A Conformal Capsule Endoscope Antenna at ISM Band

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***Abstract*—A novel conformal antenna is proposed to apply in wireless capsule endoscope. The antenna has a small planar size of 10 mm× 10.5 mm × 24 um. The planar antenna is pasted on the inner wall of a cylindrical shaped capsule to form a conformal antenna. Simulation shows that the antenna covers ISM band in body tissues of muscle, skin, small intestine, and stomach respectively. Simulation also shows that the antenna bandwidth is not sensitive to the height or radius of the cylindrical capsule.**

Keywords—implantable antenna; conformal antenna; capsule endoscipe; flexible antenna

I. INTRODUCTION

Capsule endoscope is a compact wireless medical device easy to be placed in mouth and swallowed down. The endoscope is equipped with camera and wireless transmitter which make it possible to take photos of digestion organs and transmit them outside of body. Compared with traditional gastroscope with cable, the wireless capsule endoscope has less pain on patient body and becomes popular in medical detection. Implantable antenna is an important component of a capsule endoscope. The implantable antenna is required with small size and wide bandwidth. Conformal antenna with thin thickness is a good candidate to maintain antenna miniaturization [1-4]. The popularly used frequency bands for implantable antenna include Industrial, Scientific, and Medical (ISM, 2.4-2.4835 GHz), Medical Implant Communication Services (MICS, 402-405 MHz), and Ultra-Wideband (UWB, 3.1-10.6 GHz.

In this paper, we propose a novel conformal antenna. The antenna has a small planar size of 10 mm× 10.5 mm × 24 um and is pasted on the inner wall of a cylindrical shaped capsule to form a conformal antenna. Simulation shows that the antenna covers ISM band in body tissues of muscle, skin, small intestine, and stomach respectively. Simulation also shows that the antenna bandwidth is not sensitive to the height or radius of the cylindrical capsule.

II. ANTENNA DESIGN

A. Antenna Configuration

Fig.1 shows the configuration of the proposed antenna. The antenna dimensions on planar plane are shown in Fig. 1(a). The flexible Kapton polyimide with relative permittivity ε_r=3, dielectric loss tangent of 0.02, and thickness h=24 μm is adopted as substrate. The antenna is pasted on the inner wall of a cylindrical shaped capsule forming a conformal antenna shown in Fig.1 (b). The radius and height of cylinder is set as r=6 mm and h=20mm respectively. A one-layer cubic with side length 100 mm is adopted as body phantom. The proposed antenna is in the center of the body phantom. The body tissue is assigned as muscle with ε_r=53.57 and σ=1.81 at 2.45 GHz.

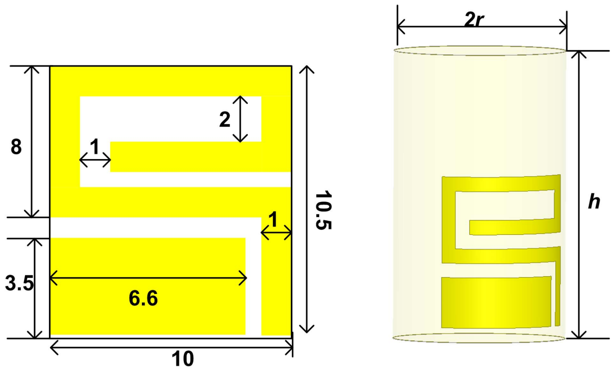

Fig. 1. Antenna configuration. (a) Antenna demensions on planar shape (unit: mm). (b) Conformal antenna.

B. Simulation

Fig.2 shows simulated $|S_{11}|$ of the proposed conformal antenna compared with the planar antenna. As shown in the figure, the wrap of the planar antenna on the inner wall of the endoscope results in the resonant frequency shifting to the right.

Fig.3 shows simulated $|S_{11}|$ of the proposed conformal antenna in different body tissues. For small intestine, ε_r=52.42 and σ=3.17. For skin, ε_r=42.85 and σ=1.59. For stomach, ε_r=62.16 and σ=2.21 As shown in the figure, the antenna has different resonant frequencies and bandwidths in different tissues. Nevertheless, the antenna bandwidth with $|S_{11}|$<-10dB covers ISM band in these four tissues.

Fig.4 shows simulated $|S_{11}|$ of the proposed conformal antenna with different endoscope radius *r*. As shown in the figures, the resonant frequency shift to the left slightly with increase of *r*. The antenna bandwidth has little change with different *r*.

Fig.5 shows simulated $|S_{11}|$ of the proposed conformal antenna with different endoscope height *h*. As shown in the figure, the antenna has stable bandwidth with change of *h*.

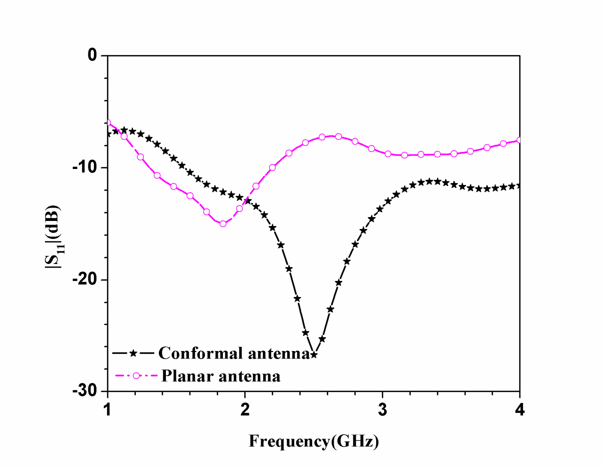

Fig. 2. Simulated $|S_{11}|$ of the proposed conformal antenna compared with the planar antenna.

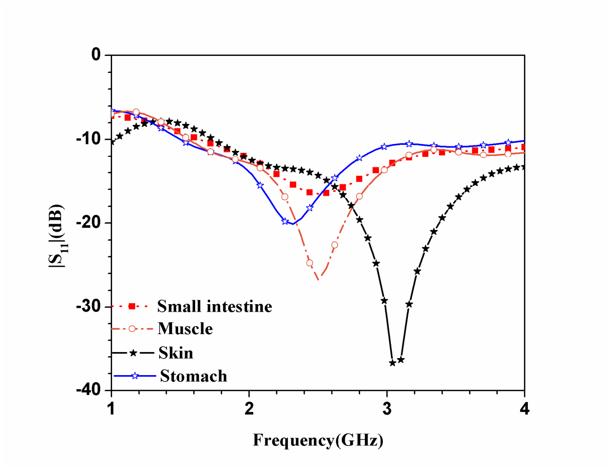

Fig. 3. Simulated $|S_{11}|$ of the proposed confromal antenna in different body tissues.

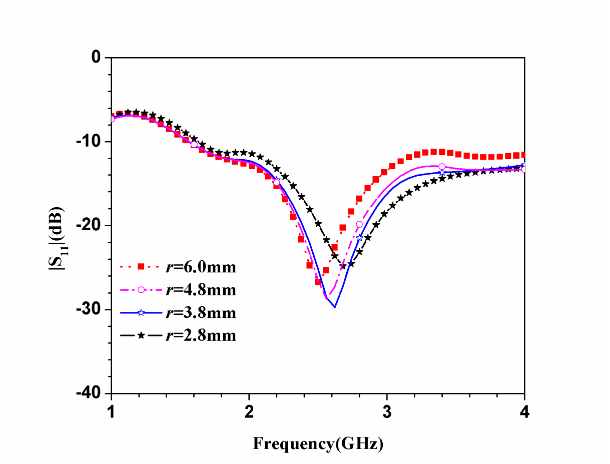

Fig. 4. Simulated $|S_{11}|$ of the proposed half-cut CPW-fed antenna with different ednoscope radius *r*.

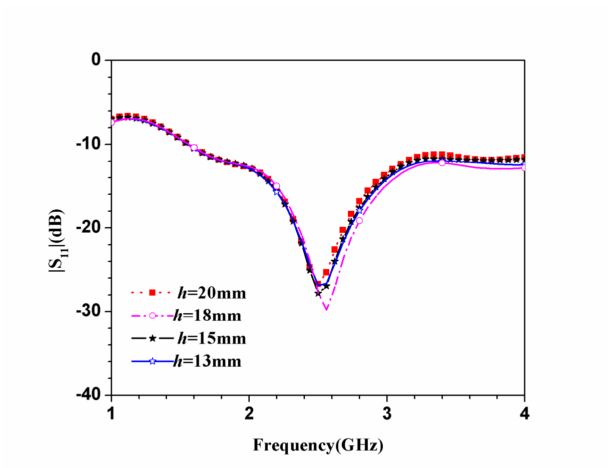

Fig. 5. Simulated $|S_{11}|$ of the proposed half-cut CPW-fed antenna with different ednoscope height *h*.

III. CONCLUSION

A flexible conformal antenna is proposed in the paper. Simulations show that the antenna has stable frequency performance at ISM band. The proposed antenna can be applied in capsule endoscopes. Fabrication and measurement will be done in the future.

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REFERENCES

[1] Liu, Changrong, Y. X. Guo, and S. Xiao, “Circularly Polarized Helical Antenna for ISM-Band Ingestible Capsule Endoscope Systems,” IEEE Trans. Antenn. Propag. Vol. 62 (12), pp. 6027-6039, 2014.

[2] Yun, Sumin, K. Kim, and S. Nam, “Outer-Wall Loop Antenna for Ultrawideband Capsule Endoscope System,” IEEE Antenn. Wirele. Propag. Lett. Vol. 9(1), pp. 1135-1138, 2010.

[3] Das, Rupam, and H. Yoo, “A Multiband Antenna Associating Wireless Monitoring and Nonleaky Wireless Power Transfer System for Biomedical Implants,” IEEE Trans. Microw. Theory Techni., vol. 65.7, pp. 2485-2495, 2017.

[4] Xu, Li Jie, Y. X. Guo, and W. Wu, “Bandwidth Enhancement of an Implantable Antenna,” IEEE Antennas & Wireless Propagation Letters, vol. 14, pp. 1510-1513, 2015.