Development of Denture Implanted RFID Tag Antennas

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***Abstract*— Denture implanted RFID tag antennas in the UHF band is presented. The measured input impedances of the antennas in the human body phantom are presented and the conjugate matching condition between the antennas and the RFID chip are evaluated. As a result, the conjugate reflection coefficient of -21 dB between the tag antenna and a RFID chip is obtained at 920 MHz.**

Keywords—RFID; denture; dipole antenna; HBEL; Resin

I. Introduction

Radio Frequency Identification (RFID) [1], a kind of wireless communication technology, is widely used all over the world, which can identify specific target and read/write related data without any mechanical or optical contact between the system and the target.

Compared with other RFID tags working in the UHF band used for metal or dielectric bodies [1], the RFID tags in-body are more challenging. In this research, a RFID tag implanted in the denture is developed for the detection of wandering elderly persons.

In this paper, the design of RFID tag antennas in the denture is presented. The successful design on the input impedances of RFID tag antenna in the human body phantom and the conjugate matching condition between developed the antenna and the RFID chip are demonstrated.

II. Experiment Setup

The experiment setup is shown in Fig. 1. A dipole antenna with the length l covered by the acrylic resin is placed at the center of the acrylic case. As a phantom of denture, the self-curing acrylic resin which is actually used as material of dentures was used. Size of a denture phantom are with the length l_r=30 mm, the width w_r=10 mm. As a phantom in the mouth, the human body equivalent liquid (HBEL) produced by SPEAG having the complex permittivity of the muscle is filled in a cubical acrylic case [2]. The complex permittivity of the acrylic resin and HBEL were measured by using the coaxial probe method. Measured relative permittivity of

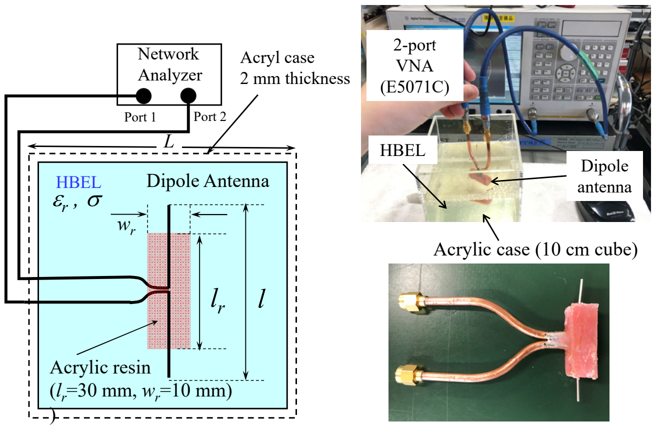

Fig. 1 Experiment setup.

acrylic resin was around ε_r =2. At 920 MHz, the relative permittivity of HBEL was almost ε_r =60 and the conductivity of HBEL is about 0.7 S/m.

In order to obtain the input impedance in broadband frequency range, the S-parameter method [2] with 2-port VNA (Agilent E5071C) was used.

III. Results

In the case when l=20 mm, a dipole antenna is placed inside the resin (ε_r=2). In our previous work [2], this case is corresponding to the small antenna as l/λ_g =0.09 where λ_g =λ_0/sqrt(2)=231 mm at 920 MHz by the presence of the resin. The resistance of dipole antenna was quite small values and the large capacitive reactance was observed.

Fig. 2 shows the measured input impedance Z_a=R_a+jX_a of dipole antenna at 920 MHz with changing the length l from 32 mm to 52 mm. When the length l is larger than l_r=30 mm (l >l_r), the antenna conductor penetrates the resin block [3]. Almost constant resistance of around R_a=50 Ω was observed and the reactance X_a was increased from -15Ω to 110 Ω. The effective wavelength in HBEL will be $\lambda_g=\lambda_0$/sqrt(60)=42 mm at 920 MHz. Therefore, the effective length is l/λ_g=0.78 when l=33 mm which is almost the half wavelength and it is considered that the half-wavelength resonance is appeared by the presence of HBEL.

It is noted that the resistance R_a=50 Ω and the reactance X_a=0 were observed when l=33 mm. On the other hand, considering the RFID applications, the impedance of antenna $Z_a=R_a+jX_a$ and the impedance of the RFID chip $Z_c=R_c+jX_c$ should meet the condition of the conjugate matching. The conjugate reflection coefficient Γ is given by

$$\Gamma = \frac{Z_a^* - Z_c}{Z_a + Z_c} \qquad (1)$$

As the RFID chip, Higgs-4 produced by Alien Technology was used. The measured impedance of the RFID chip at 920 MHz is Z_c= 60-j90 Ω. The conjugate reflection coefficient between RFID chip and the dipole antenna with resin block is shown in Fig. 3. It is observed that small reflection coefficient $|\Gamma|$= -21 dB is realized at 920 MHz when the length l=47 mm and the successful design of RFID tag antenna was realized.

IV. Conclusion

In this paper, the design of RFID tag antenna in the denture was presented and the conjugate impedance matching between the tag antenna and the RFID chip was realized. Also, to control the input impedance with partially covered resin, a new design of dipole antenna is more efficient and have better performance.

Acknowledgment

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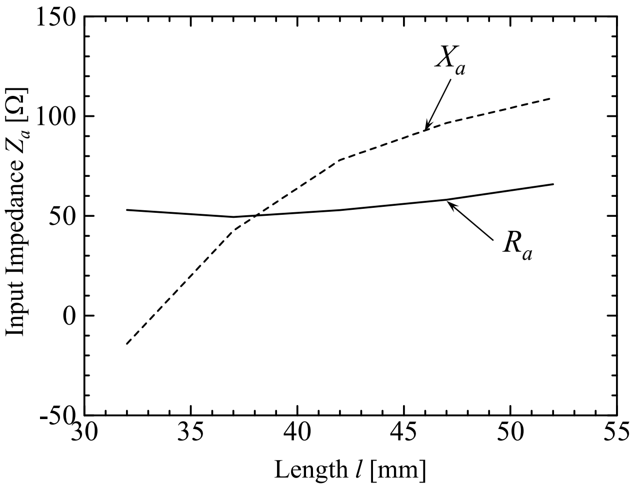

Fig. 2 Measured input impedance of tag antenna at 920 MHz.

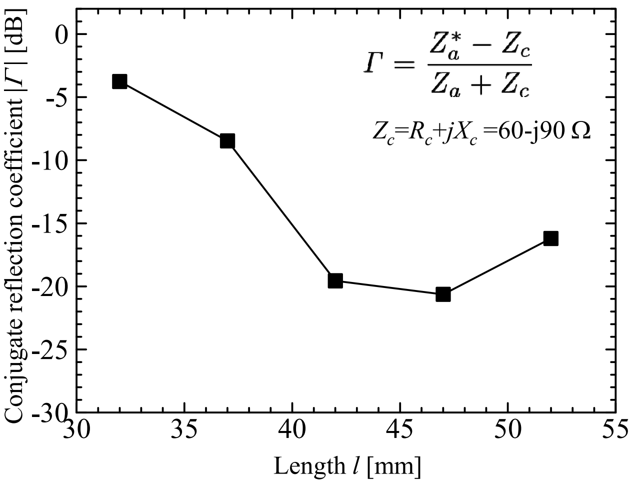

Fig. 3 Conjugate reflection coefficient between RFID chip Z_c and tag antenna with resin block Z_a at 920 MHz.