A Low Profile Double Finger Ring Antenna for BAN and PAN

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1. Introduction

Body Area Network (BAN) or Personal Area Network (PAN) is emerging technology to realize a ubiquitous society. Easy and seamless but highly secured wireless communication network in such a society should be established. Therefore, many different types of the wearable antennas have been developed and reported.[1],[2] They should to be compact and flexible, and sometimes even washable.

The wristwatch antenna for communicator was proposed to use as only an exciter of the human-body.[3] However, in the future ubiquitous world, wristwatch might be too large and should be downsized such as a finger ring. The small and wearable antenna for applicable to finger ring size communicator was proposed.[4],[5] In [4], a modified gate-shape antenna and an inverted F antenna for applicable to finger ring size communicator were proposed for 2.5 GHz band. In [5], the circular antenna with finger ring was proposed. VSWR less than 2 was realized UWB band. However, the diameter of the circular antenna element was 22 mm. So, this antenna was too large for BAN. So, the small size finger ring antenna for UWB band (7.25GHz–10.25GHz) was proposed by authors.[6] The height of the proposed monopole antenna was 6mm.

In this paper, we discuss the very low profile and wearable double finger ring antenna of UWB band (7.25GHz – 10.25 GHz) for BAN. Details of the simulated results of the proposed antenna are presented. And it is confirmed that the human finger does not affect on the input impedance characteristic of the double finger ring antenna.

2. Proposed antenna configuration

Fig.1 shows the configuration of the proposed double finger ring antenna. This antenna consisted of the U-shaped monopole antenna in X – Y plane and the double finger ring for the ground with the diameter of the human finger. VSWR of the single finger ring antenna configuration was affected by a finger. [6] So, the double finger ring antenna configuration was adopted. This proposed antenna was fed by the coaxial cable and its characteristic impedance is 50 ohm. The theoretical analysis was performed using the simulation software Ansoft HFSS.

3. Simulated results

VSWR of the proposed antenna as shown in Fig.1 was simulated as a parameter of the distance D of the double finger ring. By increasing the distance, VSWR was improved and VSWR approaches 2 from 7.25 GHz to 10.25 GHz. Wideband was realized. So, the distance D was fixed at 10 mm.

Fig.2 shows the simulated VSWR of the proposed double finger ring antenna without a finger as parameters of the antenna height H1 and the antenna length L1. The diameter of the finger ring was 18 mm. This size was average value of Japanese adult. And the ring thickness was 2mm. This was popular size. The monopole width W was 6 mm. In this simulation, the size H1 + L4 was fixed at 9 mm. Therefore, the lower resonance frequencies were generated at 6.6 GHz. And these frequencies were not changed by decreasing the antenna height H1. On the other hand, the higher resonance frequencies were increased by decreasing the antenna height H1. VSWR less than 2 was obtained the frequency range of 5.7 - 14.5 GHz at H1 = 1 mm, L4 = 8 mm. The bandwidth was 79 %. Very wide bandwidth was obtained. In reference[5],[6], the antenna heights were 22 mm and 6 mm, respectively. The proposed antenna height was 1 mm. So, very low profile antenna was realized by using the U-shaped monopole configuration.

Fig.3 shows the simulated VSWR with/without a finger. And in this simulation, the permittivity and the conductivity were changed by frequency. In this simulation, the length and the diameter of the finger were 80 mm and 18 mm, respectively. The antenna size was H1 = 1 mm, L4 = 8 mm and W = 6 mm. VSWR less than 2 was obtained the frequency range 7.25 GHz – 10.25 GHz without a finger. On the other hand, VSWR was deteriorated by a finger. However, VSWR less than 2.6 was obtained the frequency range 7.25 GHz to 10.25 GHz. VSWR was increased by increasing the frequency. Discontinuity was caused in the simulated results. A further examination is necessary.

Fig.4 shows the simulated radiation patterns Eθ with a finger. The red line shows 7.25 GHz. The green line shows 8.75 GHz. The blue line shows 10.25 GHz. In X-Y plane, the omni-directional radiation pattern was obtained at each frequency. The gain was about 3 dBi. The maximum radiation direction was Z axis. The simulated radiation pattern Eφ in X-Y plane was the directivity of doughnut type. So, the proposed antenna can be used for BAN.

To clarify the mechanism of the proposed double finger ring antenna, the current distributions were simulated for UWB band. Fig.5 shows the simulated current distributions without a finger at 8.5 GHz. The red shows the strong current distribution and the blue shows the week current distribution. From Fig.5, the strong current was flows the U-shaped antenna element and the connected the finger ring. On the other hand, the current flows to symmetry on the double finger ring. And the current flows were almost same from 7.25 GHz to 10.25 GHz.

4. Conclusions

This paper describes the simulated results of the very low profile wearable double finger ring antenna for UWB band (7.25GHz–10.25GHz). The height of the proposed antenna was 1 mm. So, very low profile antenna was realized. VSWR less than 2 was obtained for UWB band without a finger. On the other hand, VSWR less than 2.6 was obtained with a finger. It is shown that the finger doesn't affect on the input characteristic as long as the double finger ring antenna is mounted on a finger.

So, the proposed double finger ring antenna has as advantage in body-centric communication such as BAN.

The experimental results will be presented to confirm the simulated results. It is necessary to clarify the reason why the finger doesn't affect the double finger ring antenna characteristic compared with than that of a single finger ring antenna.

References

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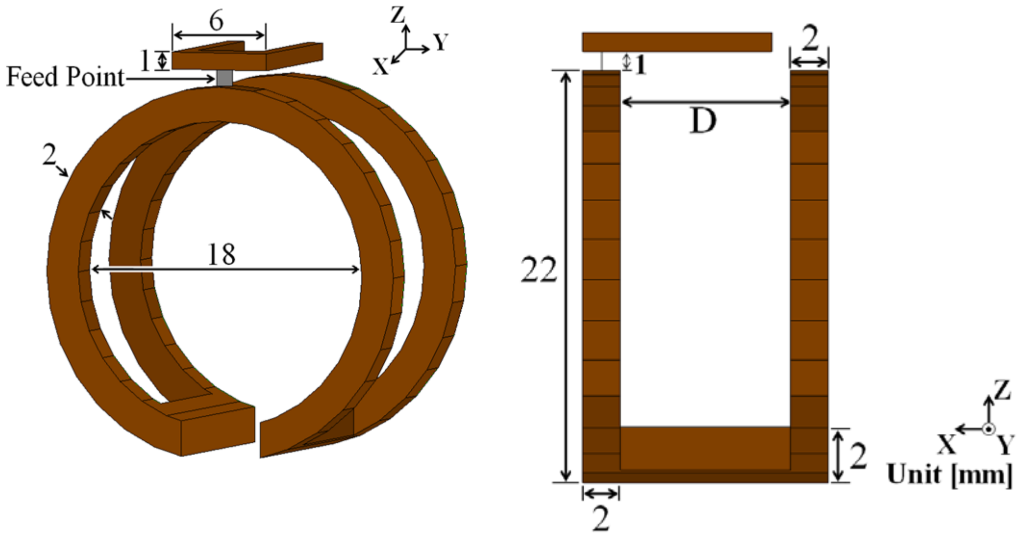


Figure 1: Proposed double finger ring antenna.

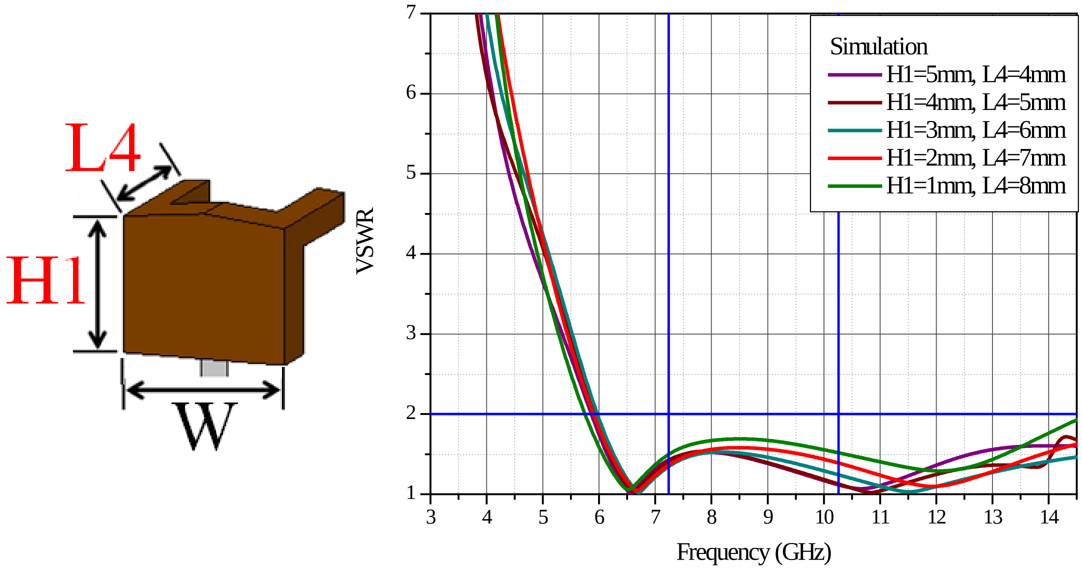
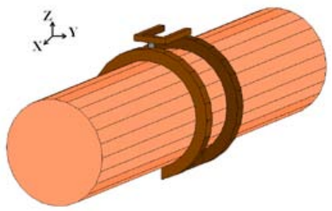


Figure 2: The simulated VSWR as parameters of H1 and L4. W = 6 mm, D = 10 mm.



Frequency Band	Permittivity	Conductivity [S/m]
6.5~7.5GHz	30	6
7.5~8.5GHz	28	8
8.5~9.5GHz	26	9.5
9.5~10.5GHz	24	10.5

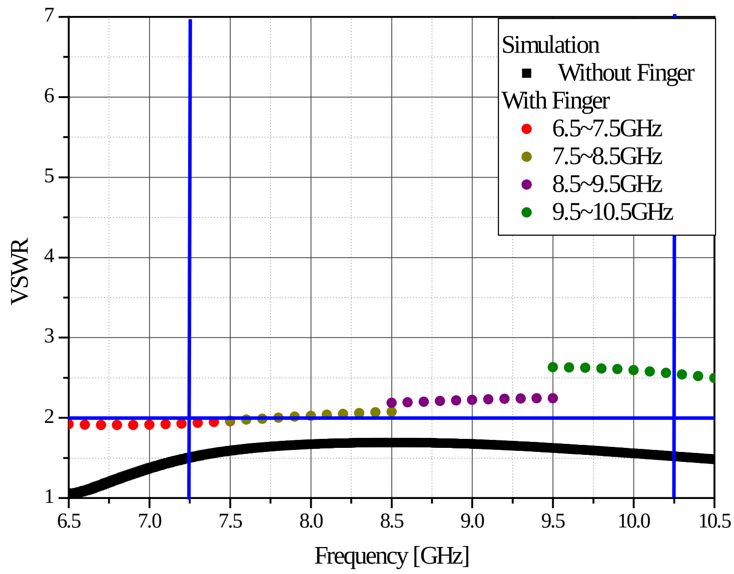


Figure 3: The simulated VSWR with/without a finger.

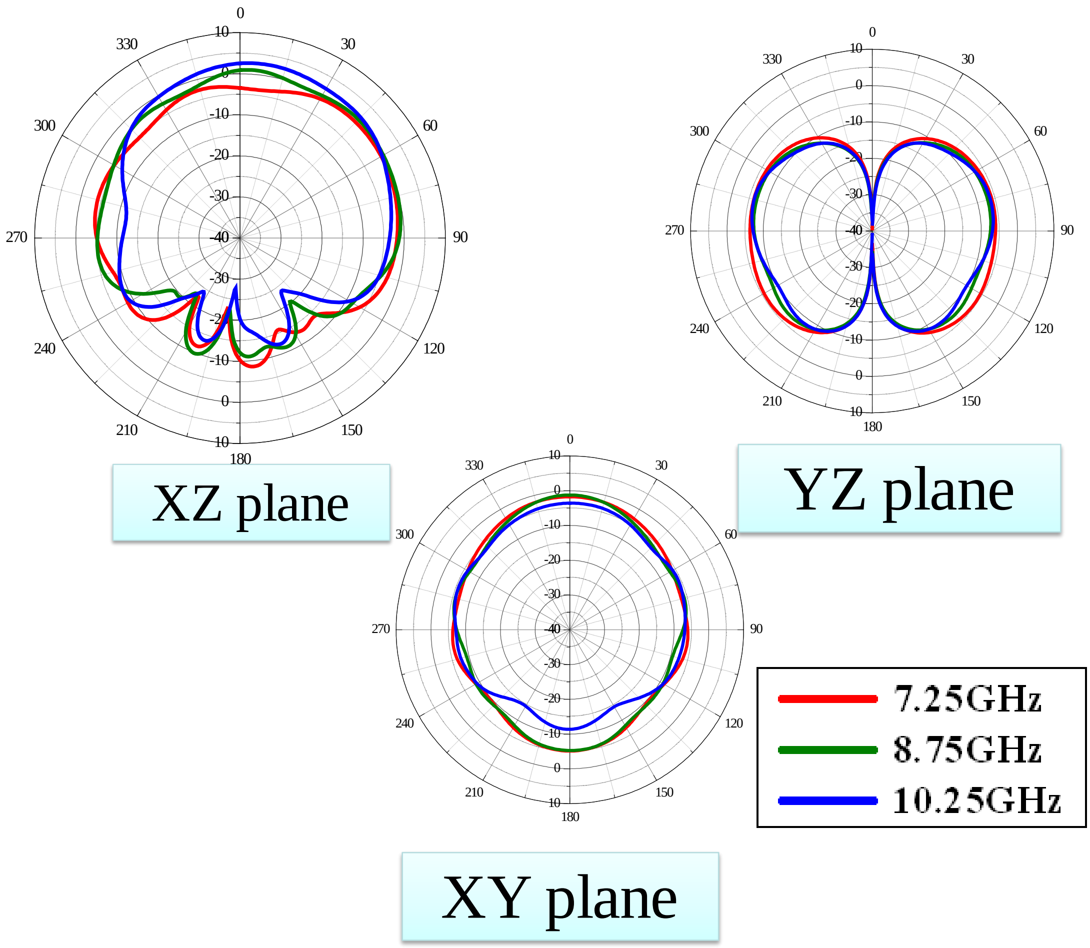


Figure 4: The simulated radiation patterns Eθ with a finger.

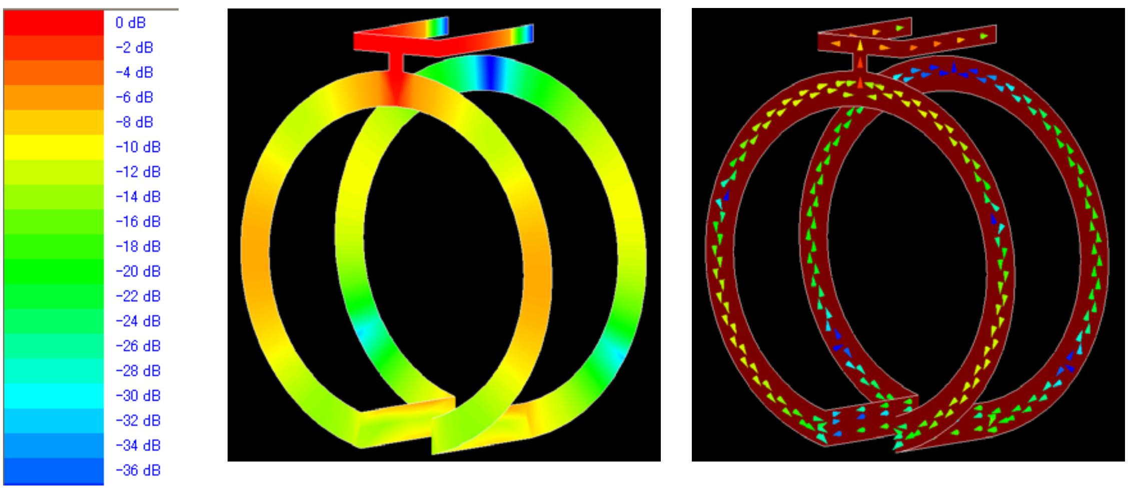


Figure 5: The simulated current distributions without a finger.
f =8.5 GHz