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Miniaturized and High-Isolation Diversity Antenna for WBAN Applications

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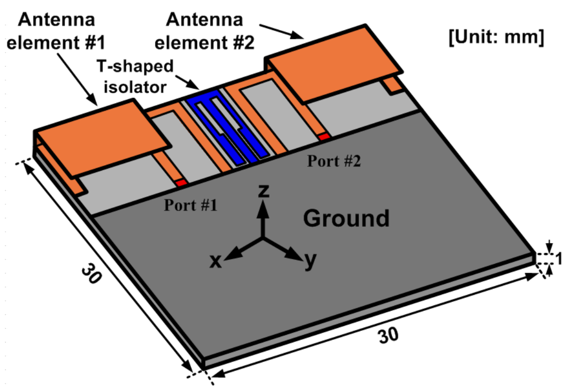
1. Introduction

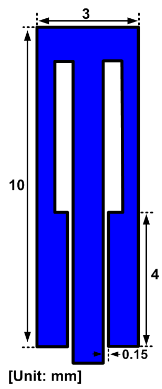
The applications of a wireless body area network (WBAN) have been expending in medical services, police and military agencies, sports training, entertainment, wearable computing, and so on [1]. In WBAN applications, antennas are required to have a small size, low human body effect and low specific absorption ratio (SAR) [2]. The human body has a high dielectric constant with a high loss tangent and low conductivity at the microwave frequency band. Therefore, the gain and radiation efficiency of an antenna can be deteriorated when an antenna is operated on or in the human body.

Recently, much work has been done to investigate the on-body communication channel at the ISM band. In WBAN system, multipath propagation can occur due to reflections from the surrounding environment and the body parts. Also multipath fading can occur due to the large relative movement of body parts, shadowing, polarization mismatch, and scattering by the body and the surrounding environment [3]. To improve the performance and overcome multipath fading, diversity is a very powerful technique. When two antennas are placed close to each other, isolation performance between antennas must be low enough to prevent one antenna from affecting.

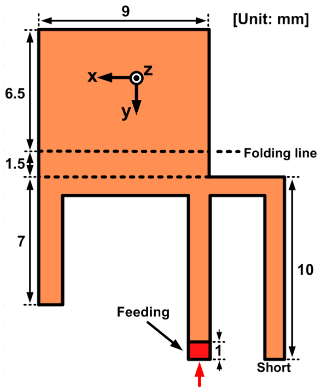
In this paper, a miniaturized and high isolation diversity antenna for WBAN applications in ISM band (2.4 GHz ~ 2.485 GHz) is proposed. To achieve compact size of an antenna for on-body communication, a planar inverted-F antenna (PIFA) technique is used. The proposed diversity antenna adopts T-shaped isolator to improve the isolation characteristic at ISM band. The proposed diversity antenna was designed and analyzed using the Ansys HFSS v14 [4].

2. Antenna Design and Performance

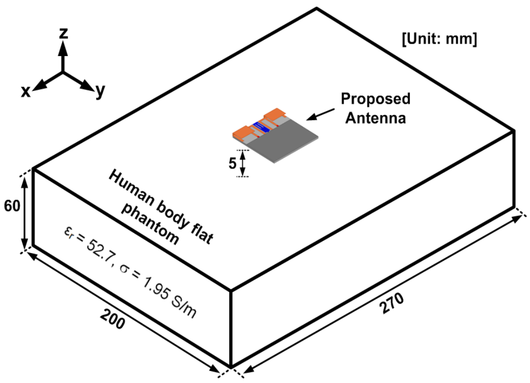




(a) Perspective view of the proposed diversity antenna (b) T-shaped isolator



(c) Antenna element



(d) Flat phantom model for numerical analysis

Figure 1. Configuration of the diversity antenna

The configuration of the proposed diversity antenna is shown in Fig. 1 (a). The proposed diversity antenna consists of two planar inverted-F antennas (PIFAs), which are located near the corners of the top edge of the ground plane, and a T-shaped isolator which is placed between the two antenna elements. The two antenna elements of the diversity antenna were symmetrically placed with respect to the y-axis. Each antenna element has a dimension of 13 mm × 10 mm × 1.5 mm and is fed by a 50 Ω coaxial cable. Fig. 1 (b) shows the structure of a T-shaped isolator used to enhance the isolation characteristic at ISM band. The ground plane is made of a 1-mm-thick FR4 substrate with a dielectric constant of 4.4 with a size of 30 mm × 30mm.

In order to analyze the antenna performance when the antenna is located on a human body, simulation were carried out by using a Human body flat phantom (200 mm × 270 mm × 60 mm) with ε_r = 52.7 and σ = 1.95 S/m as shown in Fig. 1(d). The simulated S-parameter characteristics with T-shaped isolator are shown in Fig. 2. To investigate the effect of the T-shaped isolator on the isolation characteristic, the current distributions at 2.45 GHz with and without the T-shaped isolator were simulated as shown in Fig. 3. When one of the two elements was exited, a strong field was induced at the other element in the absence of a T-shaped isolator. After the T-shaped isolator was embeded, the induced current at the non-excited element become very weak.

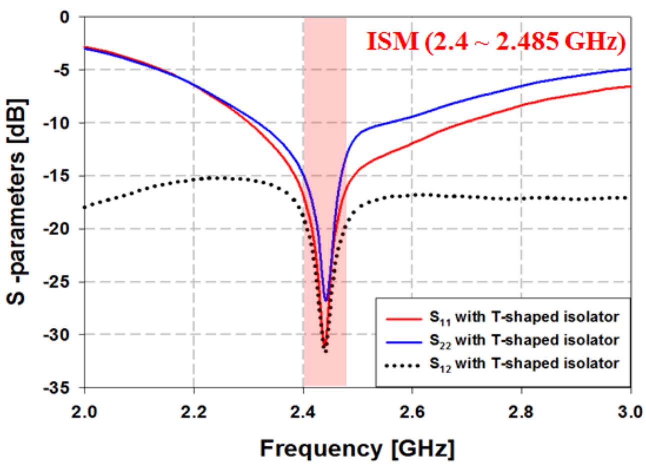
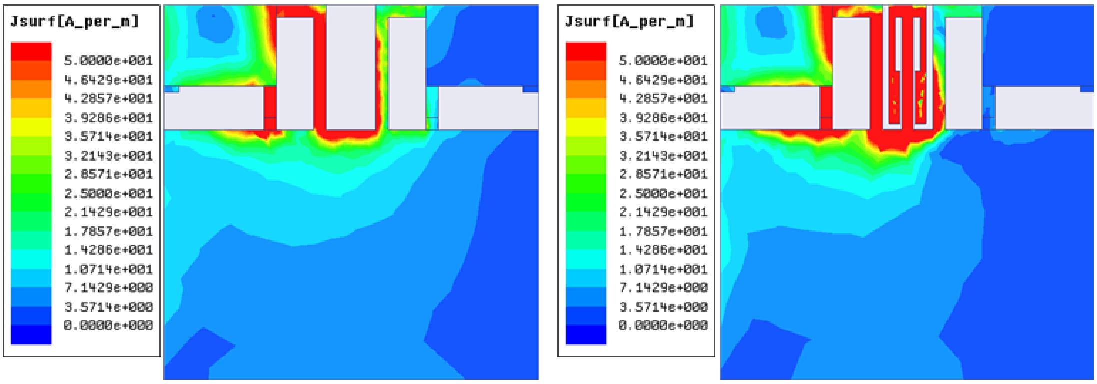


Figure 2. Simulated S-parameter characteristics

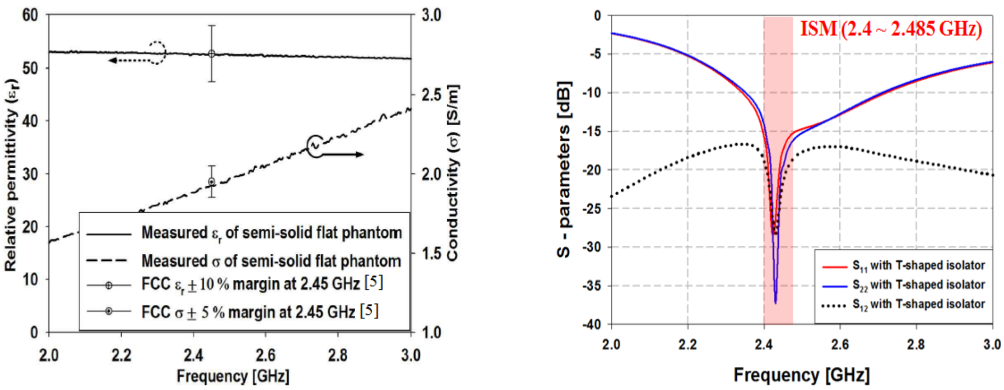


(a) (b)

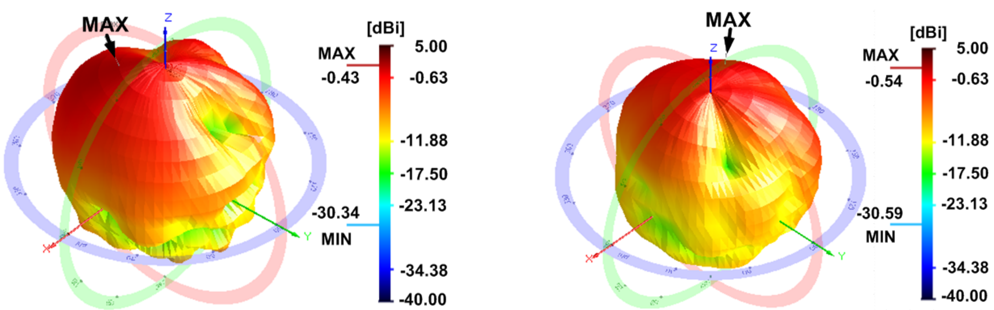
Figure 3. The current distributions of proposed diversity antenna at 2.45 GHz
(a) Without T-shaped isolator (b) With T-shaped isolator

3. Results

The measured relative dielectric constant and conductivity of fabricated semi-solid phantom [5] using an Agilent 8570E dielectric probe kit and an 8719ES network analyser are shown in Fig. 4. The phantom with a dimension of 200 mm × 270 mm × 60 mm is used to measure the S-parameter characteristics and 3D radiation patterns, as shown in Fig. 4(b), (c) and (d). The fabricated antenna has an 10dB return loss bandwidth over the ISM band from 2.35 GHz to 2.71 GHz and isolation is less than -25 dB at 2.45GHz.



(a) (b)



(b) (d)

Figure 4. The measured performances of proposed diversity antenna :
(a) Measured performance of the fabricated phantom (b) Measured S-parameter characteristics
(c) Measured 3-D pattern of Ant. #1 at 2.45 GHz (d) Measured 3-D pattern of Ant. #2 at 2.45GHz

Table 1. ECC, MEG, and MEG ratio, Actual diversity gain of the proposed diversity antenna

Freq. [GHz]	ECC	Ant. #1 MEG [dBi]	Ant. #2 MEG [dBi]	MEG ratio [dB]	Actual diversity gain[dB]
2.45	0.01	-11.015	-11.385	0.27	5.781

The performance of the proposed diversity antenna including ECC, MEG, and MEG ratio, actual diversity gain are summarized in Table 1. From Table 1, it is found that the received signals satisfy the conditions suggested in [6]. When a uniform propagation environment is assumed, the MEG ratio is almost unity, indicating that the mean power delivered from the two antenna ports are almost the same.

4. Conclusion

In this paper, a miniaturized diversity antenna with high isolation for WBAN applications is proposed to improve the overall performance and overcome multipath fading caused by large relative movements of body parts. The proposed diversity antenna has a dimension of 30 mm × 30 mm × 2.5 mm. Isolation performance was also improved by utilizing the T-shaped isolator located between the two antenna elements. It is shown that the suggested diversity antenna performance is good enough to be used for WBAN applications.

Acknowledgments

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References

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