Investigation of the Film Antenna for Wireless Power Transmission to the Capsular Endoscope

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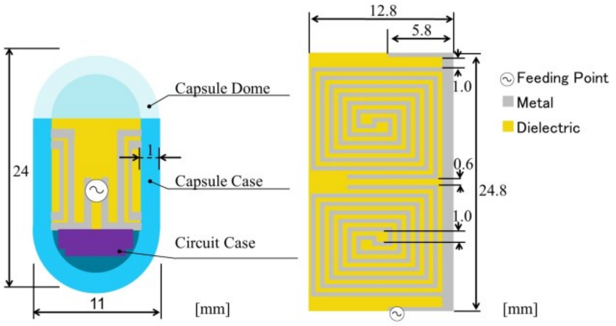
***Abstract* - Recently, the wireless power transmission has been investigated for many applications such as capsular endoscope that exists for a long time in the body. They can reduce the burden of doctors and patients, on the other hand, they has the risk due to contain cell battery that might leak toxic substances. In this paper, we examine the way of wireless power transmission to a capsular endoscope by using microwave. We propose the planar antenna that can be easily produced and can be hard to deform. Using proposed antenna, we acquired good characteristics.**

***Index Terms* — Capsular endoscope, loop antenna, wireless power transmission, microwave.**

1. Introduction

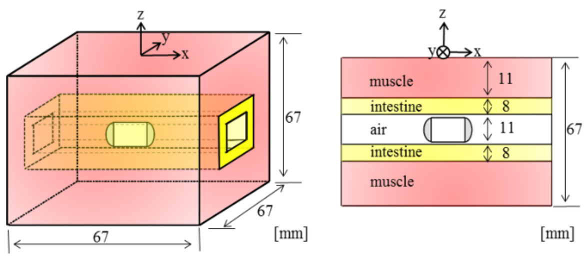
Recently, the capsular endoscope has been investigated for reducing burden on patients and doctors. Capsular endoscope is one of endoscope that has 10~20 mm length. It takes pictures of digestive organ by using camera installed in capsule and transmit pictures to outside of body using picture transmitting antenna. Capsular endoscope used today is working by cell battery, so it is hard to improve the number of image capturing and resolution of pictures. Furthermore, when it breaks in the body, it might take bad effect to patient because cell battery contains toxic substances. In other word, it is not suitable for capsular endoscope to install cell battery as power source. Therefore, we present the wireless power transmission antenna for the capsular endoscope. By using wireless power transmission, we do not have to consider how improving the times of image capturing and resolution because we do not have to rely on cell batteries with limited capacity. Furthermore, by covering the power reception and picture transmission in one antenna, it is expected that the size of capsular endoscope become to be smaller than current model.

The wireless power transmission antenna proposed by past study has stereo structure that occupies large area and poor productivity [1]. In this letter, we propose planar antenna made of flexible substrate. By using planar antenna, it enables to use limited space more effectively and produce more easily. Proposed antenna was designed at 433.92 MHz frequency in order to suit SAR threshold and realize better transmission ratio.



(a) Whole Model (b) Antenna Only

Fig.1: Antenna models. (Whole Model and Antenna Only)



(a) Overall view (b) Sectional View

Fig.2: Calculation models

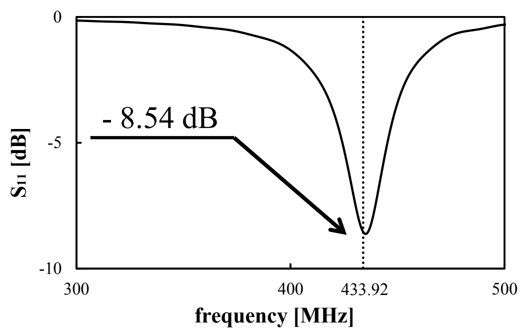


Fig.3 : Simulated S_{11} of the proposed antenna

2. Calculation Model

The capsular endoscope model for calculation is shown in Fig.1 Whole Model and plan view of antenna is shown. This antenna is made by 0.4 mm tickness metal, and it is configured in a plane. The antenna has be assumed that the it is rolled in cylindrical shape and inserted the capsular endoscope. The antenna is constructed by the loop antenna and open stub. Normally, when we use the loop antenna, we must design it to be one wave length. However, it is impossible for the capsular endoscope to equip the element that has long length, therefore it is realized impedance matching by using open stub.

Capsular endoscope is constructed by Circuit Case (ABS resin: ε_r =3.0, σ =0.0 S/m), Capsule Case (PTFE: ε_r =2.0, σ =0.0 S/m), and Capsule Dome (acrylic resin: ε_r =3.5, σ =0.0 S/m). The model used in calculation is shown in Fig.2. We simplified human body in cubic model in order to reduce the calculation time. Calculation model is constructed by only muscle (ε_r = 57.7, σ = 0.83 S/m) and intestine (ε_r =65.3, σ =1.92 S/m).The capsular endoscope model for calculation is shown in Fig.1 Whole Model and plan view of antenna is shown.

3. Results and Discussion

(1) S-parameters

The calculated S_{11} is shown in Fig. 3. We acquired -8.54 dB at 433.92 MHz.

(2) Electric field

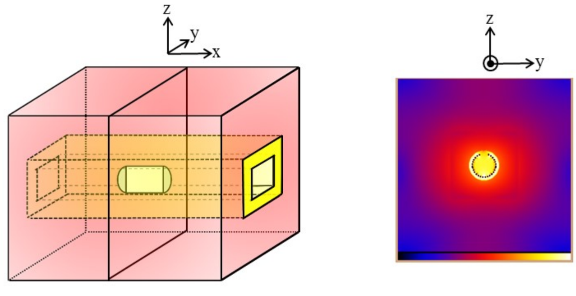
The calculated electric field intensity distribution of proposed antenna is shown in Fig.4. For the antenna installed in capsular endoscope, it is necessary to corresponding to the rotation because the capsule endoscope might become various rotational state, direction and position. The problem that capsular endoscope might be various direction and position was corresponding by using transmitting antenna by past study, so we must consider that rotation around the axis of the capsular endoscope. This antenna radiates equally around axial rotation, it meets the condition.

4. Transmission Ratio

For the calculating of wireless power transmission, the antenna proposed by past study [2] was applied. The antenna is shown in Fig.5. It is constructed by substrate (ε_r = 2.17 ,σ = 0.0) and 2 mm width metals. The antenna is adopted because it has very wide bandwidth, thus the transmission antenna is less affected by the human body. Furthermore, the antenna is circular polarization antenna, so even if receiving antenna has any direction in human body, the antenna is able to transmit power.

The model for calculating transmission ratio is shown in Fig.6. The antenna is installed towards simplified human body model and put on gel (ε_r = 80.0, σ = 0.0). The dimensions of each part are shown in Fig6. Since it is necessary to place the transmission antenna on human body model, it is larger than the model shown in Fig.2.

The calculated power transmission ratio was 0.2 %. Since more than 90 % of the electromagnetic wave radiated from transmission antenna is absorbed by the human body, most energy does not reach the receiving antenna. Thus, transmission ratio is very poor value.



(a) Cutting Plane (b) Electric field

Fig.4: Simulated radiation patterns

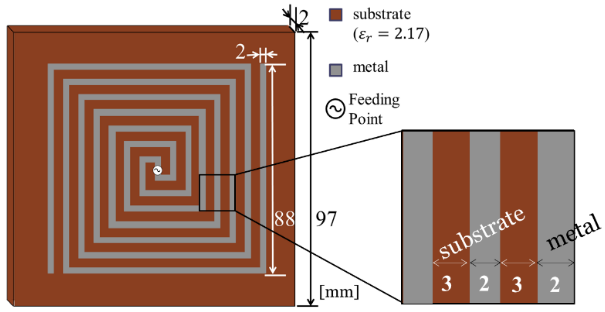
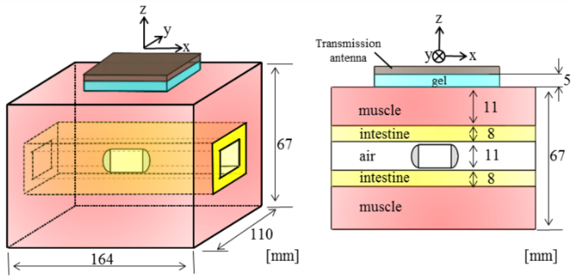


Fig.5: Transmission Antenna models [2]



(a) Overall view (b) Sectional View

Fig.6: Calculation models

5. Conclusion

We have presented the film antenna for wireless power transmission antenna of capsular endoscope. The antenna is suitable for capsular endoscope because it radiates equally around axial rotation. By using this antenna, we acquired 0.2 % transmission ratio and S_{11} at 433.92 MHz was -8.54 dB. For practical use, it is required further improvement.

Acknowledgement

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References

[1] KUMAGAI et al. , "Design of receiving antenna for microwave power transmission to capsular endoscope ," IEEE MTT-S International Microwave Workshop Series on Innovation Wireless, pp. 145-148, Uji, Japan, May 2011

[2] TSUZAKI et al., "Development of antenna for wireless power transmission to capsular endoscope," IEICE Communications Express, vol.3, No.4 pp.138-143, Apr. 2014.