 802.11ac specification, finalized in January 2014, uses the 5GHz (from 4.9~6.0GHz) radio frequency band, OFDM orthogonal frequency division multiplexing, QAM256 carrier modulation and beamforming (Beamforming) technology to achieve a transmission rate of 1.3Gbps (3 antennas/3 data streams), 7Gbps (8 antennas/8 data streams/160MHz), can transmit high-definition video (Full HD) and 4K (3840x2160) video and video streaming specifications. [2].

Due to the rapid development of modern technology, wireless mobile communication networks are becoming more and more developed. Along with people's needs and convenience, they are also inseparable from the habit of using smart phones. The development of wireless network Wi-Fi has brought many conveniences to the public, such as commercial office buildings, supermarkets, restaurants, schools, train stations, etc... Many places provide free Wi-Fi, even at home. I will also buy my own Wi-Fi sharer to use, making wireless communication networks ubiquitous. At the beginning of the

21st century, many cities around the world announced plans for city-wide Wi-Fi and there will be in the future. , with a coverage rate of 90%, Wi-Fi technology is already available in major cities around the world. Wi-Fi used in daily life can be divided into five generations. Since the 2.4GHz band in the ISM band is Widely used, such as Bluetooth and microwave ovens, they will interfere with Wi-Fi and slow down the speed, while the 5GHz frequency has less interference. Dual-band routers use 2.4GHz and 5GHz, and devices can only use a certain frequency band. Because of this demand, wireless network Wi-Fi is constantly being developed, and 5G WiFi (5th Generation of Wi-Fi) -Fi) has the fastest transmission rate and the lowest power consumption, so it has become a new generation of wireless transmission system. In view of this, we hope to conduct research on 5G WiFi antennas that can comply with the frequency band specifications of the IEEE 802.11 standard. The antenna design frequency band covers 5GHz and the bandwidth is approximately greater than 160MHz. How to design a 5G WiFi antenna is this paper. main research directions.

Metamaterials Based WiFi Antenna for 5G

The invention of metamaterial (MTM), an artificial negative index medium, was the primary driver of the remarkable advancements in electromagnetics, particularly in microstrip antenna configurations. MTMs are synthetically electromagnetic materials composed of metallic components organized in periodic patterns that are smaller than the wavelength of the incident electromagnetic (EM) wave [1]. There was a strong need to use MTM for this reason since patch antenna size reduction and mutual coupling reduction have become crucial in modern communication systems. Several techniques have been used to reduce the patch size in microstrip antennas. Patch antennas can be made more compact by increasing the reactive dielectric constant [2]. Another method for cutting the patch's dimension in half is to fold it into a multilayer structure, however this increases the patch's thickness [3]. A technique known as defective ground structures (DGS) has been used to reduce antenna size [4]. Using MTMs is the most current trend in reducing the size of microstrip antennas. In order to minimize the size of the antenna, planner MTMs are heavily utilized. They employ two distinct MTM cells to enable the antenna to create three resonances.

In this study, we use metamaterials to improve the performance of 5G WiFi antennas. Two motivations exist for the etching of complementary interdigital resonator cells on the antenna ground plane: first, to reduce the size of the antenna overall by allowing a band gap to exist in their frequency response. For this reason, several studies on the design of antennas based on metamaterials have lately been published in the literature. and secondly, to improve the antenna's performance by raising its gain and directivity. Antennas equipped with interdigital capacitors are introduced to meet the needs of 5G WiFi applications. The suggested design has an 80 MHz bandwidth and resonates at 5.5 GHz. Ansoft HFSS, a program based on the Finite Element Method (FEM), is used for the analysis and design of the suggested structure.

Design of a Interdigital Microstrip Antenna

In this part, we calculate the antenna using the Equivalent Circuit Model of a Microstrip CRLH Transmission Line as Fig.1 and Fig. 2.

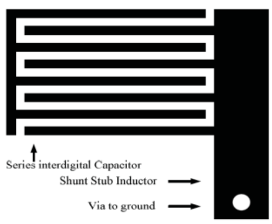

Fig. 1. Unit Cell Model CRLH Transmission Handed.

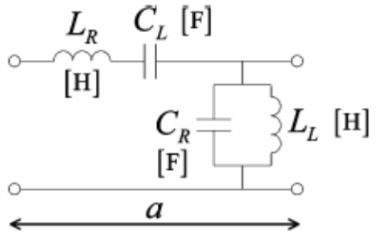

Fig.2. Equivalent Circuit Model of Microstrip Composite Right/Left Handed TL.

The calculations for the initial unit cell model design for the ZOR Antenna design. The layout was adjusted multiple times to get the desired result as shown Fig. 3.

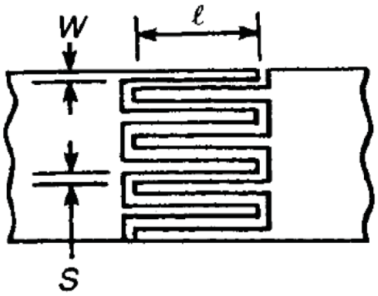

Fig.3. Layout of the Interdigital Capacitor [5] [6].

Where**:**
l: Finger Length (mm)
W: Width of the Microstrip Line (mm)
S: Spacing between Fingers
N: Number of Fingers
ε_e : Dielectric Constant of Microstrip Line
h: Height of the Dielectric Substrate.

To calculate the Interdigital Capacitor values, we use the below equation [5].

$$C(\mathrm{pF}) = \frac{\varepsilon_e 10^{-3} K(k)}{18\pi K'(k)} (N-1) l$$

where:

$$k = \tan^2\left(\frac{a\pi}{4b}\right)$$
$$a = W/2$$
$$b = (w+s)/2$$
$$K' = \sqrt{1-K^2}$$

$$\varepsilon_e = \begin{cases} \dfrac{\varepsilon_r+1}{2} + \dfrac{\varepsilon_r-1}{2}\left[\dfrac{1}{\sqrt{1+\frac{12h}{W}}} + 0.04\left(1-\dfrac{W}{h}\right)^2\right] & \text{for } \dfrac{W}{h} < 1 \\ \dfrac{\varepsilon_r+1}{2} + \dfrac{\varepsilon_r-1}{2}\left(\dfrac{1}{\sqrt{1+\frac{12h}{W}}}\right) & \text{for } \dfrac{W}{h} > 1 \end{cases}$$

RH feeding line, as seen in the image. A shunt stub inductor and a series interdigital capacitor served as the foundation for the unit cell. The substrate Rogers RT/duroid 5880, with a relative permittivity of 2.2, thickness (h) of 1.6 mm, and a dielectric loss tangent of 0. 02, is intended for use by the antenna. The antennas depicted in Fig. 4 were designed to be used with the 5.5GHz frequency. The commercial program HFSS is used to carry out the simulation.

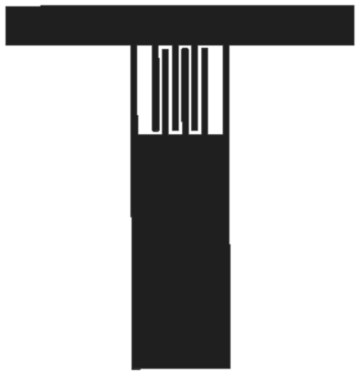

Fig.4. 2D layout of proposed antenna.

The final optimized antenna dimensions are displayed in Fig. 5. after the geometric parameters have been properly modified. The antenna's physical dimensions are 18 x 17.2 x 5 mm**.**

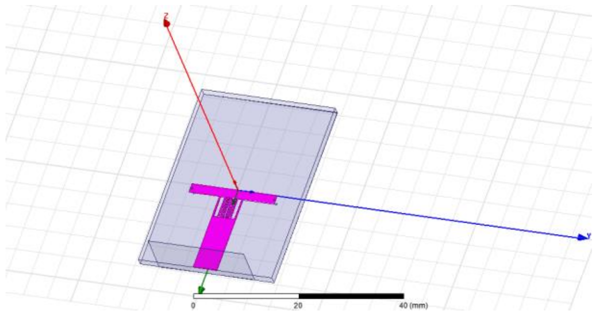

Fig. 5. Geometry Structure of proposed 5G WiFi Antenna in (mm).

In HFSS, the published structure is implemented. To acquire the scattering parameters, the required simulations are run. The antenna validation was completed when the acquired findings agreed with the reported results.

Simulated Results

It is common practice to employ simulation and design while creating antennas. Figures produce and display a variety of simulated graphs, including those for return loss, VSWR, total directivity, antenna gain, current distribution, and radiation patterns. Using electromagnetic full wave simulation, this has been verified (HFSS).

Antenna Return Loss

Fig. 6. displays the proposed antenna simulated reflection coefficient. It is evident that the reported antenna has a bandwidth that spans from 5.45 GHz to 5.52 GHz and may operate in the operational band (below -10 dB) at centered 5.5 GHz (-12.7 dB). Thus, it is evident that this operating band satisfies the 5G WiFi standard operating frequency design criteria.

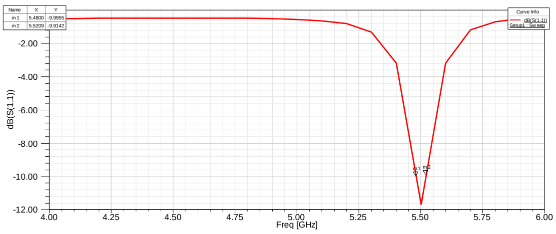

Fig. 6. Simulation results of the 5G WiFi antenna.

b- Radiation Pattern in 3D

Fig. 7. displays the radiation patterns for the antenna array designed for 5G WiFi.

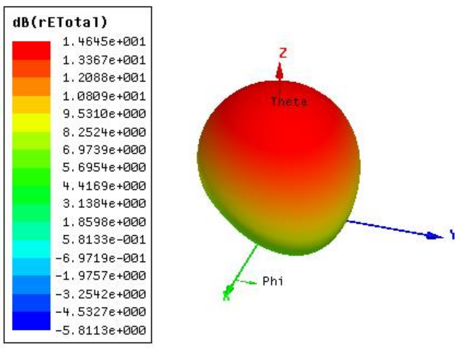

Fig. 7. 3D radiation pattern of the 5G WiFi antenna.

As can be predicted given that the antennas are patch type, the antenna design has directional shaped radiation patterns in the phi=0 deg (x-y plane) and phi=90 deg (y-z plane) planes. There is a directional pattern on the antenna.

c- Gain and Directivity

The intended antenna has a gain of 5.16 dB and a directivity of 5.312 dB, radiating in a direction. Fig. 8. below shows the 3D far field plots for gain and directivity. The antenna has a strong directivity and gain.

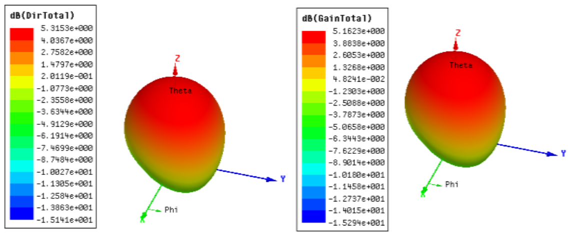

Fig. 8. Gain and directivity of the 5G WiFi antenna.

d- Voltage Standing Wave Ratio (VSWR)

The VSWR for a 5G WiFi antenna array is displayed in Fig. 9. At 5.5 GHz, we got good values of 1.7 dB, indicating well-received transmissions.

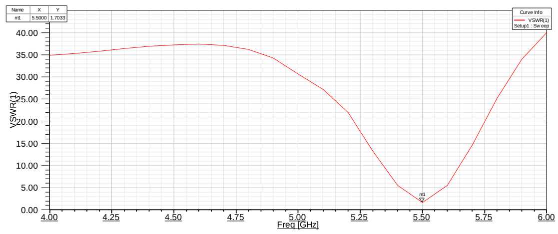

Fig. 9. VSWR of the 5G WiFi antenna.

f- Current Distribution on the antenna

As an indication of the radiation from the microstrip patch, the current distribution is defined as the field distribution between the patch and the ground plane. The present distribution pattern at 2.1 GHz is seen in Fig. 10. At this frequency, the maximum current in the suggested antenna is 1.64 (A/m); the strongest current is dispersed in a red arrow-shaped pattern within the antenna patch.

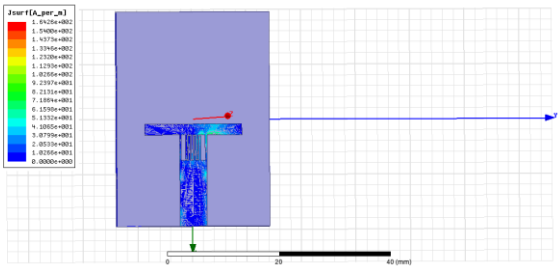

Fig. 10. Current distribution on the 5G WiFi antenna.

Conclusion

A compact and highly effective CRLH MIMO metamaterial has been showcased. Electromagnetic full wave simulations have been used to present the antenna's detailed design and analysis. One LH unit cell was used in the construction of the WiFi antenna components. The tiny dimension of the suggested antenna—just 18 x 17.2 x 5 mm represents a size reduction of nearly 60% when compared to traditional patch antennas. Additionally, at the working frequency of 5.5 GHz, the developed antenna exhibits a return loss of greater than -40 dB. In addition, the directivity is 5.31 dB and the gain is 5.16 dB.

It is possible to establish good agreement between the IEEE802.11ac specification and simulation. Thus, it is evident that these operating bands satisfy all 5G WiFi standard operating frequency design criteria.

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