Compact Ultra-Wideband Slotted Microstrip Patch Antenna for 5G, IoT and RFID Applications

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Abstract

With new emerging technologies in 5G era, the need of compact and cost-effective antenna holds significant promise for delivering contributions to society. The compact UWB omnidirectional microstrip patch antenna of 36mm × 32mm × 1.6mm for IoT, 5G and RFID applications is proposed and simulated. The proposed antenna covers frequency of 5.1256 GHz to 6.4391 GHz with UWB (bandwidth > 500MHz) characteristics. The proposed antenna has an FR4 substrate that made the antenna a cost-effective candidate in 5G era. The directivity of 5.3 dBi with gain of 3.51 dBi are obtained from the simulation results.

Keywords: Microstrip Patch antenna, UWB, ,5G, IOT, RFID

1. Introduction

Due to the rapid deployment of technology in people's lives and the users concern on their non-stop connections with different gadgets, the need of having a good antenna that can provide connections to the latest wireless technologies and providing a reliable connection between everything known as Internet of Things (IoT) under 5G's umbrella became at the center of attention of most of researchers [1].

5G or so called the fifth generation of wireless communication is the new revolution and evolution in a wireless field that speed up the advent of IoT. 5G is an essential infrastructure that allows all communications to be linked through the IoT at anytime and anywhere. The main advantages of 5G are providing larger capacity, higher data-rate, lower latency and higher application reliability. It is 1000 times more capacity, 100 times faster and 100 times more connectivity compared to 4G [1].

IoT has accelerated the development of many devices around us and has brought up possibility of many applications. Its vision is to build a fully connected environment to ensure more convenient and better human living by improving the issues like energy management, climate change, automation and transportation, healthcare and treatment, logistic management and other related fields [2].

Radio frequency identification (RFID) is a key technology for making the IoT to automatically detect objects by using wireless communication. In recent years, RFID has been widely used in many places, such as logistic management and production. RFID is one of the main IoT technologies and one of the ten most important technologies in the 21st century, as an automatic detection and data capture technology [3]. RFID uses frequency from 30 Hz to 5.8 GHz which depends on the applications [4].

According to the Federal Communications Commission (FCC) in February 2002, the specifications for UWB systems to use in the band of 3.1 GHz to 10.6 GHz and a large bandwidth of more than 500 MHz [5]. UWB provides higher data rates with very low radiation power. Hence, this technology is getting more significant and popular in wireless communication systems [6].

In this paper, the study and design of an UWB microstrip patch antenna is presented. Microstrip patch antenna is chosen over other types due to its compact size, light weight, high bandwidth, multiband properties, low cost and high gain [7]. The proposed antenna needs to cover three of the applications as well as meeting the requirements of UWB. The rise of the IoT has accelerated the development of many devices around us and has opened up the possibility of myriad applications. The IoT vision is to build a fully connected environment. This can be done by using smart objects and devices to produce data and transmit through the internet automatically for decision making purpose [7-9]. This is to ensure more convenient and better human living by improving the issues like energy management, climate change, automation and transportation, healthcare and treatment, logistic management, and other related fields. The IoT devices includes remote monitoring, tracking, collection of data, manufacturing and also for media applications. Nowadays, there are many IoT applications which are already identified globally i.e., smart city, smart home, smart logistics, smart transportation, smart healthcare and smart agriculture [8-10].

2. Antenna Design

The antenna is designed to cover frequency of around 5.8 GHz with UWB properties. The proposed antenna is fed by the microstrip line. The length and width of the antenna patch are calculated using the eq (1), eq (2) and eq (3) respectively.

$$\varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12(\frac{h}{W})}}\right] \quad (1)$$

$$Width = \frac{c}{2f_0\sqrt{\frac{\varepsilon_R+1}{2}}} \quad (2)$$

$$Length = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 0.824h\left[\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)}\right] \quad (3)$$

The geometry of the microstrip patch antenna is shown in Figure 1. The FR-4 (dielectric constant = 4.4) is used as the substrate with a thickness of 1.6mm. The copper is used as the patch and its thickness is kept at 0.035mm. The rectangular patch has a size of 16mm × 12mm with a square slot of 2mm × 2mm in it. The antenna has two inset feeds with size of 1mm × 4mm. The feedline has a length of 10mm with 3mm width.

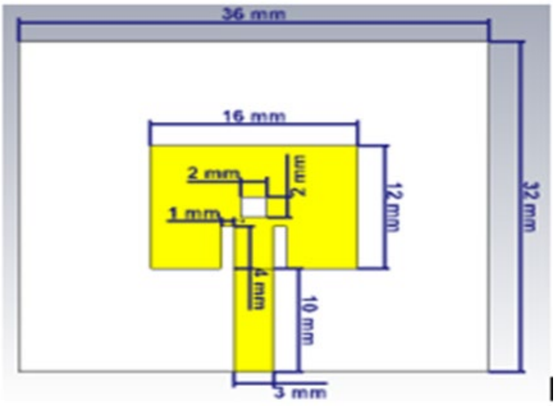

Fig. 1. Antenna dimensional parameters

3. Simulation Results

The antenna is simulated using Computer Simulation Technology (CST). A conventional rectangular patch is implemented on the top surface of FR-4 dielectric substrate in a half- length conductive ground. A rectangular $2 \times 2\ mm$ slot has been engraved at the center of the patch. The geometrical layout along with the dimensional parameters are depicted in Fig.1. The proposed slotted antenna exhibits an acceptable frequency response which is discussed in depth in the next section.

3.1. *Return Loss (S11)*

The S_{11} performance of the proposed antenna is simulated using CST Studio Suite 2019. Figure 2 illustrates the antenna resonates from 5.1256 GHz to 6.4391 GHz. The threshold value of -10 dB is taken as the base value which the mobile communication can operate perfectly [8]. At 5.8 GHz, the return loss with value of -17.927 dB has been obtained.

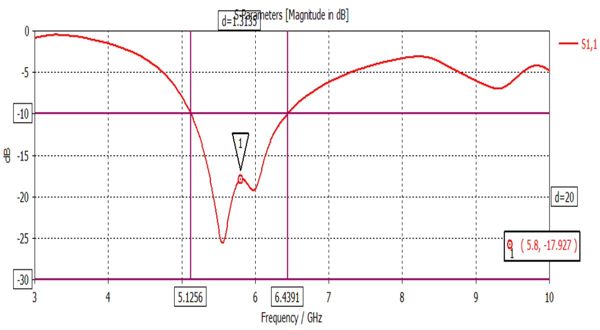

Fig. 2. Return loss at 6.4391 GHz.

3.2. *Voltage Standing Wave Ratio (VSWR)*

Figure 3 shows the VSWR of the proposed antenna. From the graph, it is observed that the VSWR value is below 2, from 5.1256 GHz to 6.4391 GHz. In fact, the VSWR value of below 2.5 is acceptable for most wireless applications [8]. If the VSWR increases, there will be more power reflected from the antenna, which is not considered as a good transmission.

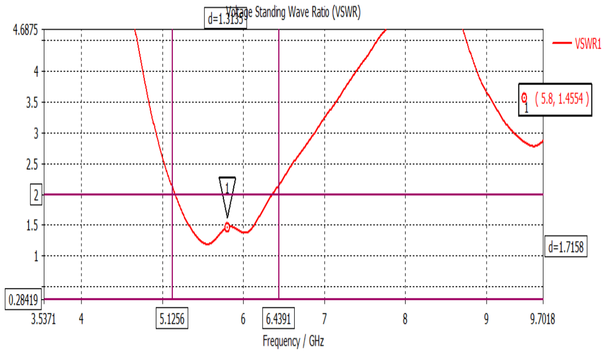

Fig. 3. VSWR value at 6.5 GHz

3.3. *Directivity of Antenna*

The directivity of the proposed antenna is 5.3 dBi at 5.8 GHz with a side lobe level of -8.1 dB, as depicted in Figure 4.

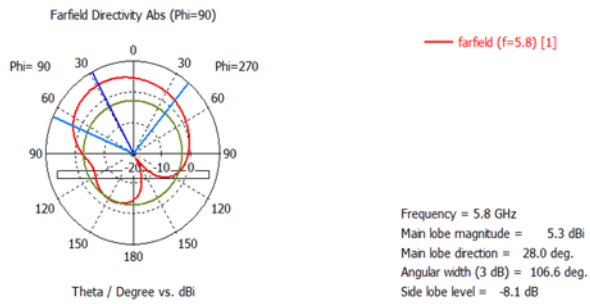

Fig. 4. Directivity of proposed antenna

3.4. *Antenna Gain*

Based on Figure 5, the gain of the proposed antenna is 3.51 dBi at 5.8 GHz, which is acceptable in terms of small size antenna. The gain is calculated by the ratio of the power emitted by it in a given direction with distance to the power emitted at the same distance by an isotropic antenna which is calculated as in (4).

$$gain = 4\pi \frac{radiation\ intensity}{total\ input\ power} \tag{4}$$

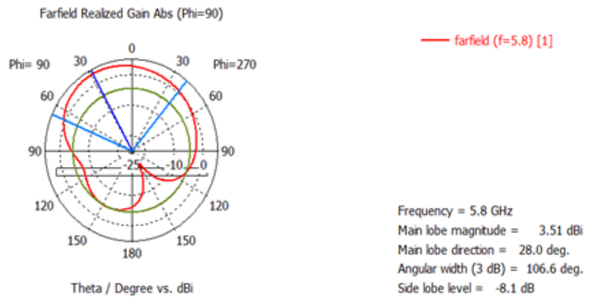

Fig. 5. Antenna gain at 6.4 GHz

3.5. *Radiation pattern*

Figure 6 shows the 3D radiation pattern of the proposed antenna. An omni-directional pattern is shown, which is good for mobile communication. The major lobe happens as the gain in the direction is high at its resonant frequency. The width of the main beam is between -3 dB. Low gain in the direction resulting in minor lobes.

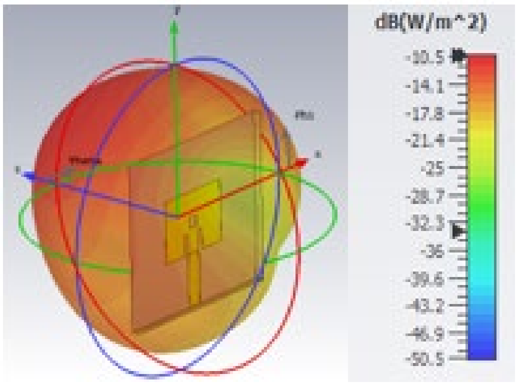

Fig. 6. Radiation pattern

4. Conclusion

In this paper, a rectangular UWB microstrip patch antenna with a compact size of 36mm × 32mm × 1.6mm is presented. This antenna can operate within 5.1256 GHz to 6.4391 GHz with UWB properties. It has a return loss of -17.927 dB, directivity of 5.3 dBi and a gain of 3.51 dBi at 5.8 GHz. The proposed rectangular microstrip patch antenna has been designed and simulated using CST Studio Suite 2019. The goal of this project is to design an UWB antenna which can operate within IoT, 5G and RFID applications. The simulated antenna can operate from 5.1256 GHz to 6.4391 GHz with a bandwidth of 1.3 GHz. This shows that the antenna satisfies the characteristics for the IoT, 5G and RFID applications.

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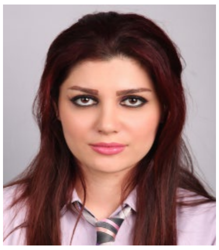

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