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Study of Compact Polarization Diversity Antenna

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Abstract: In this paper, a new design of compact polarization diversity antenna using monopole antenna is proposed. This paper will compare the simulation results of S-parameters, impedance and ECC between traditional polarization diversity antenna and proposed antenna.

Keyword: polarization diversity, diversity antenna, compact antenna, monopole antenna

1. Introduction

In recent years, Body-centric wireless communication devices, such as on-body sensor for healthcare applications are desired and studied by many researchers. For high quality communication, antenna diversity technique such as polarization diversity is very important.

Considered about the portability and the electric wave toward to human body, antennas in body-centric wireless communications, such as on-body sensor, are supposed to be small enough to be wearable and have low radiation power. However, since the limit of antenna size and radiation power, in practical application body-centric wireless communication has a problem of high attenuation in complex environment. To overcome the attenuation of wearable antennas, technique of polarization diversity is introduced. In order to make antenna wearable, a design of compact polarization diversity antenna is proposed and evaluated .

This paper is organized as follow. Section 2 describes a kind of polarization diversity antenna using two orthotropic patches. In section 3, a design of polarization diversity antenna using PIFA is proposed, the results of simulation are also performed. Design using monopole antenna and simulation results are showed in section 4. Finally, conclusions are given in Section 5

2. Polarization diversity antenna using patch antennas

In Fig.1, a traditional polarization diversity antenna design using two patch antennas is performed. And the size of patch antenna is revealed in Table.1. The two patch antennas have same structure and are placed orthotropic to each other as transmitting antennas. Red area shows the patch and green area shows the substrate of ε=3.3.

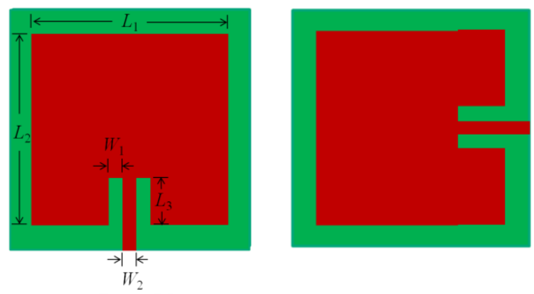

Fig.1 Polarization diversity antenna using patch antenna

Parameter	L_1	L_2	L_3	W_1	W_2
Value (mm)	41	33.5	8.5	2.6	2.8

Table.1 Parameters of patch antenna

The simulation results of S-parameters are performed in Fig.2, S_{11} is the reflection coefficient of port V and as S_{22} to port H. It can be observed that the reflection coefficients of two patch antennas are less than -20 *dB* at the frequency of 2.45 *GHz*, and S_{21} is less than -40 *dB* over the bandwidth from 2 *GHz* to 3 *GHz*.

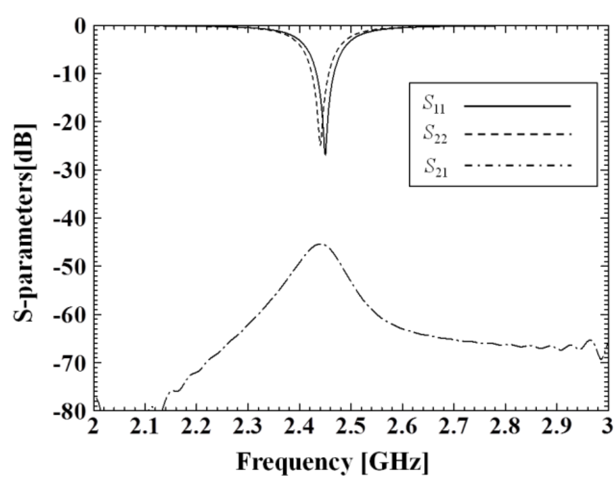

Fig.2 S-parameters of proposed antenna

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The simulation results of radiation efficiency and envelope correlation coefficient (ECC) are performed in Fig.3 and Fig.4, since there is no dielectric loss upon the antenna in simulation, radiation efficiency at frequency of 2.45 *GHz* is almost 1. And a very low ECC can be observed in Fig.4 which promises high isolation between two patch antennas.

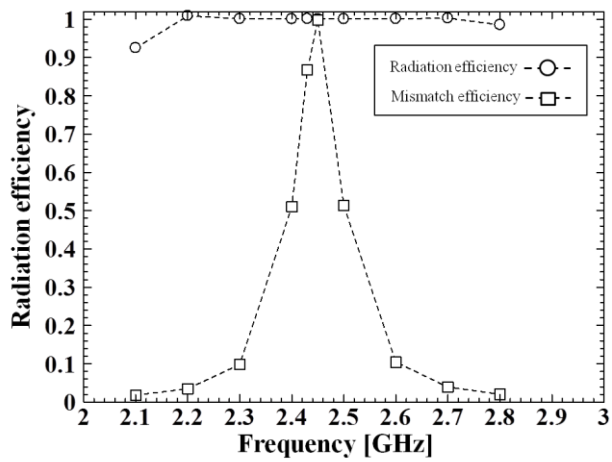

Fig.3 Radiation efficiency of proposed antenna

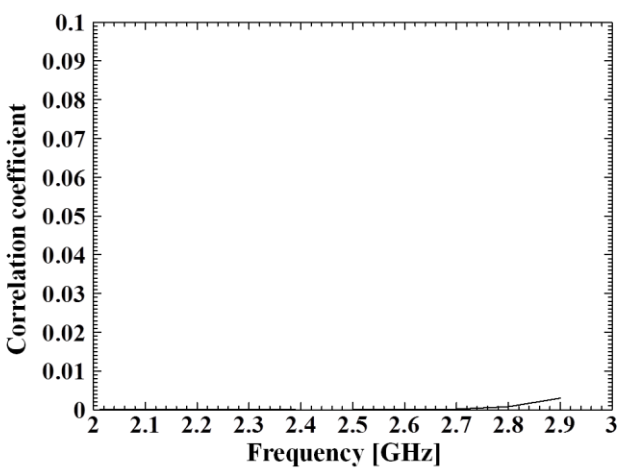

Fig.4 ECC of proposed antenna

Here, ECC is calculated by following formulas.

$$\rho_{ij} = \left| \frac{\left| R_{ij} \right|^2}{\sigma_i \sigma_j} \right|^2$$

$$R_{ij} = \int_{\Omega} \left(\frac{XPR}{1+XPR} E_{i\theta} E_{j\theta}^{*} P_{\theta} + \frac{1}{1+XPR} E_{i\phi} E_{j\phi}^{*} P_{\phi} \right) d\Omega$$

$$\sigma_i = \int_{\Omega} \left(\frac{XPR}{1+XPR} E_{i\theta} E_{i\theta}^{*} P_{\theta} + \frac{1}{1+XPR} E_{i\phi} E_{i\phi}^{*} P_{\phi} \right) d\Omega$$

$$\sigma_j = \int_{\Omega} \left(\frac{XPR}{1+XPR} E_{j\theta} E_{j\theta}^{*} P_{\theta} + \frac{1}{1+XPR} E_{j\phi} E_{j\phi}^{*} P_{\phi} \right) d\Omega$$

In this case, *XPR* is the cross-polarization ratio, while P_θ and P_ϕ represent the distribution of incoming field in terms of θ and ϕ polarization respectively.

From those charts, very ideal results are performed as a polarization diversity antenna. But for on-body use, it is still not small enough, so compact antenna is desired.

3. Polarization diversity antenna basic on PIFA

In order to make the antenna smaller, polarization diversity antenna basic on PIFA is considered. Structure is showed in Fig.5 and dimension in Table.2. Two PIFAs are placed on the substrate of ε=3.3 orthotropic to each other, length of PIFA is 18 mm and width is 1.8 mm, the distance between ground point and feeding pin is 2 mm.

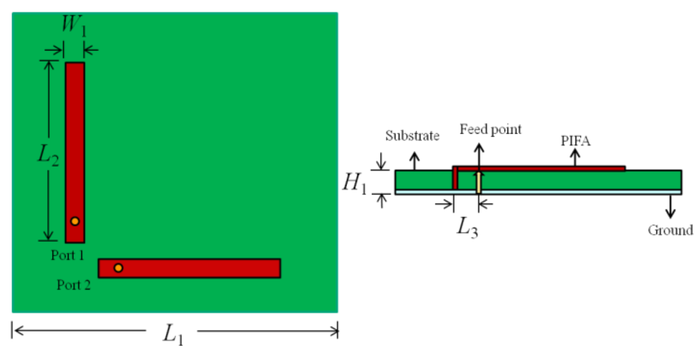

Fig.5 Polarization diversity antenna basic on PIFA

Parameter	L_1	L_2	L_3	W_1	H_1
Value (mm)	30	18	2	1.8	1.1

Table.2 Parameters of PIFA

The S-parameters of this antenna are showed in Fig.6, high reflection coefficient and transmission coefficient at 2.45 *GHz* can be observed, which indicates low radiation efficiency. However, it is difficult to correct the impedance matching to reduce the reflection.

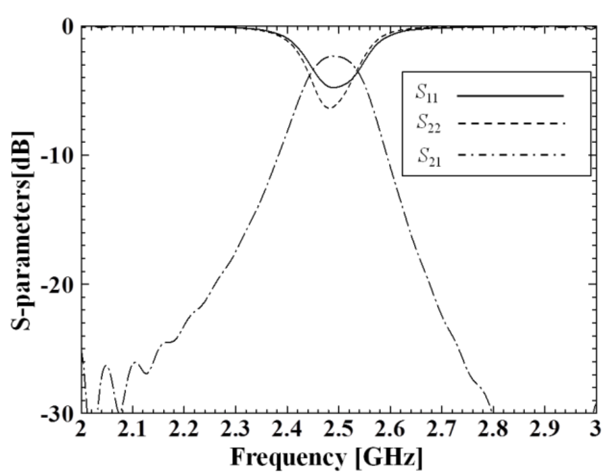

Fig.6 S-parameters of PIFA

Radiation efficiency and ECC are represented in Fig.7 and Fig.8. Low radiation efficiency and high ECC at 2.45 *GHz* can be observed due to high coupling between port 1 and port 2.

In this case, this design is not desired.

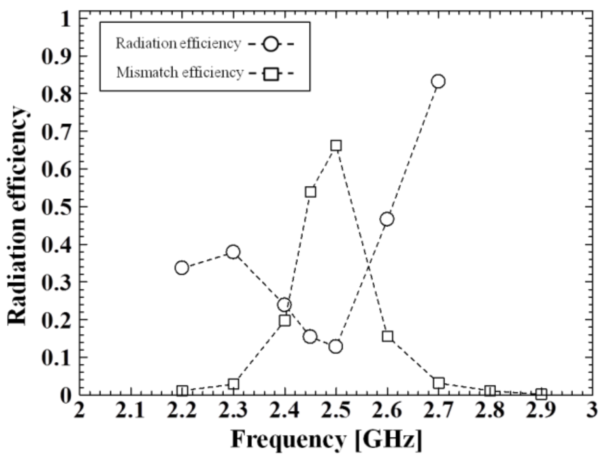

Fig.7 Radiation efficiency of PIFA

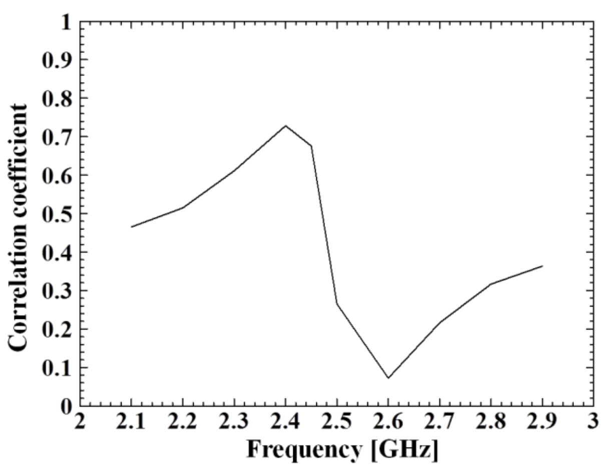

Fig.8 ECC of PIFA

4. Monopole polarization diversity antenna

To satisfy the antenna parameters and antenna size, a kind of polarization diversity basic on monopole antenna is designed.

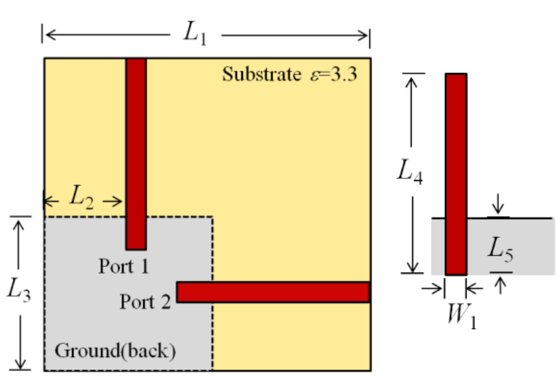

Fig.9 Polarization diversity antenna basic on PIFA

Parameter	L_1	L_2	L_3
Value (mm)	45	10	20
Parameter	L_4	L_5	W_1
Value (mm)	30	5	2.2

Table.3 Parameters of monopole

In Fig.9, the structure of monopole antenna is performed, and the parameters in Table.3. The length of monopole is 30 mm, width is 2.2 mm.

This antenna is not set on a full ground substrate, but a partially stepped ground substrate, the ground plane is 20 mm long at the back of substrate, ε=3.3.

The S-parameters are represented in Fig.10. The reflection coefficients of two ports are less than -10 *dB* upon 2.1 *GHz* – 2.8 *GHz* and transmission coefficient is less than -6 *dB*. Coupling is pretty strong comparatively, but due to the orthotropic structure, influence to ECC is very weak.

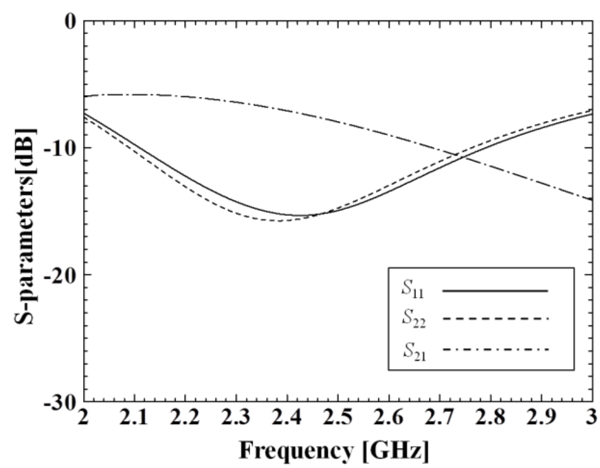

Fig.10 S-parameters of monopole

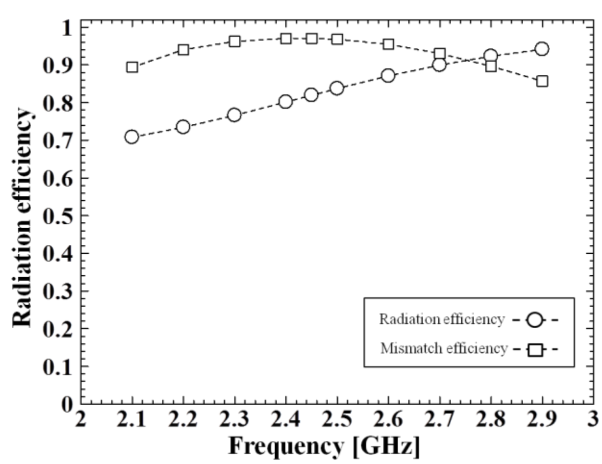

Fig.11 Radiation efficiency of monopole

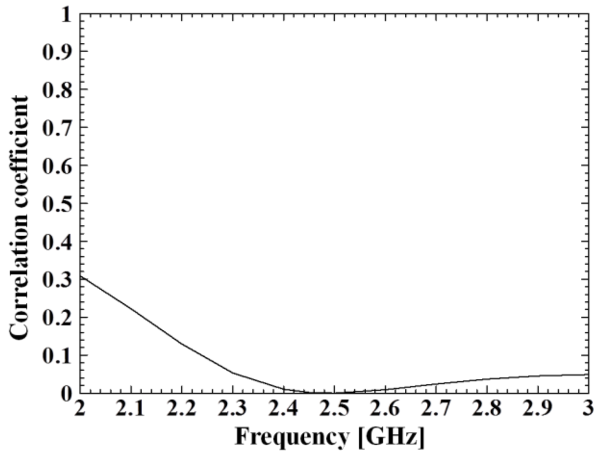

Fig.12 ECC of monopole

Radiation efficiency and ECC are showed in Fig.11 and Fig.12. Radiation efficiency is about 0.81 and ECC is almost 0 at 2.45 *GHz*. This is a good result as a compact polarization diversity monopole antenna.

To discuss the influence that human body does, simulation that involves human equivalent-phantom (SPARG) was implemented. As showed in Fig.13, antenna was placed in front of the chest of human body, the distance between human body and antenna is 4 mm. S-parameters, radiation efficiency and ECC can be observed in Fig. 14, Fig.15 and Fig.16.

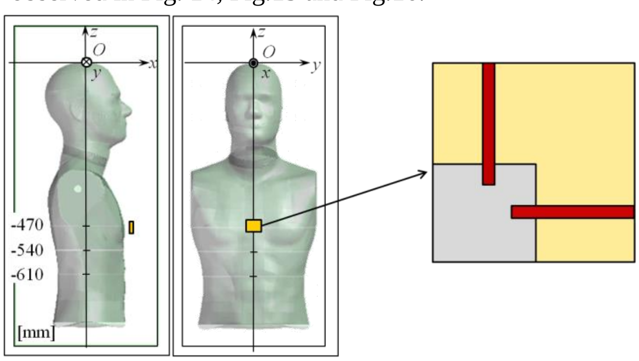

Fig.13 Monopole antenna with human body model

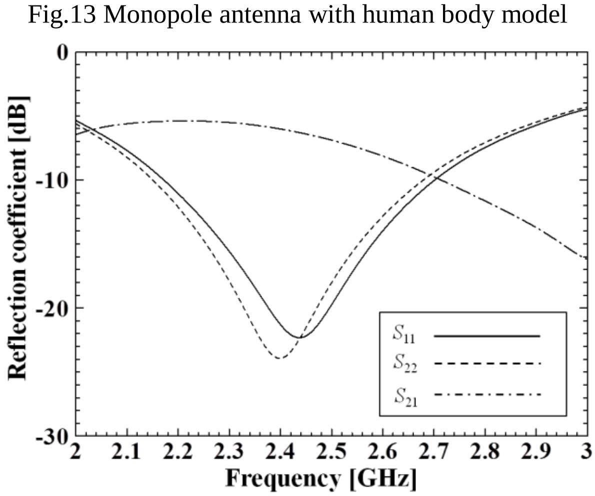

Fig.14 S-parameters with human body model

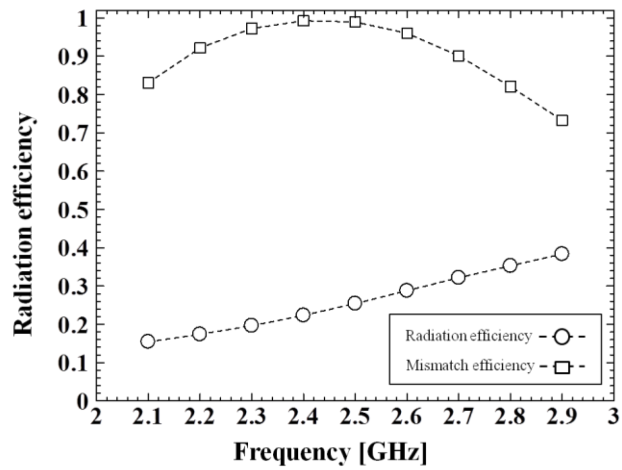

Fig.15 Radiation efficiency with human body model

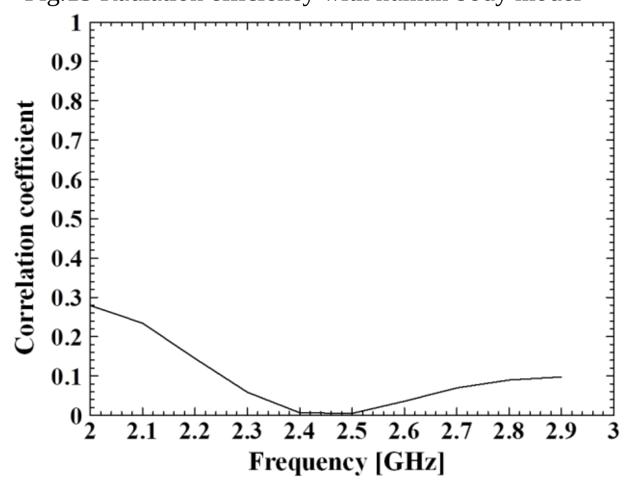

Fig.16 ECC with human body model

There is a little frequency shift for S-parameters, and ECC still has a good performance. But radiation efficiency changed a lot, due to the influence of human body model, back lobe and side lobe of radiation pattern are absorbed by human body, radiation efficiency is 0.23 at 2.45 *GHz*. It is a big challenge to improve the radiation efficiency. .

5. Conclusion

Compact polarization diversity antenna basic on PIFA and monopole antenna is designed and simulated. Monopole antenna has a good performance on S-parameters, radiation efficiency and ECC. Human body has great influence on antenna radiation pattern, solutions will be discussed next step.

Reference

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[2] SEMCAD-X Manual