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A COMPACT PIFA ANTENNA FOR INTERNET OF THINGS NETWORK LoRaWAN AT 900 MHz BAND

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Abstract—*In this paper, a planar inverted-F antenna (PIFA) for LoRaWAN network is studied. The proposed structure covers the 868MHz radio frequency band used by LoRaWAN in Europe and the 915 MHz radio frequency band used in North America. The miniaturization in the antenna size is achieved by introducing a meandered microstrip line. The setup of the meandered line allows obtaining lower resonant frequency and large -6dB bandwidth and important gain. The antenna has compact size of 40x26x1.6mm³. The radiation patterns in the operating bandwidth are almost the same as the omnidirectional characteristics. The influences of various design parameters are investigated using CADFEKO, a Method of Moment (MoM) based solver.*

Keywords: CADFEKO, Internet Of Things , LoRaWAN, PIFA Antenna, Miniaturization.

I. INTRODUCTION

LoRa (Long Range) is a patented digital wireless data communication technology developed by Cycleo of Grenoble, France, and acquired by Semtech in 2012. LoRa is a long-range wireless communication protocol that competes against other low-power wide-area network (LPWAN) wireless such as NB-IoT or LTE Cat M1. Compared to those, LoRa achieves its extremely long range connectivity, possible 100km+, by trading off data rate. Because its data rates are below 50kbps and because LoRa is limited by duty cycle and other restrictions, it is suitable in practice for non-real time applications in which one can tolerate delays [1].

Since LoRa defines the lower physical layer, the upper networking layers were lacking. LoRaWAN was developed to define the upper layers of the network. LoRaWAN is a media access control (MAC) layer protocol but acts mainly as a network layer protocol for managing communication between LPWAN gateways and end-node devices as a routing protocol, maintained by the LoRa Alliance. Version 1.0 of the LoRaWAN specification was released in June 2015 [2].

LoRaWAN defines the communication protocol and system architecture for the network, while the LoRa physical layer enables the long-range communication link. LoRaWAN is also responsible for managing the communication

frequencies, data rate, and power for all devices [3]. Devices in the network are asynchronous and transmit when they have data available to send. Data transmitted by an end-node device is received by multiple gateways, which forward the data packets to a centralized network server [4]. The network server filters duplicate packets, performs security checks, and manages the network. Data is then forwarded to application servers. The technology shows high reliability for the moderate load, however, it has some performance issues related to sending acknowledgements [5].

LoRaWAN uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America). LoRaWAN enables long-range transmissions (more than 10 km in rural areas) with low power consumption [6].

Because the PIFA antenna operates at a resonant length of ($\lambda/4$), it is highly conducive to a small and lightweight design, and thus well-suited for use as an internal antenna for LoRaWAN boards. The PIFA antenna has the advantage of a low profile, but its narrow bandwidth makes it difficult to realize multiband capability with a single resonator. While this problem can be resolved by using additional resonators [7], such additions tend to increase the size of the antenna. This means that with a PIFA, it is difficult to simultaneously achieve miniaturization and multiband capability.

The miniaturization can affect radiation characteristics, bandwidth, gain, radiation efficiency and polarization purity. The miniaturization approaches are based on either geometric manipulation (the use of bend forms, meandered lines, PIFA shape, varying distance between feeder and short plate, using fractal geometries[8-11]) or material manipulation (Loading with a high-dielectric material, lumped elements, conductors, capacitors, short plate [12]), or the combination of two or more techniques [13].

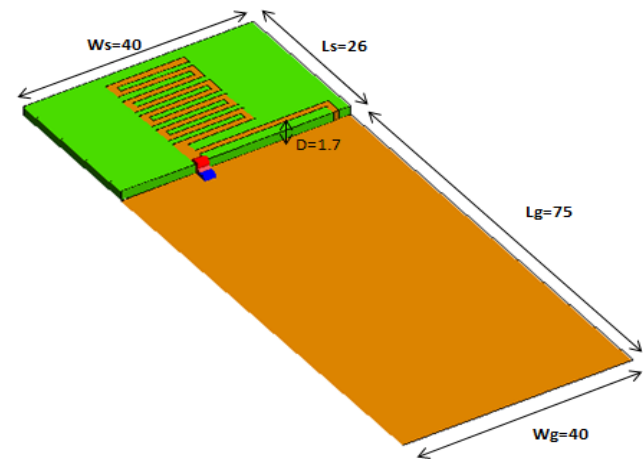
In this paper, we introduce a meandered microstrip line in the PIFA structure to generate a lower frequency. The meandered microstrip line is a powerful miniaturization technique which is used to lengthen the path over which current travels, thus helps reducing the resonant frequency. By combining the technique of shorting used by the PIFA and the technique of folding a microstrip line it is possible to obtain a

small antenna .The final antenna has a suitable bandwidth of 102 MHz [848 -950 MHz] and a reasonable gain.

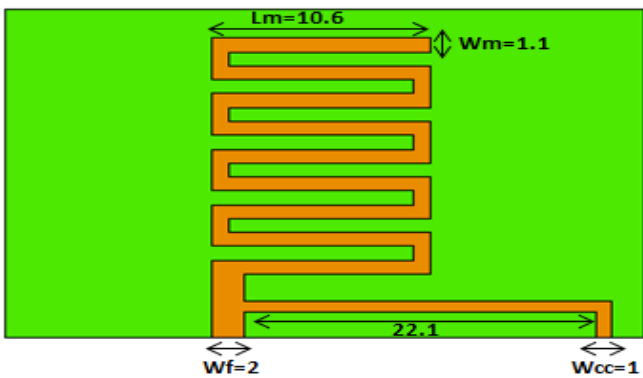
II. DESIGN METHODOLOGY

Fig. 1(a) shows the 3-D geometry of the proposed antenna, which consists of a meandered microstrip radiator printed in the center of the antenna. For efficient radiation, the ground (GND) found on the bottom surface of the substrate was turned by 180 degrees. The system GND for the antenna has a dimension of 75 mm length and 40 mm width and it is connected with the top radiators elements using a shorting strip. The volume under the radiating elements is filled by air except a thin region 1.6 mm who is composed of FR4_epoxy substrate with relative permittivity of 4.4.

Fig. 1(b) shows in details the geometry of the printed radiator as seen from above. The antenna takes up an area occupying 40*26 mm on the upper surface of the substrate. The radiators elements are placed at a height $D=1.7$ mm from the horizontal plan of the ground plane. The height D is composed of 1.6 mm the thickness of the substrate and a 0.1 mm of the Air. The proposed structure is excited with a microstrip feed line of input impedance ($Z_0= 50$ ohms).



(a)



(b)

Fig.1. (a) 3-D geometry of the proposed antenna. (b) Patch antenna geometry as seen from above in mm

Fig. 2 shows the simulated reflection coefficients for the proposed antenna. As Fig. 2 shows, the proposed antenna has one resonant frequency $f_r=896$ MHz with a reflection coefficient of -44.66 db.

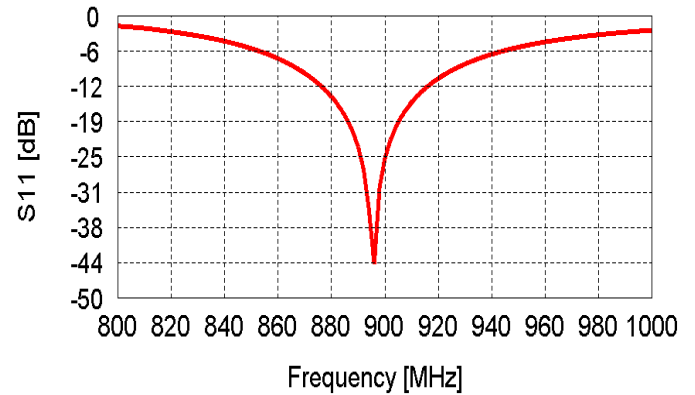


Fig.2. Simulated S11 versus frequency graph of the final antenna

The analysis of the S11 parameter (Fig. 2) shows that, for the band of 800 – 1000 MHz, the antenna has -6dB bandwidth of 102MHz (848 –950 MHz).

The choice of Lm parameter:

By varying the parameter Lm from 10.2 mm to 11 mm the S11 parameter of the antenna versus frequency is shown in Fig. 3. From the simulation results, it's clear that the parameter Lm affect the bandwidth and the resonant frequency of the antenna. In addition from the graph we note that as Lm is increased, the resonant frequency is decreased.

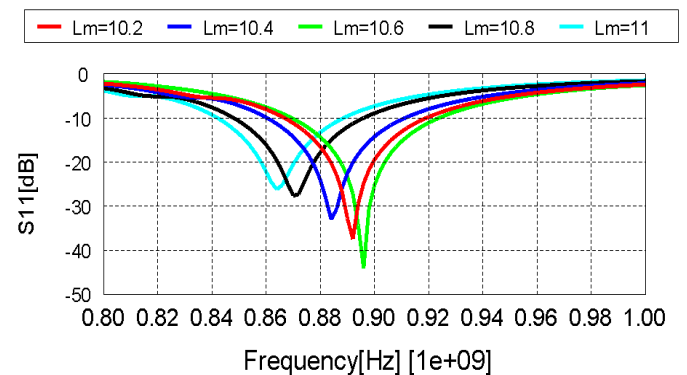


Fig. 3. Simulated S11 versus frequency by varying Lm in mm.

Table 1 summarizes the bandwidth and resonant frequency obtained by varying the parameter Lm. From table 1 we note

that $L_m=10.6\text{mm}$ will allow us to have a good antenna in terms of bandwidth and also in terms of impedance matching.

Table. 1: Resonant frequency and bandwidth versus the parameter L_m

$L_m(\text{mm})$	Resonance frequency(MHz)/S11 (dB)	Bandwidth (MHz)
10.2	892/-37.80	98:(846-944)
10.4	884/-33.21	93:(841-934)
10.6	896/-44.66	102:(848-950)
10.8	870/-27.85	87:(830-917)
11	864/-26.42	84:(825-909)

III. THE ANTENNA PERFORMANCE

From the previous parametric study of the proposed antenna, we obtained an optimized structure which has a compact size and an interesting reflection coefficient in the operating studied band. Fig.4 shows the maximum gain of the proposed antenna. The maximum gain is stable and it is equal to 2.1 dBi in the whole band.

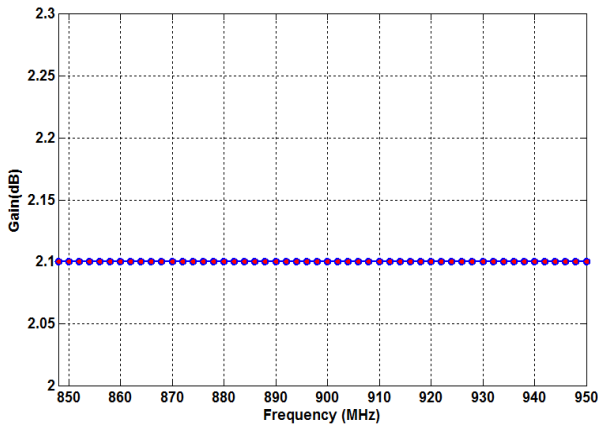


Fig.4. Maximum gain of the proposed antenna

Fig. 5 and 6 show the 2D and 3D radiation patterns of the proposed antenna for the resonant frequency respectively. As shown in those figures, the radiation pattern for the resonant frequency is omnidirectional.

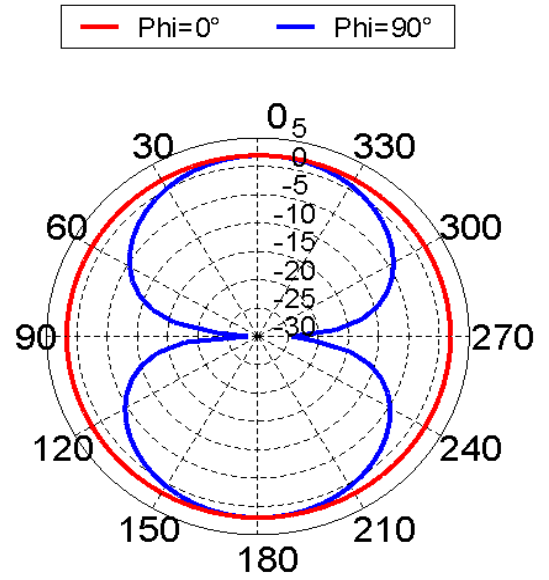


Fig.5.The 2D radiation pattern of the final antenna

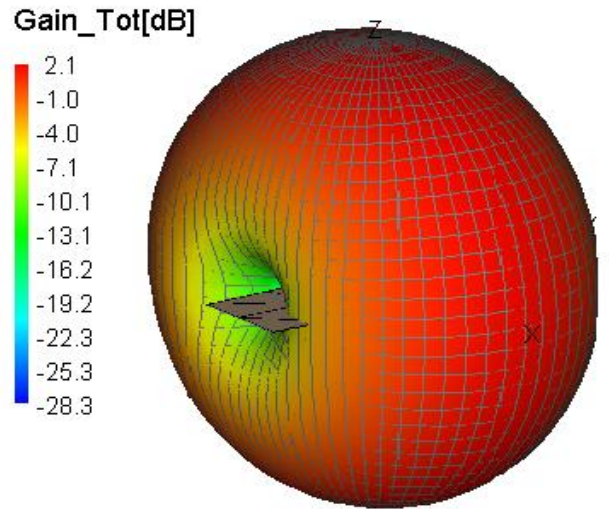


Fig.6.The 3D radiation pattern of the final antenna

IV. CONCLUSION

In this paper, a compact PIFA antenna for LoRaWAN application was proposed. The antenna has a small volume of 1.768 cm^3 , which makes it suitable for use as an internal antenna. The simulated results show that the bandwidth of the proposed antenna covers the two radio frequencies: 868 MHz and 915 MHz used in LoRaWAN network.

In the next work, fabrication and measurement should be done to confirm the simulated results. Also, more refinements should be done to cover the 169 MHz and 433 MHz bands.

REFERENCES

- [1] <https://www.thethingsnetwork.org/docs/lorawan/limitations.html>.
- [2] <https://www.businesswire.com/news/home/20150616006550/en/LoRaWAN-R1.0-Open-Standard-Released-IoT>
- [3] www.lora-alliance.org
- [4] www.link-labs.com
- [5] Bankov, D.; Khorov, E.; Lyakhov, A. (November 2016). "On the Limits of LoRaWAN Channel Access". 2016 International Conference on Engineering and Telecommunication (EnT): 10–14. doi:10.1109/ent.2016.011.
- [6] Sanchez-Iborra, R.; Sanchez-Gomez, J.; Ballesta-Viñas, J.; Cano, M.-D.; Skarmeta, A.F. Performance Evaluation of LoRa Considering Scenario Conditions. *Sensors* **2018**, *18*, 772. <https://doi.org/10.3390/s18030772>
- [7] D. Liu and B. Gaucher, "A new multiband antenna for WLAN/cellular applications," in Proc. IEEE. Veh. Technol. Conf., Sep. 2004, vol. 1, pp. 243–246.
- [8] H.-T. Chen, K.-L. Wong and T.-W. Chiou, "Pifa with a meandered and folded patch for the dual-band mobile phone application", IEEE Transactions on Antennas and Propagation, vol. 51, no. 9, pp. 2468-2471, 2003.
- [9] A. Reha, A. El Amri, O. Benhammouch, and A. Oulad Said, "Fractal Antennas: A Novel Miniaturization Technique for wireless Networks," Trans. Netw. Commun., vol. 2, no. 5, Oct. 2014.
- [10] S. Sun and L. Zhu, "Miniaturised patch hybrid couplers using asymmetrically loaded cross slots," IET Microw. Antennas Propag., vol. 4, no. 9, p. 1427, 2010.
- [11] P.-L. Chi, R. Waterhouse, and T. Itoh, "Antenna Miniaturization Using Slow Wave Enhancement Factor from Loaded Transmission Line Models," IEEE Trans. Antennas Propag., vol. 59, no. 1, pp. 48–57, Jan. 2011.
- [12] A. K. Skrivervik, J.-F. Zürcher, O. Staub and J. R. Mosig, "PCS Antenna Design: The Challenge of Miniaturization," IEEE Antennas and Propagation Magazine,
- [13] A. Reha, A. El Amri, M. Saih, O. Benhammouch, and A. Oulad Said, "The behavior of a CPW-Fed microstrip hexagonal patch antenna with H-Tree Fractal slots," Rev. Méditerranéenne Télécommunication, vol. 5, no. 2, pp. 104–108, Jun. 2015.