

# A Small Planar Inverted-F Antenna for Body-Centric Wireless Communications

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## 1. Introduction

Recently, the study on body-centric wireless communications has become a very active area of research. By adopting body-centric wireless communications, numerous applications will be enhanced, such as personal healthcare, smart home, personal entertainment, and identification systems. However, the human body environment is uninviting and often hostile for a wireless signal [1]. Therefore, as an interface between the transceiver and propagation environment, antennas in these systems need to be carefully designed. This is a big challenge for antenna designers. A small cavity slot antenna proposed in [2] is a good example. The antenna has a relatively high efficiency in the vicinity of the human body owing to the effects of equivalent magnetic current. Accordingly, the general requirements for antennas in body-centric wireless communications are summarized: small size, low profile, and high efficiency [2]. In [3], a circular patch antenna was designed for Bluetooth applications. The study also investigated the bending effects on input-impedance matching and impedance bandwidth. Besides, EBG materials were also adopted in a 2.45-GHz patch antenna to enhance the surface wave propagation [4]. These antennas are of low profile but considering the antenna size they are relatively large.

The planar inverted-F antenna is a suitable candidate. It is relatively immune to fading during body postures' changing because of their nondirectivity [5]. Therefore, in this paper, we propose a small planar inverted-F antenna for body-centric wireless communications. By introducing a small L-shaped ground shield, the antenna has a relatively high efficiency of more than 50% even in the vicinity of the human body. The operation bandwidth reaches about 110 MHz, covering the whole Bluetooth band (2400 - 2480 MHz).

## 2. Antenna Configuration and Human Phantom

The proposed small planar inverted-F antenna is illustrated in Fig. 1. The radiating top patch has dimensions of  $L$  mm  $\times$  26 mm (where  $L$  is to be determined from this study), and the ground plane has dimensions of 22 mm  $\times$  30 mm. The antenna height is 4 mm, and no dielectric material is used between the top patch and the ground plane for this case. The feed pin is in the center line of the top patch, and  $F$  mm away from a shorting plate of  $W$  mm in width (where  $F$  and  $W$  are to be determined). In order to improve antenna efficiency, a small L-shaped ground shield is added next to the shorting plate. Its vertical portion and horizontal portion have the same dimensions of 4 mm  $\times$  30 mm. Thus, the proposed planar inverted-F antenna has compact dimensions of 30 mm  $\times$  26 mm  $\times$  4 mm.

To study the influence of the human body on the antenna, the antenna is located close to a 2/3 muscle-equivalent phantom (dimensions, 200 mm  $\times$  200 mm  $\times$  50 mm; relative permittivity,  $\epsilon_r = 35.2$ ; conductivity,  $\sigma = 1.16$  S/m [6]), as shown in Fig. 2. The distance between the antenna and the phantom is set at 2 mm to simplify equipment packaging.

## 3. Calculated Results and Discussion

All of the simulated results are obtained by XFDTD (Remcom Ltd., USA), and in order to simplify the simulation, the diameter of the feed pin is not considered.

Owing to the phantom's impact, the impedance of the antenna could be changed. Therefore, we need to retune the antenna by adjusting parameters of  $L$ ,  $W$ , and  $F$ . A parametric study has been conducted. The optimized values of the parameters are as follows:  $L = 19$  mm,  $W = 6$  mm, and  $F = 3.5$  mm. The simulated reflection coefficient is shown in Fig. 3. The operation bandwidth is about 110 MHz covering the whole Bluetooth band. The antenna gain is 1.03 dBi and the radiation pattern is shown in Fig. 4. It is found that in the half-sphere without phantom the radiation pattern is relatively non-directional, which is relatively immune to fading during body postures' changing. Another important finding is that even when the antenna is very close to the human body (phantom), the radiation efficiency still reaches 50.5%.

As a comparison, the performance of the antenna without L-shaped ground shield (with no other parameters changing) was also examined. The calculated results are listed in Table 1, including the operation bandwidth, center frequency, antenna gain, and radiation efficiency. From the table, it is apparent that by adding a small L-shaped ground shield the antenna efficiency is improved from 42% to 50.5%.

## 4. Conclusions

In the paper, a small planar inverted-F antenna for body-centric wireless communications is proposed for the 2.45 GHz band. By adding a small L-shaped ground shield, the antenna has an improved efficiency of 50.5% even when it is very close to human body. It is also found that the antenna has a wide operation bandwidth (110 MHz) and attractive radiation pattern for body-centric wireless communications.

Now, we are fabricating the antenna to validate the design, and will further optimize the antenna and examine the specific absorption rate (SAR).

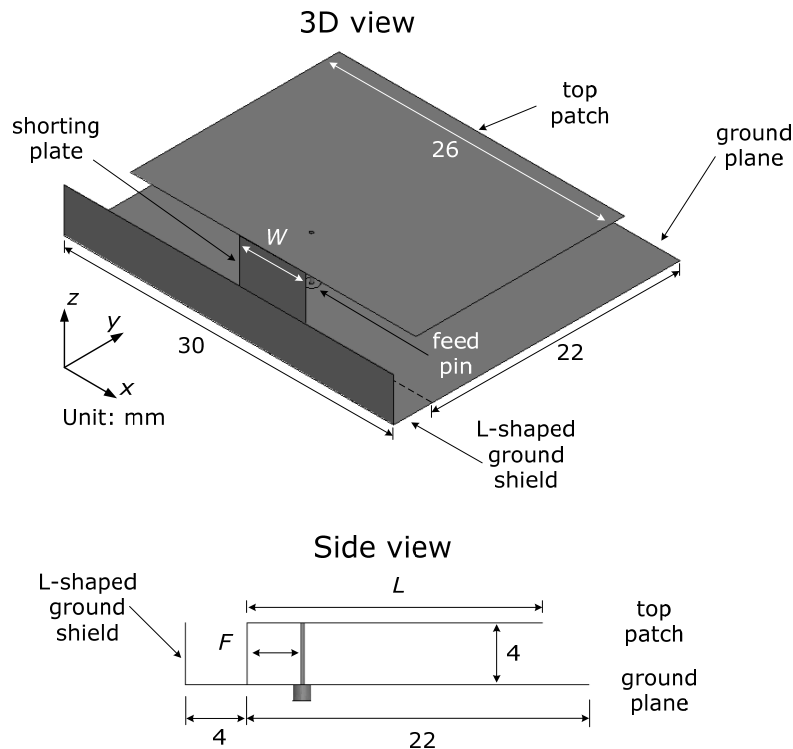


Figure 1: Geometry of the Proposed Planar Inverted-F Antenna

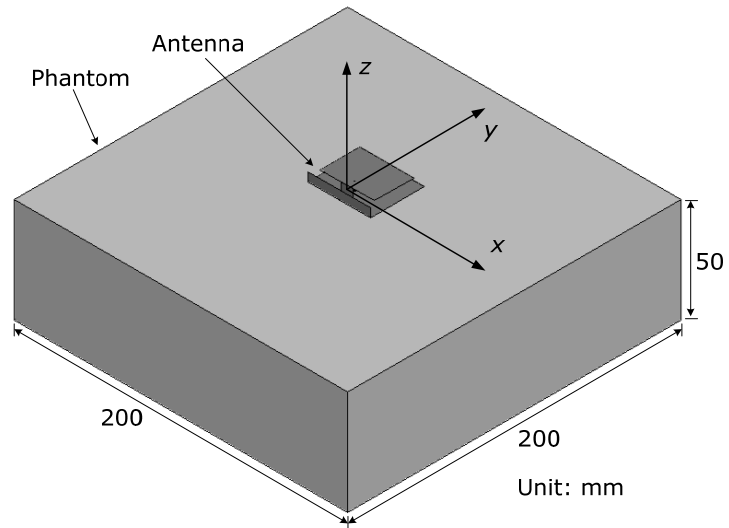


Figure 2: Antenna and 2/3 Muscle-equivalent Phantom

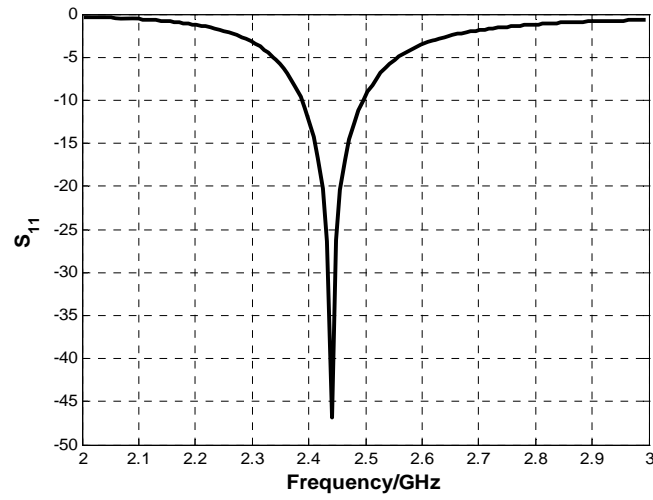


Figure 3: Reflection Coefficient

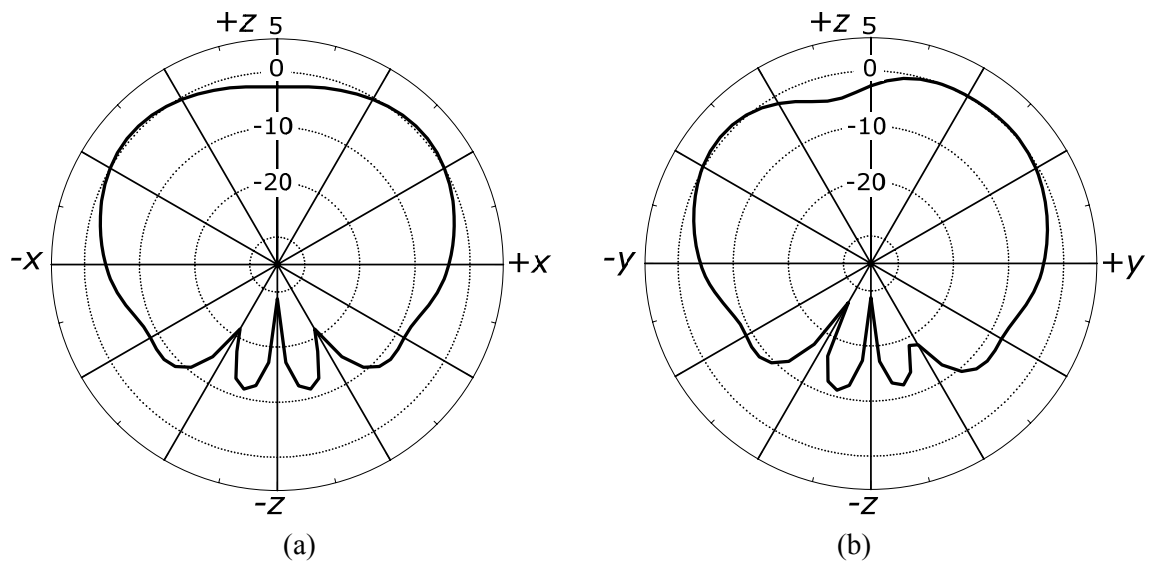


Figure 4: Radiation Patterns: (a) x-z plane; (b) y-z plane

Table 1: Performance of the Proposed Antenna and the Antenna without L-shaped Ground Shield

	Bandwidth (GHz)	Center frequency (GHz)	Gain (dBi)	Radiation efficiency
The proposed antenna	2.387-2.496	2.44	1.03	50.5%
The antenna without L-shaped ground shield	2.317-2.434	2.38	0.51	42%

## References

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