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Directional Lora Antenna at 433mhz for Point-To-Point Communication

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Abstract: In modern communication, a number of modulation approaches for long-range wireless sensor networks running at sub-GHz frequencies have recently gained popularity. Various technologies are employed in LoRa use license-free I.S.M. (Industrial, Scientific and Medical) bands of frequencies. Their operating frequencies are in sync at wavelengths of 35 cm or more, resulting in improved performance propagation in both indoor and outdoor environments. These radio waves are very useful in the presence of obstruction because of better penetration and/or diffract more around compared to transmissions at 2.45 GHz, which are extensively used. The I.S.M. band has a wavelength of only 12 cm. There are several unlicensed frequency bands available. The available bands in Europe such as 434 MHz, 868 MHz, 2.45 GHz, and 5.8 GHz. The 434 MHz band has the best propagation qualities of the four, but the wavelength is shorter. Wearable antennas for this frequency tend to be shorter than 70 cm grown quite substantial. The 868 MHz band provides excellent coverage solutions that combine small, wearable antennas with excellent propagation properties. The radiation pattern obtained are in both directional and omnidirectional for meander-line antenna for all the frequencies. The simulated return loss and radiation pattern are used to demonstrate the performance of the antenna.

Keywords: LoRa Antenna, 433MHz, I.S.M Bands

1. Introduction

LoRa (short for long range) is a chirp spread spectrum (CSS)-based spread spectrum modulation method. LoRa is a long-range, low-power wireless network that has become the Internet of Things wireless platform (IoT). LoRa devices and networks enable smart IoT applications that address some of the world's most pressing issues, including energy management, natural resource conservation, pollution control, infrastructure efficiency, and disaster prevention. LoRa devices are used in smart cities, houses and buildings, communities, metering, supply chain and logistics, agriculture, and other

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applications. The world will be a smarter place by using LoRa devices through connecting hundreds of millions of devices to networks in over 100 countries and expanding.

Due to the increased demand for wireless and LoRa technologies, wired communication systems have gradually been superseded as the present communication system advances and evolves. In this transition phase, antennas, which are metallic devices that capture signals in the air, serve a critical function [9]. Wireless applications are required by consumers all around the world. Aside from that, electronics nowadays are increasingly easy to carry and used in IoT technology. As a result, the built-in antenna must be small enough to fit into the mobile device. At the same time, a high directional antenna increases the communication distance. Thus, a compact directional LoRa antenna is required for mobile IoT devices.

The goal of this research is to come up with the best configuration and design for a LoRa antenna. This research will address three different areas. The primary need is that the design antenna be tiny, have long range connectivity, and consume little power. The second goal is to use computer simulation technology (CST) software to develop and simulate the LoRa antenna. After designing the LoRa antenna in the simulation [8]. The third scope will be to manufacture the antenna out of FR4 and measure the proposed antenna's parameters such as return loss, gain, and radiation pattern. Finally, the simulation results will be compared to the real antenna, and a report will be generated.

The goal of this project is to provide the best possible LoRa antenna layout. The antenna design is hoped to aid the communication and technology industries, particularly in small towns where a good antenna will boost connectivity. The benefit of a thin profile inserted into the PCB during the manufacturing process will lower the size of the devices indirectly.

Table 1: Summarization of literature review comparison

Item	Parameter Name	Antenna	Frequency Band
[3]	Low-Profile Dual-Polarized Microstrip Antenna Array for Dual-Mode OAM Applications	Microstrip antenna	5.5GHz
[2]	Compact Quasi Yagi Antenna for UHF Wireless Communication Systems with Enhanced Performance at UHF ISM Bands.	Quasi Yagi antenna	433MHz & 866MHz
[5]	Miniaturized meander PCB antenna for 433MHz.	PCB antenna	433MHz
[6]	Dual-band LoRa Antenna: Design and Experiments.	PCB antenna	433MHz
[4]	Design and Performance Analysis of LoRa LPWAN Antenna for IoT Applications.	Microstrip antenna	433MHz

Researchers are paying close attention to the LoRa antenna because it has the possibility to save space and money, especially in mobile devices. Low-profile antennas, rather than huge and heavy antennas, may be used in future mobile devices. Furthermore, the Antenna is less sensitive to component and ambient noise. Aside from that, compared to other antenna, the LoRa antenna required less simulation time. Because of its robustness, simplicity of design and ease of fabrication in FR4, LoRa antennas were chosen over other antennas [7]. Table 1 shows the comparison of other types of antenna summary.

For the low profile dual polarized microstrip antenna. The overall size of the four-element DP OAM antenna array is 120 mm × 112 mm × 5.3 mm. The measured −10 dB bandwidth is 300 MHz (5.39–5.69 GHz) for port 1 (mode −1) and 290 MHz (5.37– 5.66 GHz) for port 2 (mode +1), respectively. Meanwhile, the measured isolation between two ports is more than 25 dB. The main drawback is dual- polarized increase the complexity of the antenna [3]. In the Broadband Compact Quasi Yagi Antenna, the design is implemented on A4 panel size (approximately 304.8 mm × 228.6 mm or 12 inches × 9 inches) of Rogers 4003C dielectric substrate. From the measured gain values, the antenna is said to have more than 4 dBi gain over the entire band of 428 MHz–896 MHz. Besides, it provides minimum 4.5 dBi gain at the frequency bands of 428 MHz–500 MHz and 800 MHz–900 MHz where the gain values are 5.6 dBi and 5 dBi at 433 MHz and 868 MHz, respectively [2]. However, the main drawback is the antenna is large to fit in small devices. For the miniature meander PCB antenna for 433MHz, the antenna is printed on substrate FR4 with dielectric constant 4.4 and thickness 1.6 mm. The size of antenna is 40mm x 50mm. The main drawback of the meander are reducing the size of the antenna has several limitations, and it might also affect the performance of the antenna [5] . In the dual-band LoRa antenna, the terminal is based on a 1.6mm-thick 90*30mm Printed Circuit board (PCB). The antenna achieves simulated radiation and total efficiency of -5.8dB at 433MHz and -4.3dB at 868MHz [10]. However, these designs used complicated optimization process [6]. For LoRa LPWAN antenna for IoT application, the substrate used is FR4 lossy, having length of 210.82 mm and width of 164.79 mm with a dielectric constant of 4.4 for lower frequency, due to its's low-cost and easy availability. The antenna was successfully simulated using Computer Simulation Technology (CST) studio suite with efficient return loss of -15.186518 dB and gain of 2.194 dB respectively but the main drawback are the gain is not high but better than the former design[4].

In summary for this project, the antenna must have directional radiation pattern and 433MHz frequency to increase the communication distance. Furthermore, the antenna must be low-profile to make sure the antenna is easy to fabricate and design [11].

2. Methodology

This project is divided into three stages. A final report will be produced after the third stage is completed. The methodology's flowchart is shown in Figure 1. The three stages are as follows:

- Stage 1: Design a microstrip patch antenna to be applicable with 5G application
- Stage 2: Computer Simulation Technology (CST STUDIO SUITE 2018) is used to simulate the proposed antenna.
- Stage 3: Thesis report Writing

2.1 Design and Simulation

This project uses Computer Simulation Technology (CST) software to create the desired antenna since CST allows users to design and model antennas without having to fabricate a prototype. CST is one of the most popular antenna design programs. Antenna parameters such as antenna return loss, radiation pattern, and gain will be obtained using the software in this project.

On a FR4 substrate, the proposed antenna is accomplished. The patch, which measures 25 4 mm in front view, serves as a ground plane and improves bandwidth. The distance between the excited dipole and the reflector with a thickness of W = 10 mm is 147.3 mm, and the length of the dipole is 294.2 mm, which equates to 0/4 and 0/2 in free space at almost 510 MHz, respectively. To obtain the second resonance frequency in the ISM band around 866 MHz, three thick and closely spaced directors (0.9 mm) are utilized, and gain values at ISM frequencies of 866 and 915 MHz are increased. [1]

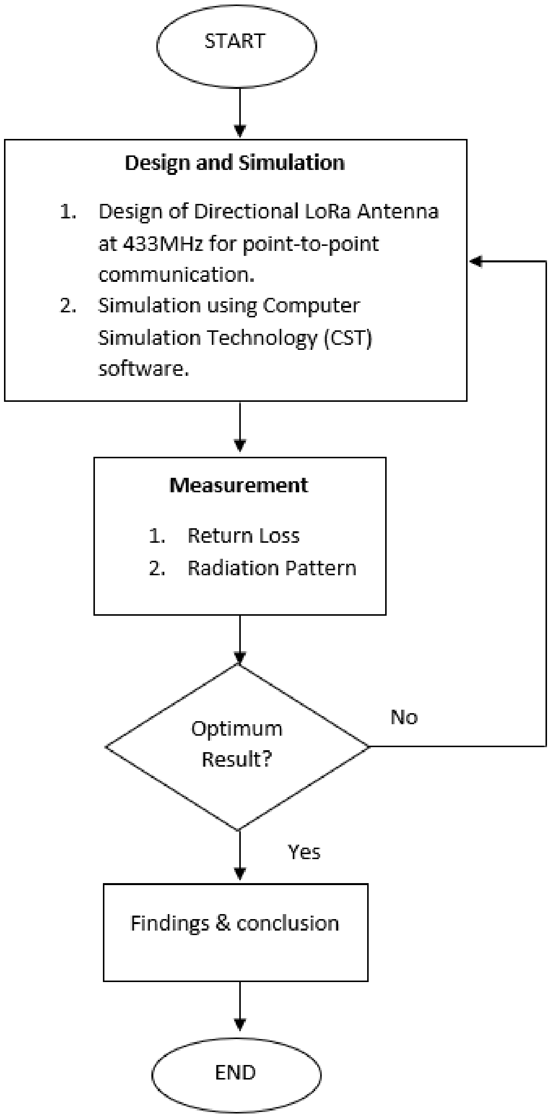

Figure 1: Flowchart of project

2.2 Antenna Frequency

A printed Yagi antenna with thick and closely spaced directors is realized in the UHF band in this work. The design focuses on the triple ISM bands of 433-434 MHz, 863-870 MHz, and 902-928 MHz, with a minimum of 10 dB return loss, 4 dBi gain, and a 10 dB front-to-back (F/B) ratio. It's also a goal to achieve moderate gain and return loss values over a large UHF band in a small antenna configuration.

2.3 Antenna Design and Dimension

This section briefly describes the designed antenna structure. The antenna is designed on FR4-subtrate with a thickness of 1.6mm and copper substrate of 0.0035mm. The designed antenna was simulated by using Computer Simulation Technology (CST) software. The proposed antenna consists of 3 parts, the reflector, driven element and three directors. Figure 2 and figure 3 shows the dimension of the designed antenna. The size of the antenna is L= 306.9mm X W=310.0mm. Figure 4 and figure 5 shows the same antenna but with meander-line. To make the overall antenna shorter, the conductors are intended to be folded back and forth. The size of the antenna is L= 306.9mm X W=200.0mm. A total size reduction up to 35% is achieved due to meander-line.

Table 2: Dimension of antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
a	40	h	4
b	40	i	25
c	40	W	10
d	83	k	168.3
e	97	l	150
f	122	m	7
g	0.9	n	2.9
H	306.9	L	310

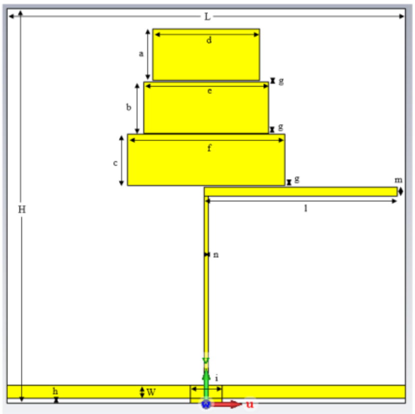

Figure 2: Front view of antenna.

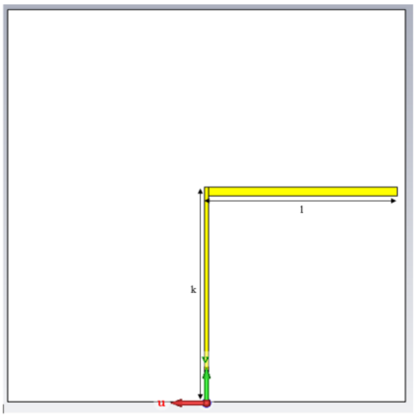

Figure 3: Back view of the antenna.

Table 3: Dimension of antenna with meander-line.

Parameter	Dimension (mm)	Parameter	Dimension (mm)
a	40	h	4
b	40	i	25
c	40	W	10
d	83	k	168.3
e	97	l	65
f	122	m	2
g	0.9	n	8.7
H	306.9	L	200
o	17	p	38

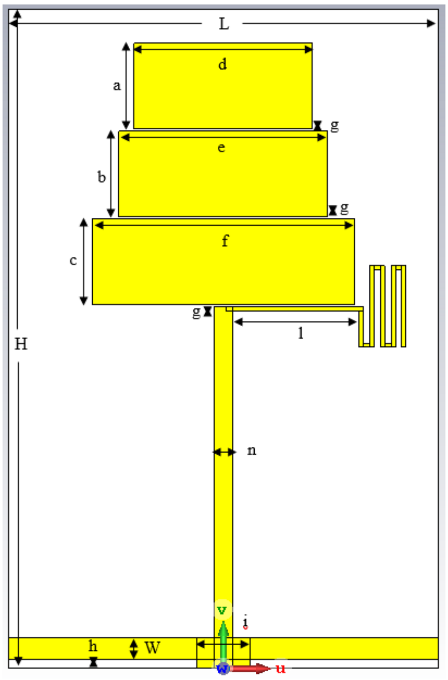

Figure 4: Front view of the antenna with meander-line.

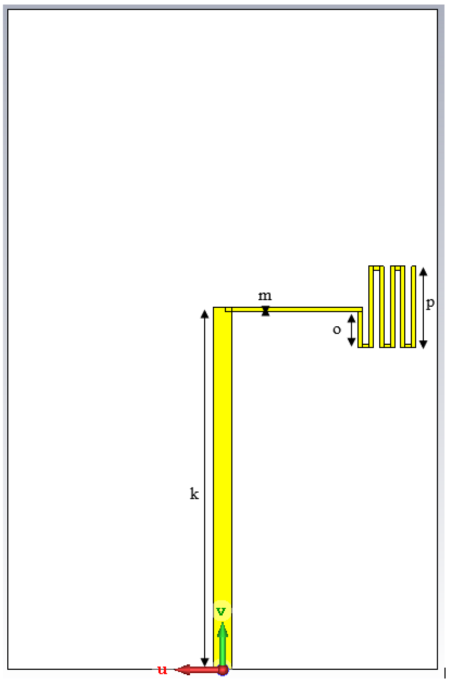

Figure 5: Back view of the antenna with meander-line.

3. Results and Discussion

3.1 Return loss

The key parameter of the antenna is measured by using the Computer Simulation Technology (CST) software whereby the value is then analyzed to ensure that the antenna design is supported by theory. The parametric study value of S11 is monitored closely to ensure the value is high as possible that are suitable for communication system. Figure 6 represent the return loss of the antenna with normal configuration while Figure 7 represent the return loss of the antenna with meander-line configuration. The antenna with normal configuration is resonating at 433MHz and 868MHz with a bandwidth of 0.41503GHz to 0.49018GHz and 0.70902GHz to 0.91944GHz. Meanwhile, the antenna with meander-line configuration is resonating at 433MHz and 868MHz with a bandwidth of 0.41984GHz to 0.43968GHz and 0.79559GHz to 0.86968GHz. Both antennas are operating at the designated frequency for LoRa application.

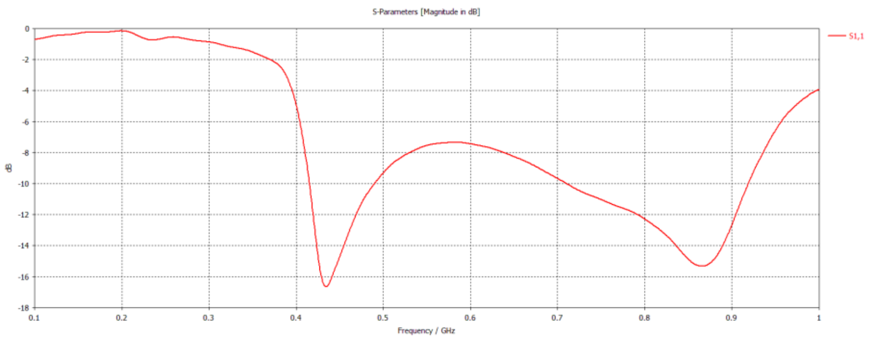

Figure 6: Return loss of the antenna.

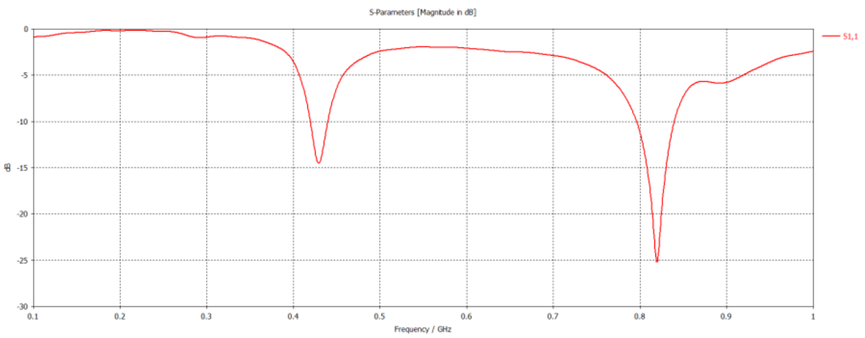

Figure 7: Return loss results of the antenna with meander-line.

3.2 Radiation Pattern

Figure 8 and Figure 9 shows the radiation pattern of the simulated antenna for E-plane. The simulated angular width and side lobe level is tabulated in Table 4 and 5. For figure 8, the radiation pattern of antenna is directional with a gain of 5.5dB. Meanwhile, for figure 9 show the radiation pattern of antenna is omnidirectional with a gain of 3.09dB. It was found that the radiation pattern became omnidirectional and low gain compare to the normal antenna configuration due to decrease of total length of ground plane.

Table 4: Angular width and side lobe level of the antenna.

Frequency, GHz	Main lobe magnitude, dBV/m	Main lobe direction	Angular width (3dB)	Side lobe level, dB
0.433GHz	20.2	90.0 deg	146.9 deg	-9.9dB

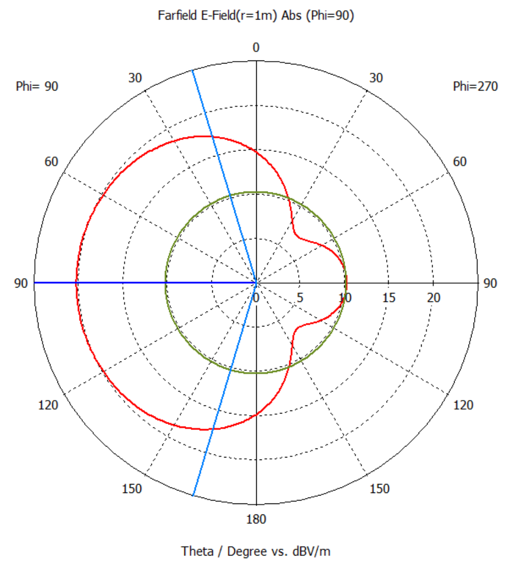

Figure 8: Simulated radiation pattern for 0.433GHz

Table 5: Angular width and side lobe level of the antenna with meander-line.

Frequency, GHz	Main lobe magnitude, dBV/m	Main lobe direction	Angular width (3dB)
0.433GHz	16.3	-83.0 deg	89.3 deg

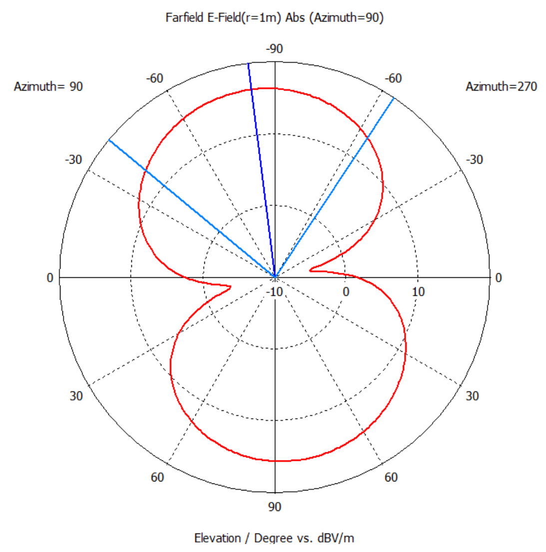

Figure 9: Simulated radiation pattern with meander-line.

4. Conclusion

There are a huge number of ongoing researches done on LoRa antenna especially with meander-line antenna due to the advancement of technologies in communication. The objective of this project has been achieved. In this study, LoRa antenna with 433MHz has been successfully designed, simulated and optimized. The LoRa antenna with meander-line designed in this project is to make reduce the size of the antenna, the conductors are intended to be folded back and forth. Although the antenna size is smaller, the bandwidth, efficiency, and radiation resistance all decrease.

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