Operational Frequencies of In-Body/Out-Body Dual Use Antenna for Tablet/Pill Implementation

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Abstract – **Operational frequencies of miniaturized in-body/out-body dual use antenna are described. For miniaturization, millimeter-wave dipole antenna is employed. In the out-body condition, its operational frequency is 60 GHz and in the in-body condition (we assume it in the water), it drops to 10-20GHz due to the high dielectric constant medium (i.e. human body or water). Since the propagation loss inside of human body becomes high at high frequency range, we can reduce the loss by using relatively lower frequency with same antenna. This result shows the feasibility of the in-body/out-body dual use antenna which utilizes different frequencies at millimeter-wave/microwave range.**

Index Terms — **Antennas, propagation, MMW, In-body, Water, Communication, microwaves.**

1. Introduction

Recently wireless communication has been applied to medical applications. In the case of in-body communication, the propagation loss of human body is extremely high at microwave frequency range and the most of the developments have been done at below 2.5GHz [1]-[3]. When we consider wireless communication for tablets or pills, the size of antenna is a great concern. In this case, we would like to communicate in both out-body and in-body conditions to manage the tablets or pills (whether the patient take medicine or not). In the out-body condition, we would like to check the tablet within 1 to several meter range and in the in-body condition, within several to ten centimeter range. Since the antenna should be implemented or imprinted to the small tablets or pills, the antenna size should be less than 5mm.

In order satisfy these requirements, we propose usage of microwave/millimeter-wave antenna for this application. A 60GH-band planar dipole antenna [4] developed for millimeter-wave wireless personal area network (W-PAN) is used for this study. We simulate and measure the change of return loss of this antenna in out-body (in the air) condition and in-body (in water) condition. Both results show that the miniaturized millimeter-wave antenna can be used as a microwave antenna at 10-15GHz in the in-body condition and can be reduced the propagation loss from the original millimeter-wave usage.

2. Antenna Structure

Figure 1 shows the structure and dimensions of the planar dipole antenna [4] developed for 60GHz-band W-PAN application. All metal is Cu and the substrate is MEGTRON6 (Panasonic) multi-layered substrate (εr=3.5 and tanδ = 0.002 at 2GHz). The gain of this antenna in the air is 8.1dBi at 61.1GHz.

3. Simulation and Measurement

Figure 2 shows the simulation model in the in-body (In water) condition. The water covers the antenna element completely, but it does not affect to the transition section of the 1.85mm coaxial connector. The depth of the water from the water surface is set to 15mm and the thickness of the water from the antenna surface is set to 15mm. We use the values of εr=64 and tanδ = 0.42 at 10GHz as the water medium. In the out-body (in the air) condition, the water is removed.

Figure 3 is the photograph of measurement setup for antenna return loss in the in-body (in water) condition. Water temperature is room temperature (around 20 degrees centigrade.) Both depth and thickness of the water is greater than the simulation condition (15mm).

Figure 4 shows the simulated and measured return loss of the antenna in each (in-body/out-body) condition. In the out-body (in the air) condition, the antenna is matched in 60GHz-band. In the in-body (in water) condition, matching center is shifted toward lower frequency (around 10-15GHz) due to the relatively high dielectric constant medium (i.e. water). This result indicates that this antenna can be used as 60GH-band W-PAN communication in the out-body (in the air) condition whereas it also would be used around 10-15GHz range in the in-body (in water) condition. Since the absorption peek the water exists over 15GHz, it would be better to use lowest frequency around 10-15GHz.

Figure 5 shows the simulated water depth/thickness dependence of antenna return loss. As increase of the depth and thickness of the water (d_{water}), the return loss changed, but when d_{water} exceeds 10mm, the characteristic will not change. From this figure, we confirm that the simulation/measurement water condition is reasonable.

4. Conclusion

Miniaturization of antenna is a great concern to realize wireless communication / RFID tag for medical tablets and pills. In this paper, the operational frequency of in-body/out-body dual use antenna is discussed using 60GHz-band W-PAN dipole antenna which can be implemented to the tablets or pills. Both simulation and measurement show that it would operate around 10-15GHz frequency range and be able to reduce the in-body propagation loss from that at 60GHz.

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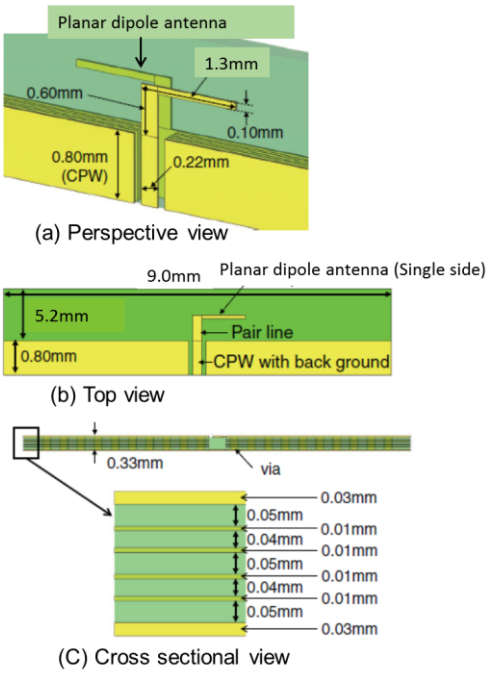
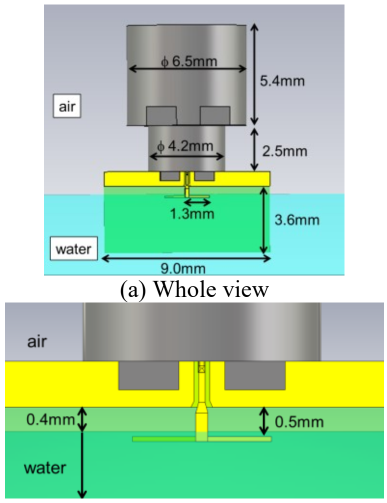


Fig.1 Structure and dimensions of planar dipole antenna [4] developed for 60GHz-band W-PAN.



(b) Enlarged view of antenna (water)

Fig.2 Simulation model in the in-body (in water) condition.

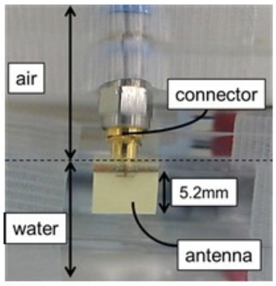


Fig.3 Photo of measurement setup.

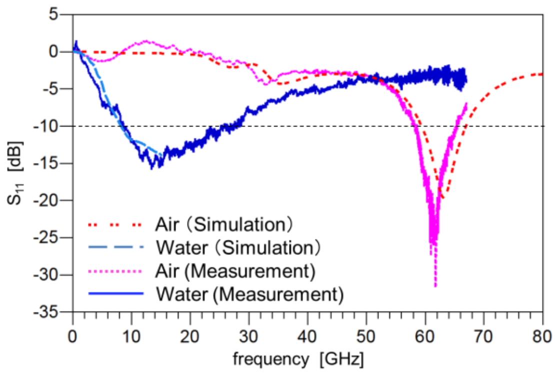


Fig.4 Simulated and measured return loss in the out-body (in the air) and in-body (in water) conditions.

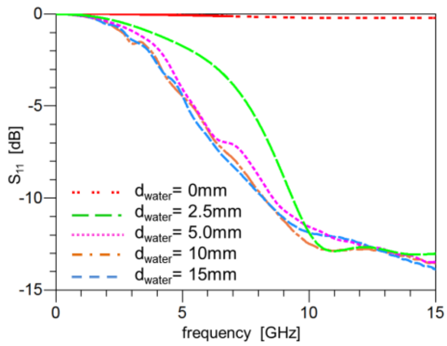


Fig.5 Simulated water depth/thickness dependence of return loss. (d_{water} = Depth = Thickness.)