Bow-tie Shaped Meander Slot on-body Antenna

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Abstract-In this paper a meander slot on-body antenna is proposed for the use of wireless body area network. In order to reduce the human body radiation, metallic foil has been used on the back of the antenna. To realize miniaturized antenna having large bandwidth, the bow-tie meander slot construction is combined in this paper. A hybrid-ring coupler is used to provide phase difference. Results show that the proposed antenna has 460MHz bandwidth on the central frequency of 17GHz.

I. INTRODUCTION

Recently, the millimeter wave band has been identified as a highly attractive solution for future wireless body area networks (WBAN). Rigorous requirements for antennas such as small size, large bandwidth and stable performance are under consideration when the antenna is applied to the various parts of human body.

For the Engineering application of microwave and millimeter wave, on-body antenna is receiving more and more attention because of its low radiation to human body [1] ~ [4]. To protect human from radiation, metallic foil has been used to weaken the antenna on the human body injury [5]~[8]. In order to make antennas available to integrated circuits, high frequency and a suitable dielectric constant is proposed [9]~[12].One of the main challenges for the design of antennas for BANs involves the adaption of the antenna topology to the shape of the human body. For this purpose, bow-tie shaped meander slot antenna has been studied to realize miniaturized antennas having large bandwidth [13] ~ [19].

In this paper, metallic foil is reserved on the back of the antenna to reduce the radiation of the human body. Bow-tie shape has been used to realize wide bandwidth and small size. In order to apply the antenna to the integrated chip and minimize the size, high frequency of 17GHz and low dielectric constant of 2.6 have been used.

II. ANTENNA DESIGN

The configuration of the proposed antenna is shown in Fig.1. The antenna is constructed by making meander slots in a perfectly conducting plane supported by a dielectric substrate of 1 mm thickness and relative dielectric constant of 2.6. On the back of the antenna, metallic foil has been used to reflect the radiation of antenna to protect the human body.

The values of design parameters are listed in Table 1.

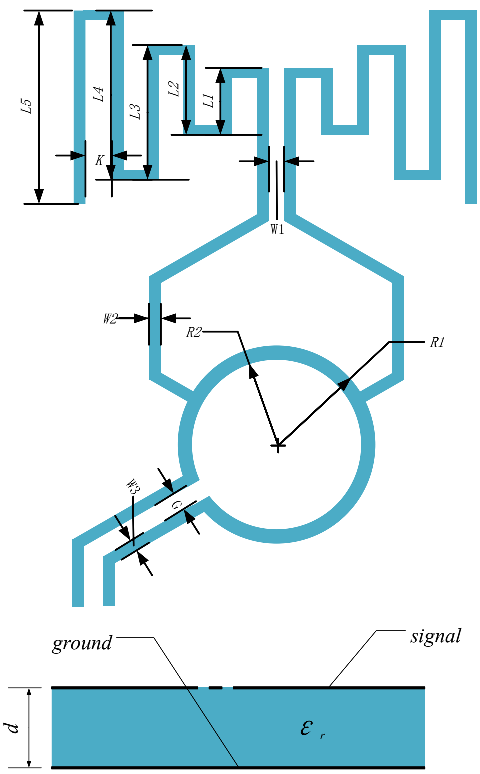

Fig. 1 The construction of the body antenna (top view and side view)

TABLE I

VALUES OF DESIGN PARAMETERS (ALL IN MILLIMETRES)

L1	*L2*	*L3*	*L4*	*L5*	*W1*	*W2*
1.83	2.44	3.66	4.58	5.19	0.42	0.32
W3	*K*	*R1*	*R2*	*G*	*d*	ε_r
0.31	0.66	2.46	2.64	0.49	1	2.6

The use of the meander slot radiators is to reduce the size. As shown in Fig. 2, the radiation is mostly generated from the turnings. To generate different polarizations, the values of constant *H*, *L* and *D* can be modulated [20]~[22].

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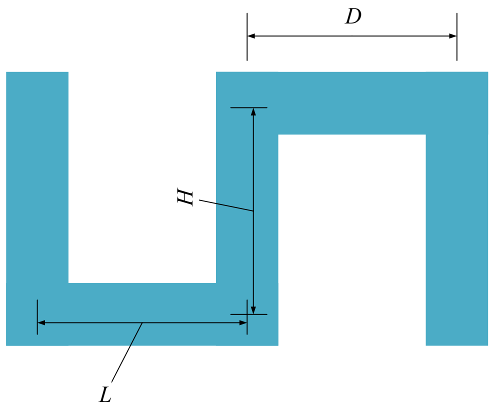

Fig. 2 The schematic diagram of meander slot

The meander slots and bilateral symmetry is divided into several sections. The slot width of the antenna is equal to the spacing between the parallel slots. To have the larger bandwidth, the construction of bow-tie slot and meander slot geometries can be used. The equivalent antenna length *L5* are introduced and calculated according to:

$$L5 \approx \frac{0.5\lambda_0}{\sqrt{\varepsilon_r}} \tag{1}$$

where ε_r is the dielectric constant of the substrate and λ_0 is the wavelength in free space at central frequency. The spacing between the parallel slots and the width of the slot are all 0.5 mm. The values of design parameters in Table 1 above are optimized by commercial electromagnetic simulation software finally.

The hybrid ring coupler, also called the rat-race coupler, is a four-port 3 dB directional coupler consisting of a $3\lambda/2$ ring of transmission line with four lines at the intervals shown in Fig.3. Power input at port 1 splits and travels both ways round the ring.

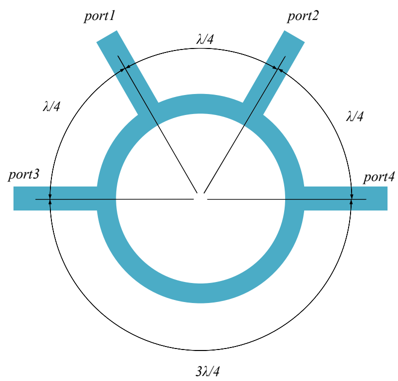

Fig. 3 The diagram of hybrid-ring coupler

The scattering matrix of hybrid-ring coupler is given by:

$$[S] = -\frac{j}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -1 \\ 1 & 0 & 0 & 1 \\ 0 & -1 & 1 & 0 \end{pmatrix} \tag{2}$$

The hybrid ring is not symmetric on its ports; choosing a different port as the input does not necessarily produce the same results. If one of the ports is omitted to form a three-port network, as is shown in Fig.4, the scattering matrix of three-port hybrid-ring coupler is given by:

$$[S] = -\frac{j}{\sqrt{2}}\begin{pmatrix} 0 & 1 & -1 \\ 1 & 0 & 0 \\ -1 & 0 & 0 \end{pmatrix} \tag{3}$$

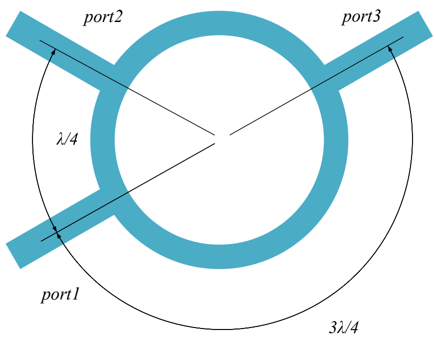

Fig. 4 The diagram of three-port hybrid-ring coupler

The impedance of the slot line ring is given by

$$Z_s = \sqrt{2}Z_{CPW} \tag{4}$$

where Z_{CPW} is the impedance of the CPW feed, the radius of the slot line ring is designed by

$$2\pi r = \frac{3}{2}\lambda \tag{5}$$

where λ is the guide wavelength of the slot line ring.

The hybrid-ring coupler shown in Fig.4 provides a hybrid ring coupler with a slot line ring by CPW feed to extend the bandwidth with structure and simple design procedure. The distances between two arms of the CPW feed are $3\lambda/4$ and $\lambda/4$, where λ is the guide wavelength [23]~[25].

III. SIMULATED AND EXPERIMENTAL RESULTS

The front and back of the proposed antenna to be discussed is shown in Fig.5 and Fig.6, of which has the similar size with the coin.

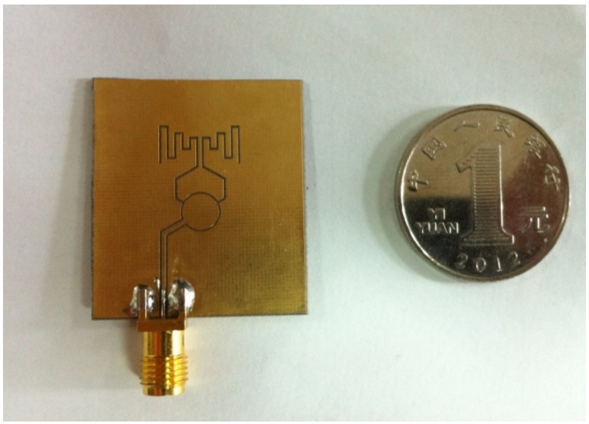

Fig.5 the front of the proposed antenna

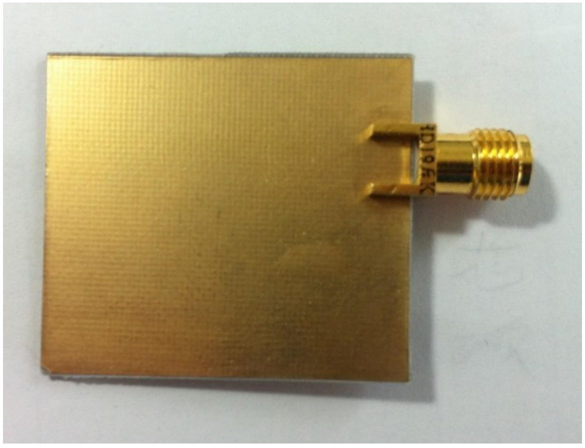

Fig.6 the back of the proposed antenna

The analysis of the body antenna is completed by using the Ansoft HFSS software. The simulated and measured return loss from 16GHz to 18GHz of the antenna is shown in Fig.7 and Fig.8. It can be seen that the antenna has an impedance bandwidth of 460MHz.

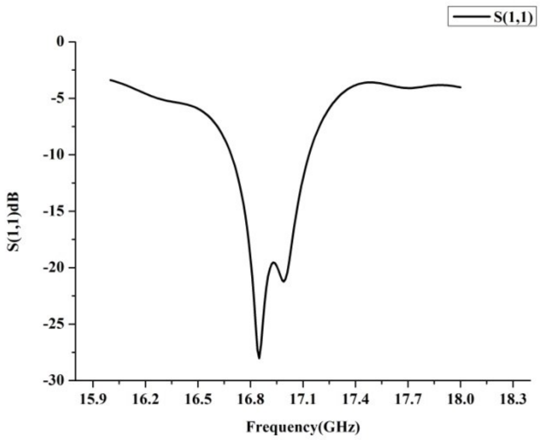

Fig.7 the simulated return loss of the proposed antenna

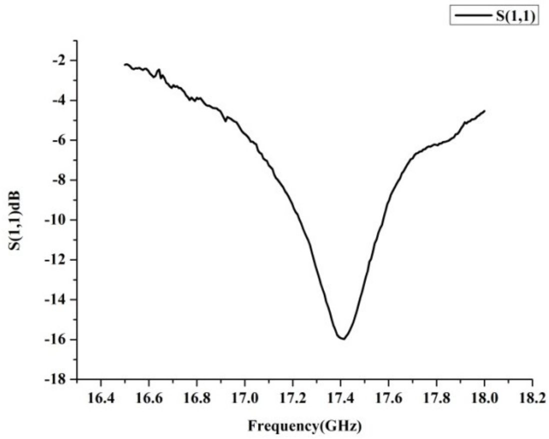

Fig. 8 the measured return loss of the proposed antenna

From the simulated and measured return loss shown in Fig.7 and Fig.8 respectively, the measured return loss have only 340MHz bandwidth. The central frequency has moved to 17.4GHz.The simulated and measured patterns of E-Plane and H-Plane at central frequency of 17 GHz are shown in Fig. 9 and Fig. 10 respectively.

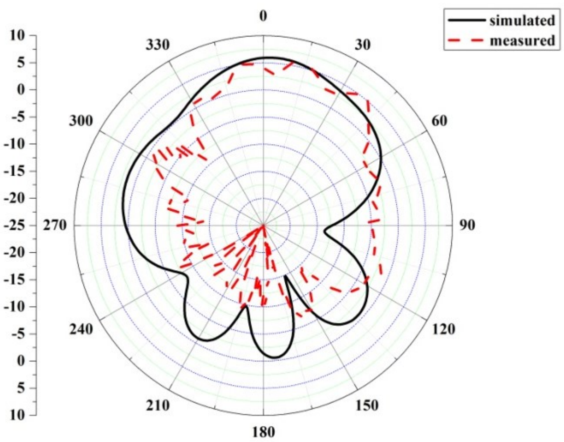

Fig. 9 E-plane radiation pattern at 17GHz

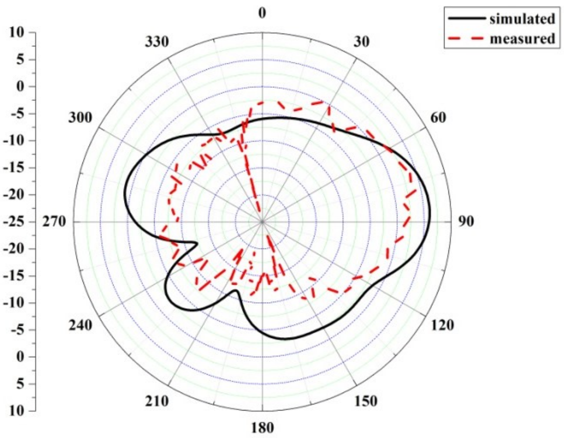

Fig.10 H-plane radiation pattern at 17GHz

The measured E-Plane and H-Plane patterns at 17 GHz are shown in Fig.9 and Fig.10 respectively. From the figure of radiation pattern above, the radiation of the front of the antenna have gain of 5dB, much higher than the back, which protect human body from radiation. The measured simulated results are not as good as simulated with several reasons of the influence of unideal test environment. From the E-plane and H-plane radiation pattern, lower radiation to human has been presented.

IV. CONCLUSION

We proposed a bow-tie shaped meander slot on-body Antenna with 460 MHz bandwidth and central frequency of 17GHz. The proposed antenna takes advantage of low radiation to human by retaining metallic foil and small size applied on the integrated chip. As the limits of test measurement environment, the experimental results are not as good as simulated. All these deficiencies need to be considered seriously and improved in further research.

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