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AN EFFICIENT MINIATURE LORA ANTENNA FOR IOT APPLICATIONS USING HFSS

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ABSTRACT

The internet of things is becoming more main stream, it's increasingly important to be able to send tiny bits of information from sensors over long distances while keeping their power usage low. And an effective solution for that is a Long-Range Wide Area Network. This paper presents the design of a Microstrip patch antenna operating in the 868 MHz LoRa frequency band with a gain of 7.05 dB and VSWR of 1.21.

1. INTRODUCTION

Researchers have experimented with various methods to design miniature antennas to work at Sub Giga Hz frequencies. A circular antenna with radius of 5.2%λc operating at 474MHz was proposed in[8].The antenna meets the dimension requirements but has a limited bandwidth of only 2.2 MHz An antenna with improved bandwidth of 23% was designed in with the use of Hex ferrite substrate Co2Z (Ɛ= 12, μ=15). However, the high material loss of this expensive magnetic material degrades the energy efficiency and is not feasible and affordable for the IoT devices. A printed inverted F antenna with slots, exhibiting 9.3% bandwidth at 410 MHz and compact size is proposed in . An antenna with a wired patch is proposed in is applied for wearable devices has achieved a horizontal pattern and circular polarization . The antenna has a massive potential in the world of the Internet of Things (IoT). However, the miniaturized antenna design is a massive task as lora WAN applications consume relatively lesser power. The design in this paper is a miniaturized E-shaped patch antenna for LoRa devices. The patch's physical dimensions for the proposed antenna are 160mm*170mm*1.6mm on the FR-4 board. The simulated results were found satisfactory and can operate over the 868 MHz frequency band In the digital era of modern communications, human beings' communications are essential and how things communicate is also a vast area, leading to a new technology called IoT. Few existing communications like Bluetooth, Wifi, 3G, 4G communications have their advantages and disadvantages. There are few basic criteria such as data rate, low power, and long-distance communication to evaluate a system.[1] A machine-to-machine communication (M2M) requires both long ranges and low power to work for more hours, and it can compromise at data rates, so a new novel solution is demonstrated called LoRa technology.[2,3] Lora system is a Low Power Wide Area Network

(LPWAN) that serves IoT in large areas. It uses Semtech's spread spectrum modulation scheme and holds many advantages compared to conventional mechanisms, including low power, high efficiency, long-range, etc.[4] LoRa's work over the range of frequencies 433MHz, 868MHz in Europe, and 915MHz in American.[5] A narrow bandwidth of 5MHz could be expected because of low traffic and low data rates. The size of the antenna depends on the frequency chosen. IoT devices should be of low cost, compact in size, and should have high mobility. In considering the above facts, the size of the antenna should be miniaturized.[6] Miniaturization of antennas can increase the overall performance of antennas in terms of quality factor, narrow bandwidth,[10] and also reduces interference effects which are important characteristics in the design of IoT antennas. In the present work, a LoRa antenna is designed and examined for Lora frequencies. Their sizes are accustomed to a rectangular box, and antennas are used for radiating signals of LoRa devices. These devices can be used for things to communicate. First, we will discuss some previous literature in the Next section, and then, we show antenna design and its simulated results. Finally, in the last section, we will see the research and mention its orientation. LoRa is a technology with high prospects, but very few people are working on its antenna design. Nevertheless, the antenna holds a prominent position in communicating devices.

2. LITERATURE SURVEY

Internet of things as the name suggests is a collection of various sensors, electronic devices, processors and wireless communication technologies. The rapid evolution of internet of things made every smart object connectable to internet leading to new forms of interactions between human and smart devices or a direct machine to machine communication [1]. Many a type of household appliances are becoming smart and can be remotely operated and wearable devices like smart watches have become part of our lives with the advent IoT making homes, hospitals, transportation and agriculture smart. Slowly IoT is evolving as a powerful candidate in the upcoming communication world[2] The existing communication devices like mobile phones and computers are advanced enough for connecting people across the globe, but Machine to Machine communication (M2M) requires improved performance for longer distances and minimum power requirements to operate independently at remote localities [3].These applications require a robust, reliable low-power communication over a long range showing LPWAN as the best possible solution. SIGFOX, Ingénue TM and LoRa are the prominent technologies for Low power wireless area networks [4]. LoRa being effortlessly accessible one in the rural areas as well, supports communication of longer messages over larger distances, is the best for IoT applications. LoRa operates at different unlicensed frequency bands below 1GHz in various countries of the world, 863-870MHz in Europe, 902-928 MHz in United States of America and, 410-441 MHz in China. [5]. LoRa with a LOS propagation of 20Kms and a battery sustainable for longer life spans shows better performance characteristics for Internet of Things applications, compared to the existing Bluetooth and Wi-Fi technology. The limitation of LoRa is lower data rates (50KBps) which is not a cause of severe latency in IoT IoT applications unlike the regular communication applications require miniature antennas with ultra narrow bandwidth, good efficiency, integrated into compact devices. An antenna is considered to be a miniature when each of its dimension is less than or equal 0.1λ. [7]. Such smaller dimensions degrades the efficiency of the antenna ,but on the other hand improves the quality factor, and provides a minimum bandwidth and decreased interferences, which is the basic requirement of IoT antennas. Researchers have experimented with various methods to design miniature antennas to work at Sub Giga Hz frequencies. A circular antenna with radius of 5.2%λc operating at 474MHz was proposed in[8].The antenna meets the dimension requirements but has a limited bandwidth of only 2.2 MHz An antenna with improved bandwidth of 23% was designed in [9] with the use of Hex ferrite substrate Co2Z (Ɛ= 12, μ=15). However, the high material loss of this expensive magnetic material degrades the energy efficiency and is not feasible and affordable for the IoT devices. A printed inverted F antenna with slots, exhibiting 9.3% bandwidth at 410 MHz and compact size is proposed in [10]. An antenna with a wired patch is proposed in [11] is applied for wearable devices has achieved a horizontal pattern and circular polarization .Two logo antennas based on inverted f antenna have been destined in [12] provide a gain of 1.55 dB at 868 MHz band . A low profile micro-strip patch antenna with compact size for medical applications was proposed in [13] which operated at 868MHz band antenna

The miniature antenna was presented in two different designs which are UIT form and UCA form. The antenna was printed on FR4 in the dimension of 34mm*80mm*0.8mm. The antennas designed based on geometry of Inverted F Antenna (IFA). In order to ensure the antenna always work, the antenna length is always equal to a quarter of the wavelength. However, this design would face a problem when the frequency is lower. When the frequency is low, the harder the process due to the long length. In result, this journal only shows the simulation for the UIT design. The total bandwidth of 23MHz is achieved from 857MHz to 880MHz. Besides, the maximum total gain has reached 0.721dB while maximum directivity is 1.91dB [14].

3. EXISTING SYSTEM

FR4 is a class of printed circuit board base material made from a flame retardant epoxy resin and glass fabric composite. FR stands for flame retardant and meets the requirements of UL94V-0. FR4 has good adhesion to copper foil and has minimal water absorption, making it very suitable for standard applications. The material is very low cost and has excellent mechanical properties, making it ideal for a wide range of electronic component applications. The antenna is designed on FR4 lossy (Ɛr=4.4) substrate with the dimensions L=200mm,w=300mm .The patch length is 100mm and width is 120mm .The H-shape slot with a vertical length of 80mm , horizontal length of 90mm and width 10mm is cut in the

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ground plane to resonate the antenna at required frequency band. The ground plane with slots is mentioned in the Fig 5.1.The two T shaped slots with 40mm x 20mm dimensions are cut along the width of the ground plane to improve the gain over the operating frequency of 868 MHz band.

4. PROPOSED SYSTEM

IoT devices need affordable miniature antennas and Microstrip antennas due to their features like low profile, light weight, planar structure conformal to the device dimensions and ease of fabrication meet the requirements. The proposed antenna is a rectangular patch antenna designed by Calculating antenna’s dimensions from the standard dimension formulae for the preferred operating frequency and slots are cut on the ground plane. Choosing proper dimensions of the slots improves various parameters of the antenna. The efficiency of the antenna is improved compared to the simple ground plane and reduce the operating frequency to below 1GHz and also the bandwidth is narrowed leading to lesser interferences. The figure Fig shows the top view of the simple patch structure and the cross sectional view of the antenna is shown above. top view of the Proposed Antenna

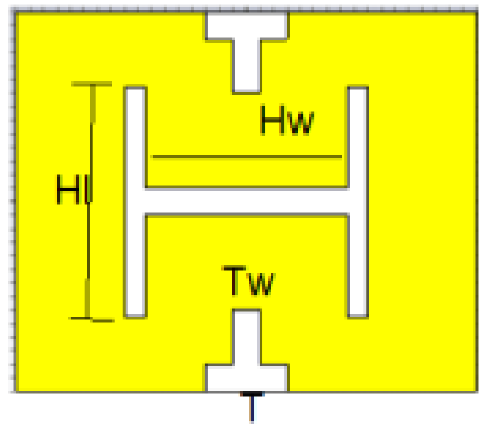

Fig1.Bottom View of the Antenna

The antenna is designed on FR4 lossy (Ɛr=4.4) substrate with the dimensions L=200mm,w=300mm .The patch length is 80mm and width is 47.913mm .The I-shape slot with a vertical length of 14.5mm , horizontal length of 58mm is cut in the ground plane to resonate the antenna at required frequency band. The ground plane with slots is mentioned in the Fig 5.3.The two I shaped slots are cut in the ground plane to improve the gain over the operating frequency of 868 MHz band. All the dimensions are mentioned in Table

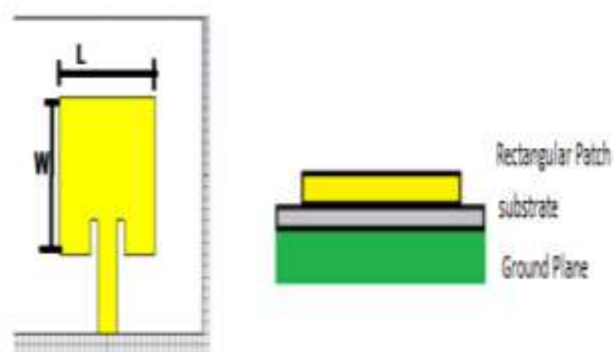

Fig 2. Cross sectional view of the proposed rectangular patch Antenna

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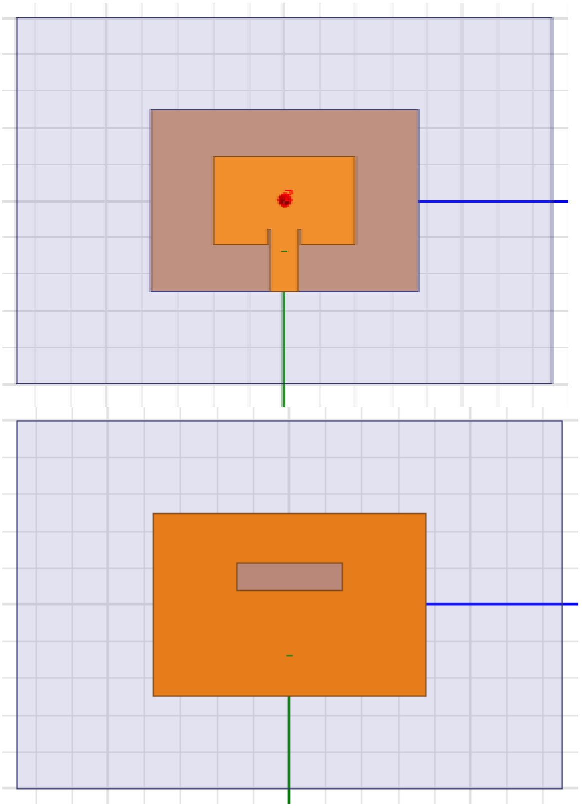

Fig 3. (a) top view of the Proposed Antenna (b) Cross sectional view of the proposed rectangular patch Antenna

TABLE.1 Dimensions of the Antenna Dimensions of proposed structures

Parameter	Dimensions(mm)
Lg	100
Wg	150
H	1.58
L	47.913
W	80
Lp	8
Wp	18
Lf	40
Wf	15.5

5. RESULTS

Return loss commonly known as reflection coefficient (S_{11}) is a measure of the power reflected by the antenna. The presents the return loss of the proposed antenna is -20.331 dB at the resonant frequency and the operating bandwidth is 9.2MHz-850MHz.

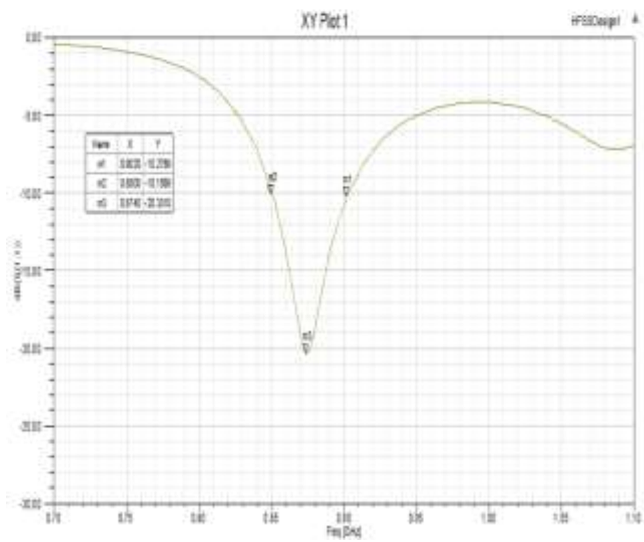

Fig4.Return loss Simulationresult ofproposed structure

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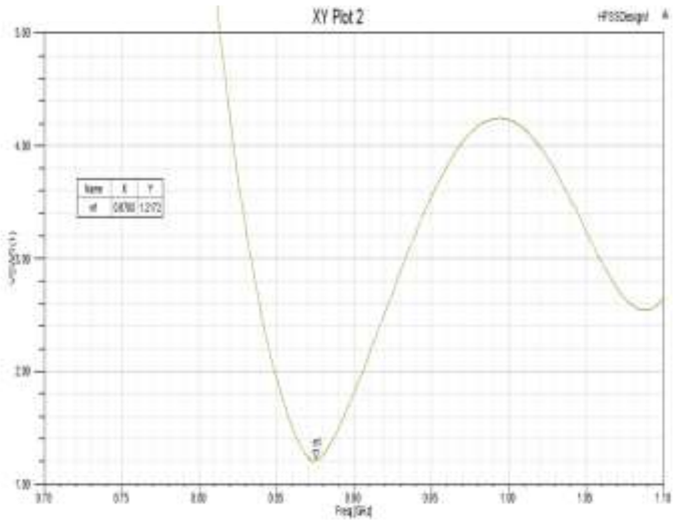
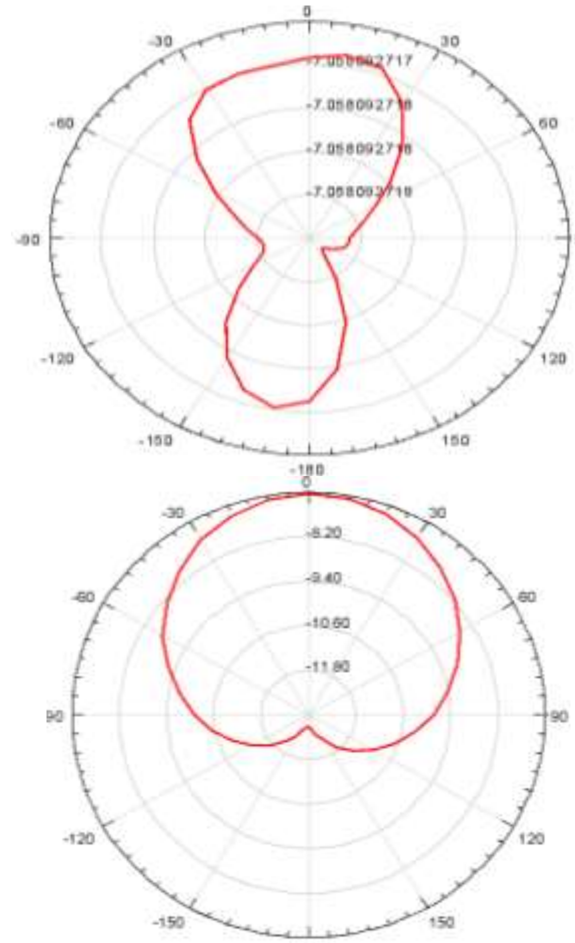


Fig.5 presents the voltage standing wave ratio at 876MHz is less than 1.217.



the surface current distribution of the antenna, implying the reduced distribution at the presence of slots in ground plane and a good current distribution along the corners of the patch.

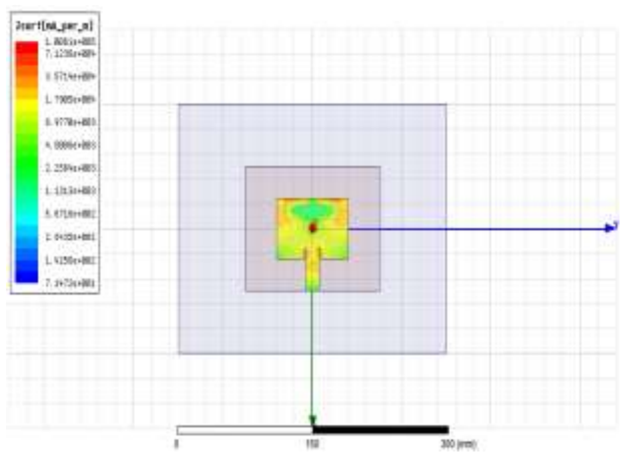


Fig. 6.Surface Current Distribution of the proposed antenna

Fig.7 shows the radiation pattern of the antenna is similar to that of a dipole antenna pattern and has circular polarization.

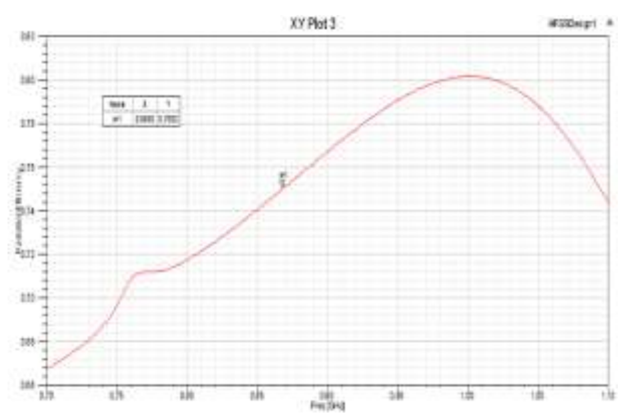


Fig. 8 Efficiency of the proposed antenna over the operating bandwidth

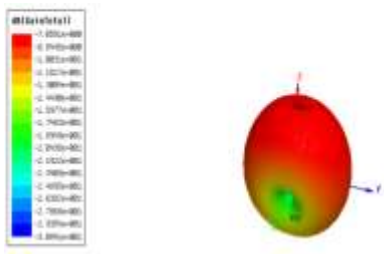


Fig.9 polar plot of the proposed antenna

Comparison Table:-his table given improvement of proposed system with existing system

	Dimensions	S_{11}(dB)	VSWR	Gain (dB)	%η
Existing	200X300	21.471	1.192	3.51	72
Proposed	100X150	2033	1.217	7.05	75

6. CONCLUSION

A novel rectangular patch antenna with slots in the ground plane is proposed in this paper. The antenna achieved acceptable dimensions for IoT applications. The slots in the Ground plane of the simple Microstrip patch antenna improved the efficiency of the antenna and meet the bandwidth requirement. The antenna achieves a circular polarization and gain of 7.053dB. the return loss is less than 25dB and a good VSWR value<2 is presented. The size of the antenna can be further reduced by introducing slots in the patch.

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