

# Study of Implantable Antenna for Artificial Knee Joints

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## 1. Introduction

In recent years, implantable devices embedded into human bodies have attracted attention as a form of miniaturization of wireless communication devices [1]. The implantable devices are supposed to be utilized in diverse scenes, such as door access control of critical facilities or protection of pet.

We applied the implantable devices to artificial knee joints. Figure 1 shows the artificial knee joints structure. The artificial knee joints are composed four parts, two metal parts (femoral component and tibial component) and dielectric parts (patellar component and plastic spacer). Plastic spacer continues to be worn away. Hence patients are necessary to exchange parts of their artificial knee joints every 15-20 years. The artificial knee joints are may be unknown its product information caused by that the life of it is very long. In that case, looking into information takes time and effort. Therefore a burden of the patients in the reoperation is increased. However, if implantable devices are embedded into bodies with artificial knee joints, it becomes possible to detect product information quickly with non-invasive by using Reader/Writer. To read the information, it is necessary to excite the IC (Integrated Circuit) chip in the implantable devices. Therefore, a role of an antenna which is mounted on the device is important. In addition, the characteristics of the antenna are changed by influence of the surrounding environment [2]-[5]. In this paper, we evaluated characteristics of the antenna embedded into human body using a high-resolution artificial knee joints models.

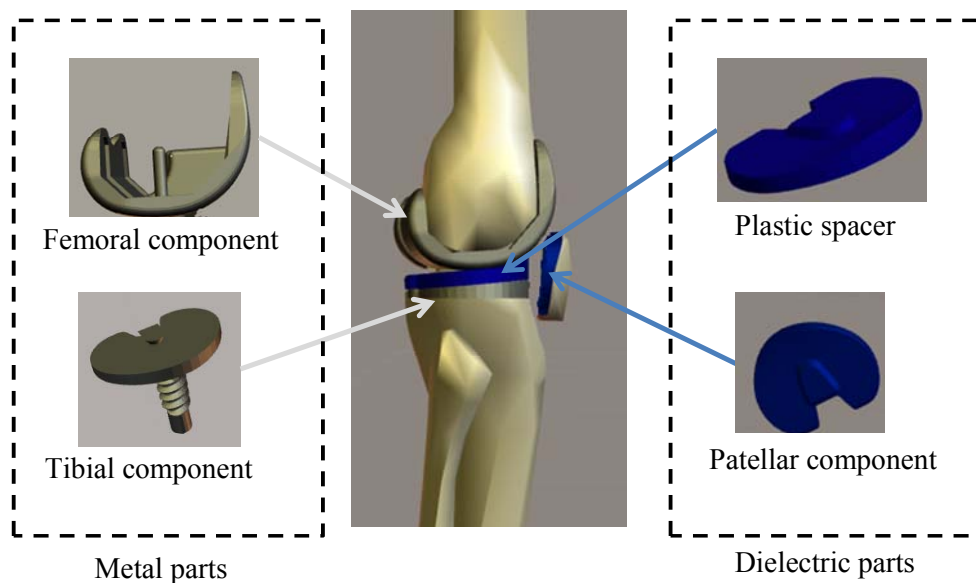


Figure1: Artificial knee joints structure.

## 2. Calculation Models

Figure 2 shows the high-resolution model of human's knee and the artificial knee joints parts. We assumed the person is sitting for reading the product information, therefore we calculated the model with crossed knee in our study. The parts models are composed of two metal parts: perfect electric conductor and two dielectric parts:  $\epsilon_r = 2.3$ ,  $\sigma = 0.0$  [S/m].

The prototype antenna structure is shown in Figure 3 (a). The sheet type meander line antenna is used as RFID tag. The tag is  $60.0 \text{ mm} \times 1.5 \text{ mm}$  in size. In order to reduce the antenna size in the artificial knee joints, we bent the two meander parts into right angle, as shown in Figure 3 (b). The feeding point of this tag is set at the center of the tag. The operating frequency of the antenna is 950 MHz, because antenna can be miniaturized at high frequency [6], [7]. Embedded position of the antenna is shown in Figure 4. The antenna is embedded into plastic spacer which is dielectric parts. The distance between antenna and tibial component is 2 mm

Received antenna is shown in Figure 5. The received antenna is a half-wave length dipole antenna for 950 MHz, and is 150 mm in length. The dipole antenna is located at 10 mm away from the knee so as to be parallel with the implantable antenna.

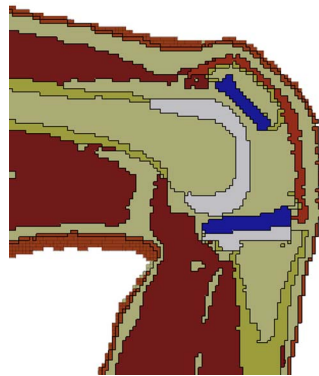
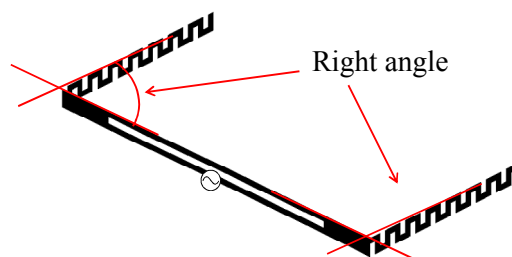
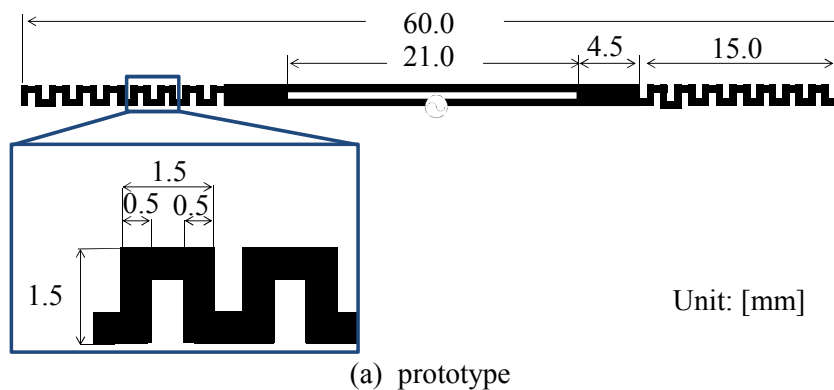


Figure 2: Calculation model.



(b) proposed antenna

Figure 3: Antenna configuration.

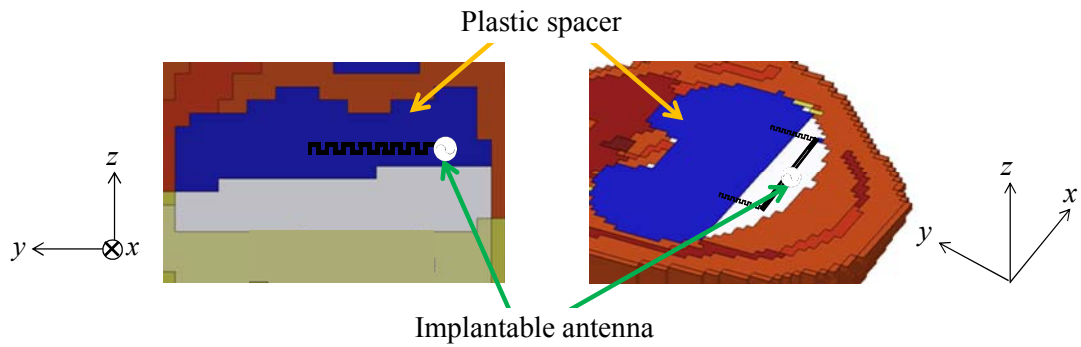


Figure 4: Embedded position of implantable antenna.

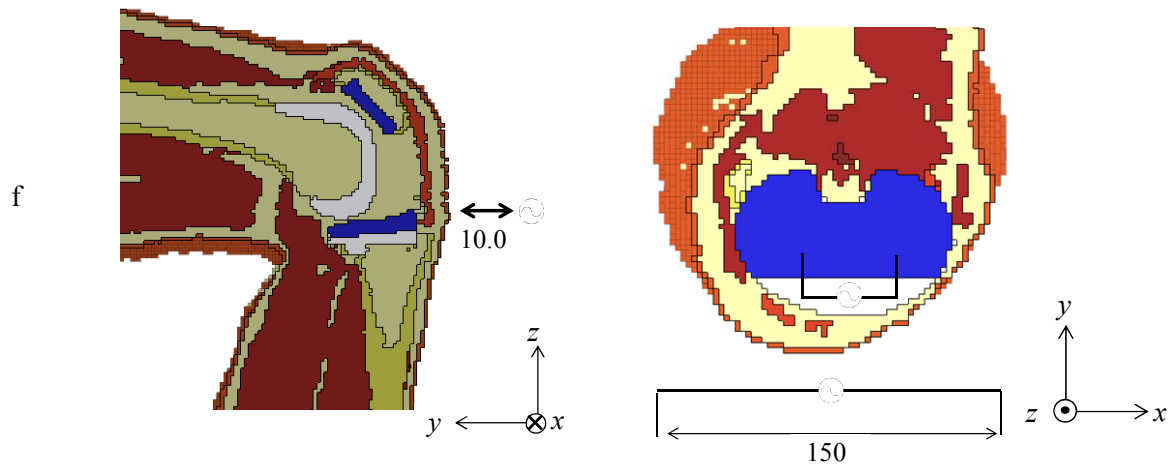


Figure 5: Receiver antenna.

### 3. Results

Figure 6 shows the electric field distribution of the implantable antenna in human's knee. From the result, the distributed electric field in front of knee is stronger and wider than behind of knee. Therefore, we placed Reader/Writer in front of the knee to detect the product information of the artificial knee joints. The transmission coefficient between the implantable antenna and the received antenna is shown in Figure 7. The transmission coefficient at 950 MHz is -15.3 dB. From the transmission coefficient, the requirement of the transmission power is 0.34 W if the power required to drive IC chip is 10 mW. The power used with Reader/Writer is up to 1.0 W in assumption. Therefore the transmission power of this result is value which can actually be used.

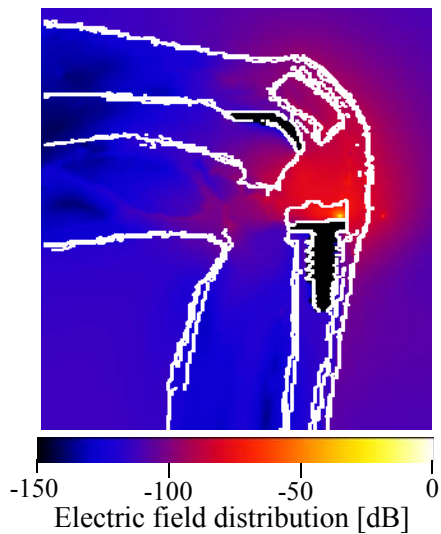


Figure 6: Electric field distribution

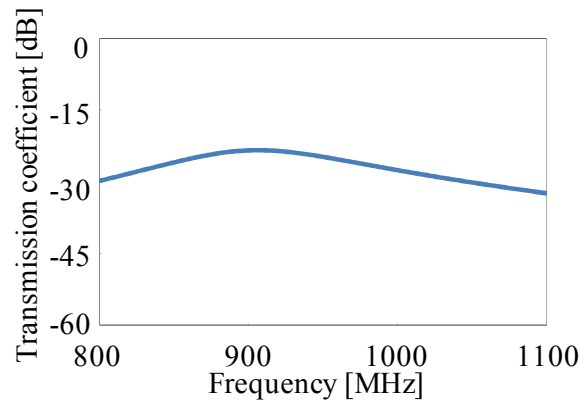


Figure 7: Transmission coefficient

## 4. Conclusion

We evaluated characteristics of the antenna embedded into human body using a high-resolution artificial knee joints models. From this result, when the position of the implantable antenna is installed at nearly edge of the plastic spacer, implantable devices had better communication with Reader/Writer than at the center of plastic spacer. However, the impedance of the IC chip located in the antenna used this study was unknown. For that reason, the results of this study was not considered on loss due to mismatch. In the future, we will investigate the impedance of the IC chip and optimize the implantable antenna.

## References

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