Compact Antenna Design for Wireless Sensor Network

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Abstract

We have proposed a compact antenna for sensor node of wireless sensor network. The proposed antenna consists of a circle-shaped slot, air gap, folded sleeve, and two shorting pins. The antenna has compact and simple structure, high gain, and omni-directional radiation patterns. Details of the proposed antenna design and experimental results are presented and discussed.

Keywords : Sensor node, wireless sensor network, omni-directional pattern, sleeve, air gap

1. Introduction

Wireless sensor networks (WSNs) are used for many commercial and military applications, and successfully realized. For the sensor network technology, there are many elements for the operations including the industrial, manufacturing automation, air traffic control, and environmental screening. The antenna miniaturization is one of the important works towards achieving the miniaturization of sensor modules and successful functionality of sensor networks. Also the sensor network consists of a number of sensor nodes placed at various locations where detection and monitoring data are to be monitored. So the antenna at the sensor node must be small size and flat structure for convenient installation. Generally, the antenna gain is relatively low due to the small size of the sensor node antenna, resulting in the short communication range. And also, the server node must link with the sensor nodes around it. Thus, the sensor node antenna must have omni-directional patterns [1-2]. Recently, compact antenna [3] and low-profile omni-directional antenna [4] for sensor node have been proposed and studied.

In this paper, our goal is to design high gain, omni-directional patterns, and compact antenna. For this goal, we have proposed a compact antenna, which is monopole-like antenna using a circle-shaped slot, two shorting pins, air gap, and folded sleeve. The height of the proposed compact antenna for sensor node is less than $\lambda/20$. We have simulated the proposed antenna using the commercial software HFSS. The proposed antenna is manufactured and measured. The simulated and measured results have a good agreement. The measured impedance bandwidth is 19MHz (418-437MHz) for VSWR < 2. The measured antenna patterns are dipole-like patterns and the gain is about 0.66dBi. The simulated and measured antenna characteristics versus the antenna geometry are presented

2. Antenna Design and Experimental Results

The geometry of the proposed compact antenna is shown in Figure 1. The proposed compact antenna is positioned on the black box (wireless sensor network system) with the spacing AG (air gap). The proposed antenna is fixed on the black box by using the bolts of the low dielectric constant.

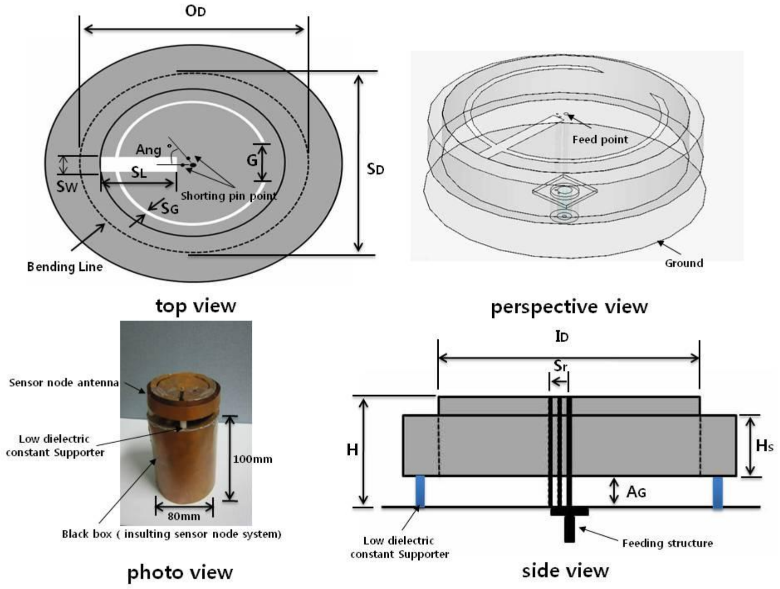

Figure 1: Geometry of the proposed compact antenna.

We have chosen the frequency of ISM band at 427MHz to avoid the very higher demanding traffic at 2.4GHz and to cover a larger area. The proposed antenna consists of a circle-shaped slot, air gap, folded sleeve, and two shorting pins. The optimized dimensions of the proposed antenna are as follows: H=35mm, H_S=13mm, A_G=10mm, I_D=35mm, Sr=2.5mm, Sw=4mm, S_L=31mm, S_G=2mm, S_D=27mm, Ang=60°, and O_D=39mm based on the extensive simulation using HFSS.

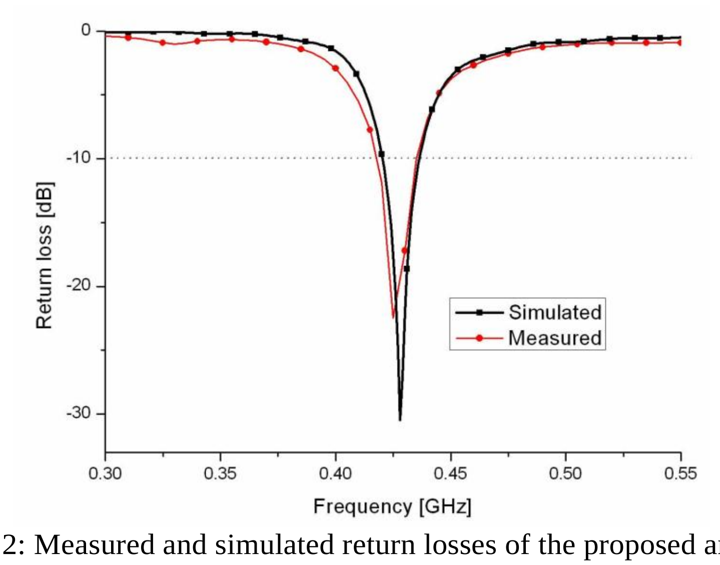

Figure 2: Measured and simulated return losses of the proposed antenna.

The proposed antenna was manufactured and measured using an Anritsu Vector Network Analyzer (37397C) in an anechoic chamber. Figure 2 shows the simulated and measured return losses of the proposed antenna. The measured results agree well with the simulated ones. The some difference between the simulated and measured results seems to be caused by the effect of soldering the feeding connector and the antenna in fabrication. The measured impedance bandwidth of the proposed antenna is 19MHz (418~437MHz).

To design the compact size antenna, we have used four techniques: two shorting pins, circle-shaped slot, folded sleeve, and air gap.

By using the two shorting pins, we have realized the impedance matching and miniaturization. We have studied the return loss characteristics according to the shorting pins.

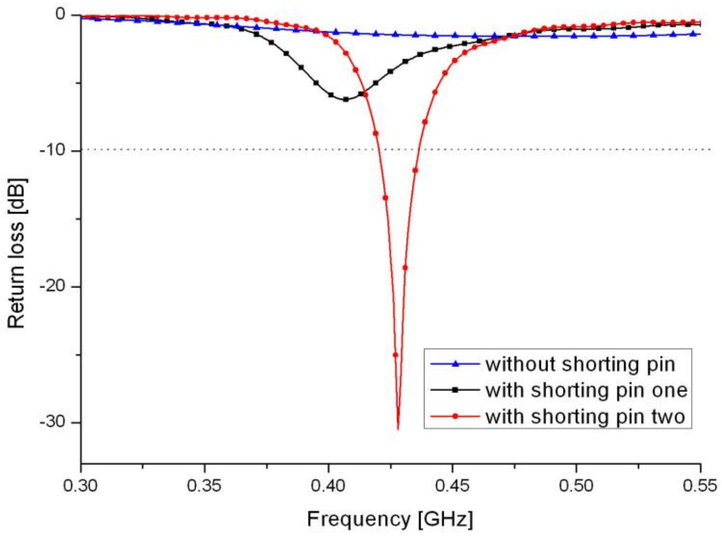

Figure 3: Simulated return losses of the proposed antenna versus the shorting pins.

Figure 3 shows the simulated return losses of the proposed antenna versus the shorting pins. In this figure, we can show that as two shorting pins are applied, the resonant frequency is moved to the low frequency and the good impedance matching is obtained.

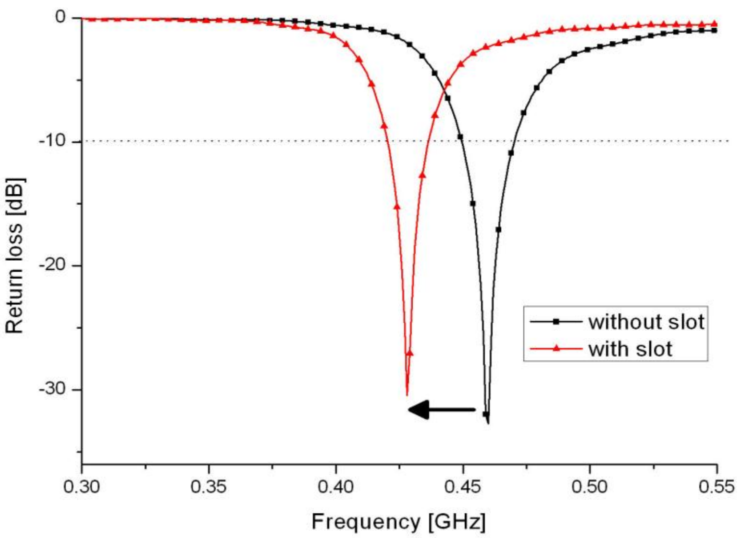

Figure 4: Simulated return losses of the proposed antenna as a function of the circle-shaped slot.

Second, we have studied the return loss characteristics of the proposed antenna according to the circle-shaped slot. Figure 4 shows the simulated return losses of the proposed antenna as a function of the circle-shaped slot. In this figure, we can show that as the circle-shaped slot is applied, the resonant frequency is moved to the low frequency.

We have used the air gap to increase the antenna gain. The air gap technique is well known in the antenna engineering [5]. Figure 5 shows the measured radiation patterns at 420, 427, and 435MHz. In this figure, the measured radiation patterns are dipole-like patterns (omni-directional patterns) over the operating frequency band.

Figure 6 shows the simulated and measured antenna gain of the proposed antenna. As can be seen from the figure, the gain of the proposed antenna is 0.66dBi, which is high at the antenna length of less than $\lambda/20$.

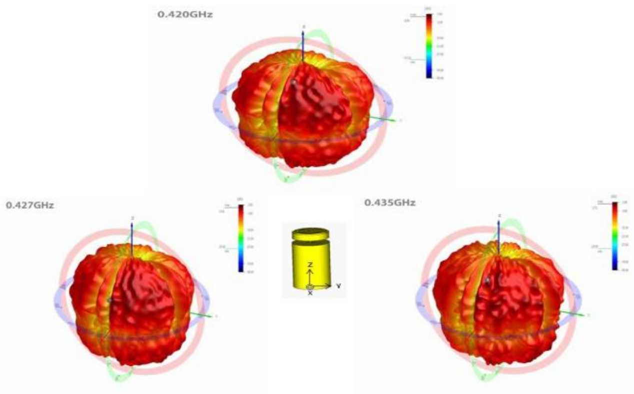

Figure 5: Measured radiation 3D patterns.

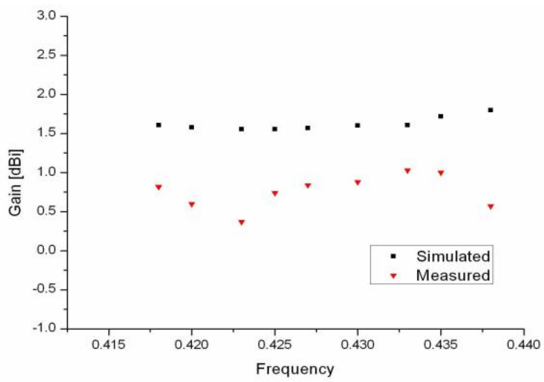

Figure 6: Measured and simulated gains.

3. Conclusion

We have proposed the compact antenna for wireless sensor network system. The proposed antenna has designed, fabricated, and characterized for wireless sensor network system. The proposed antenna covers the ISM band frequency (419-437MHz). The effects of the antenna geometry on the return loss were presented. The proposed compact antenna has omni-directional radiation pattern and relatively high gain over the frequency band, though the antenna is simple structure and very compact size (λ/20). Thus, the proposed compact antenna is suitable for WSNs communication applications.

References

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Acknowledgments

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