Antenna System for Radio Wave Type Laparoscope

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***Abstract*—In this paper, an antenna system for a radio wave type laparoscope is proposed. The antenna system consists of one transmitting antenna and four receiving antennas. Two arrangements of the transmitting antenna are investigated using the simulated transmission coefficients. The differences between the transmission coefficients in the cases with and without the blood vessel are observed.**

Keywords—Laparoscope, blood vessel, microstrip antenna, transmission coefficient

I. Introduction

In current laparoscopic surgery, it is necessary to know the position of the blood vessel in fat. However, it is impossible to find it using a camera type laparoscope which is used in current laparoscopic surgery. In this paper, the aim is to develop a radio wave type laparoscope that can project an image of the blood vessel in real time. The proposed system consists of one transmitting antenna and four receiving antennas. The position of the blood vessel is detected by signal-processing the received radio wave to image data by the method of processing synthetic aperture. In this paper, the possibility of the proposed method is investigated by examining the differences between the transmission coefficients in the cases with and without the blood vessel.

II. Antenna design and Analytical model

In this system, the diameter of the practical laparoscope is usually 10mm. In this study, however, a system with a 25mm-diameter (a 2.5-times scale model) is investigated in order to facilitate of the measurement.

Fig. 1 shows the antenna of the proposed laparoscope. Rectangular microstrip antennas are used in the laparoscope. A transmitting antenna (Antenna element #5) is located at the center and four receiving antennas (Antenna element #1- #4) are arranged in the vicinity of the transmitting antennas. In this paper, the arrangement of the two types is investigated. The transmitting antenna is located along the y-axis in Type A and it is located along ϕ=45degrees in Type B. In all of the antennas, the dimension of the rectangular patch is W_a x L_a. The relative dielectric constant, the thickness and the loss tangent of the dielectric substrate are ε_r =3.8, h_a =1.6mm and tanδ= 0.022, respectively.

Fig. 2 shows the analytical model. The transmitting antenna and the receiving antennas which are located on top of the fat, face the both the fat and the blood vessel. The dimension of the fat is W_f x L_f x D_f =200mm x 200mm x 50mm. The diameter of the blood vessel is d_b. The relative dielectric constant and the conductivity of the fat are 8 and 0.08S/m, respectively. Those of the blood vessel are 55 and 2S/m, respectively.

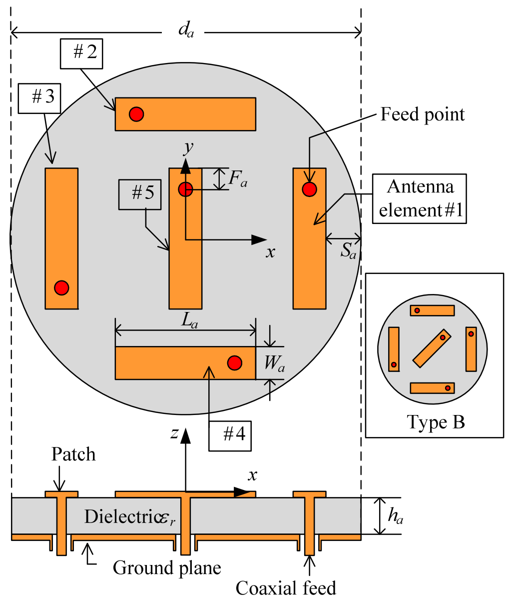

Fig. 1 Proposed antenna system (Type A)

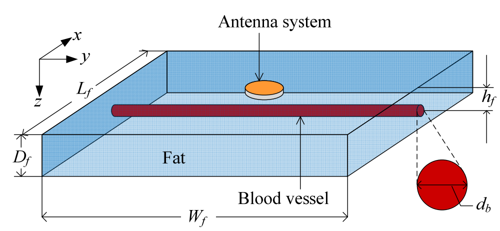

Fig. 2 Simulation model (Fat & Blood vessel)

III. Analytical Results

For the simulation in this paper, the simulation software package XFDTD ver. 7.4, which is based on the finite difference time domain method (FDTD) is used. In this simulation, the blood vessel is located at the center of the fat x=0, z =D_f/2 along the y axis. The dimensions of the designed rectangular patch are W_a=3.0mm, L_a=7.92mm, F_a=0.96mm, and S_a=1.5mm.

A. Reflection Coefficients

Fig. 3 shows the reflection coefficient |S55| of the transmitting antenna. The value of the minimum reflection coefficients depends on the diameter of the blood vessel. However, the difference between |S55| in the cases of, with and without the blood vessel, is small. Therefore, it is difficult to detect the position of the blood vessel using the reflection coefficient.

B. Transmission Coefficients

Figs. 4 (a) and (b) show the transmission coefficients |S35| and |S45|, respectively. |S35| is the case in which the receiving antenna is placed parallel to the transmitting antenna. |S45| is the case in which the receiving antenna is placed perpendicularly with the transmitting antenna. The differences between |S45| in the cases of, with and without the blood vessel, are small. However, those in |S35| are observed from 5GHz to 7GHz. It is confirmed that although the distance between the transmitting and receiving antennas is small, the transmission coefficient is affected by the direction of the transmitting antenna.

Table 1 shows the comparison between the transmission coefficients of Type A and Type B. The values in the table indicate the maximum difference between the transmission coefficients of the cases with and without the blood vessel from 5GHz to 7GHz. The transmission coefficients less than -40dB aren't included. |S35| and |S45| in Type B have similar values. |S45| in Type B is improved compared with that in Type A. However, although the receiving antenna #2 has the same direction as the antenna #4, |S25| deteriorates. This is due to the following reason. The feed point of the antenna #2 is different from that of the antenna #4. As the electric current around the feed point is much greater, |S25| is different from |S45|. In Type B, the two polarized waves that are mutually perpendicular can be received. In the Type A, the only one polarized wave is received, but its magnitude is greater than that of the two polarized waves of Type B.

IV. Conclusion

An antenna system for radio wave type laparoscope has been proposed. In this paper, the arrangement of the transmitting and receiving antennas was investigated. It was confirmed that the antennas had to be arranged in consideration to the direction of the antennas. Moreover, the differences between the transmission coefficients of the cases with and without the blood vessel were observed.

Acknowledgment

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References

[1] http:// www.remcom.com/xf7.

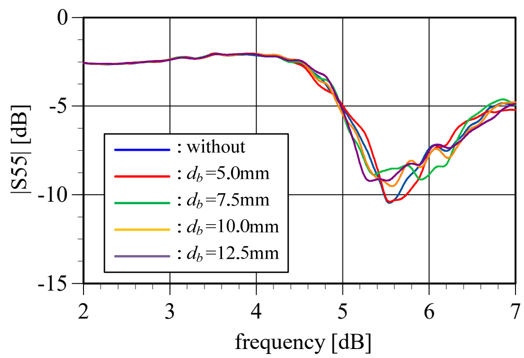
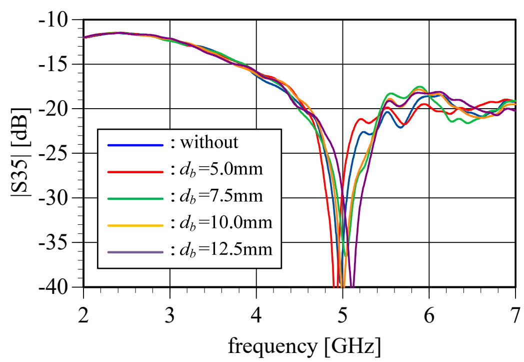
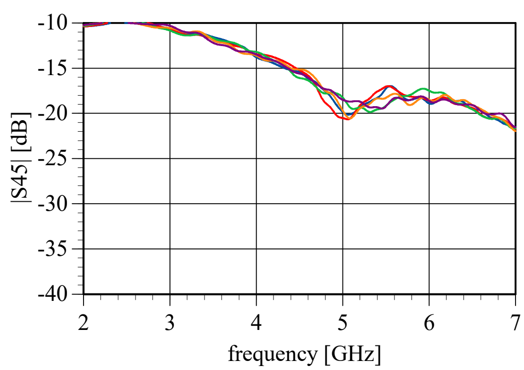


Fig. 3 Reflection coefficients |S55|



(a) |S35|



(b) |S45|

Fig4. Transmission coefficients

Table 1 Comparison between Type A and Type B

	Type A				Type B			
d_b [mm]	|S15| [dB]	|S25| [dB]	|S35| [dB]	|S45| [dB]	|S15| [dB]	|S25| [dB]	|S35 [dB]|	|S45| [dB]
5	2.2	1.5	8.0	0.7	1.3	1.3	1.5	1.6
7.5	4.6	1.6	7.5	1.6	1.9	1.2	2.4	3.2
10.0	3.9	1.0	3.4	0.7	1.3	1.0	2.1	2.2
12.5	6.4	2.2	11.9	1.5	3.8	1.2	6.2	3.8