블루투스 대역에서 동작되는 미앤더 형 2중층 구조를 가진 패치 안테나의 구현

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Compact Meander-Type Antenna with a Two Layer Structure for Bluetooth Operation

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요 약

본 논문에서는 블루투스 응용이 가능한 두 층을 가진 소형 미앤더 형태의 안테나를 제안하고 실험하였다. 제안된 안테나는 아래층의 패턴, 위층의 패턴, 그리고 3개의 비아 홀을 통해 두 층이 연결되어 있는 구조를 갖는다. 측정 결과 임피던스 대역폭은 S11=-7.5dB 을 기준으로, 220MHz(2.34-2.56GHz)을 얻었다. 또한 안테나 방사 패턴과 이득이 블루투스 대역 내에서 측정되었다.

Key Words : antenna, meander-type antenna, two-layer structure, Bluetooth operation

ABSTRACT

In this paper, a compact meander-type antenna with a two-layer structure for Bluetooth applications is proposed and experimentally studied. The antenna consists of a lower pattern in the bottom layer, an upper pattern in the top layer, and three via for connecting the two layers. The simulation results for the effect of lengths and widths of the meander-type line for Bluetooth applications are investigated. From the experimental results, the measured impedance bandwidth, defined by S11=-7.5dB, can reach an operating bandwidth of 220 MHz (2.34 - 2.56 GHz). Also, the antenna radiation patterns and gains within the Bluetooth band are measured and studied.

Ⅰ. Introduction

Bluetooth technology is a short-range communications technology intended to replace the cables connecting portable and fixed devices while maintaining high levels of security. The key features of Bluetooth technology are low power consumption, two-way radio specification that operates in the license-free 2.4 - 2.484GHz ISM band worldwide and is capable of data transfer of up to 1Mbps. A fundamental Bluetooth wireless technology strength is the ability to simultaneously handle both voice and data transmissions. This enables the user to enjoy a variety of innovative solutions such as a hands-free headset for voice calls and printing and fax capabilities for mobile phones, PDAs, portable computers, and digital cameras. Undoubtedly, this Bluetooth-based communication capability will be playing an important role in current and future consumer electronics.

As is well known, a conventional microstrip antenna is attractive due to its low profile. However,

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its disadvantages include its large lateral size and narrow impedance bandwidth. In the literature, several techniques have been reported to reduce the size of the patch antenna [1]. Many studies have been made to reduce antenna size for Bluetooth applications[2 - 8]. Inverted-F type[2], meander-type [3], small-chip-type[4], EBG-assisted slot type[5], Hilbert-type[6], two-layer patch type[7], and watch type[8] antenna have been developed. The current design trend is to implement Bluetooth technology in small integrated circuits. The available Bluetooth antenna designs still require a relatively large space. So, antennas used for Bluetooth applications need to be small in order to be integrated with the system.

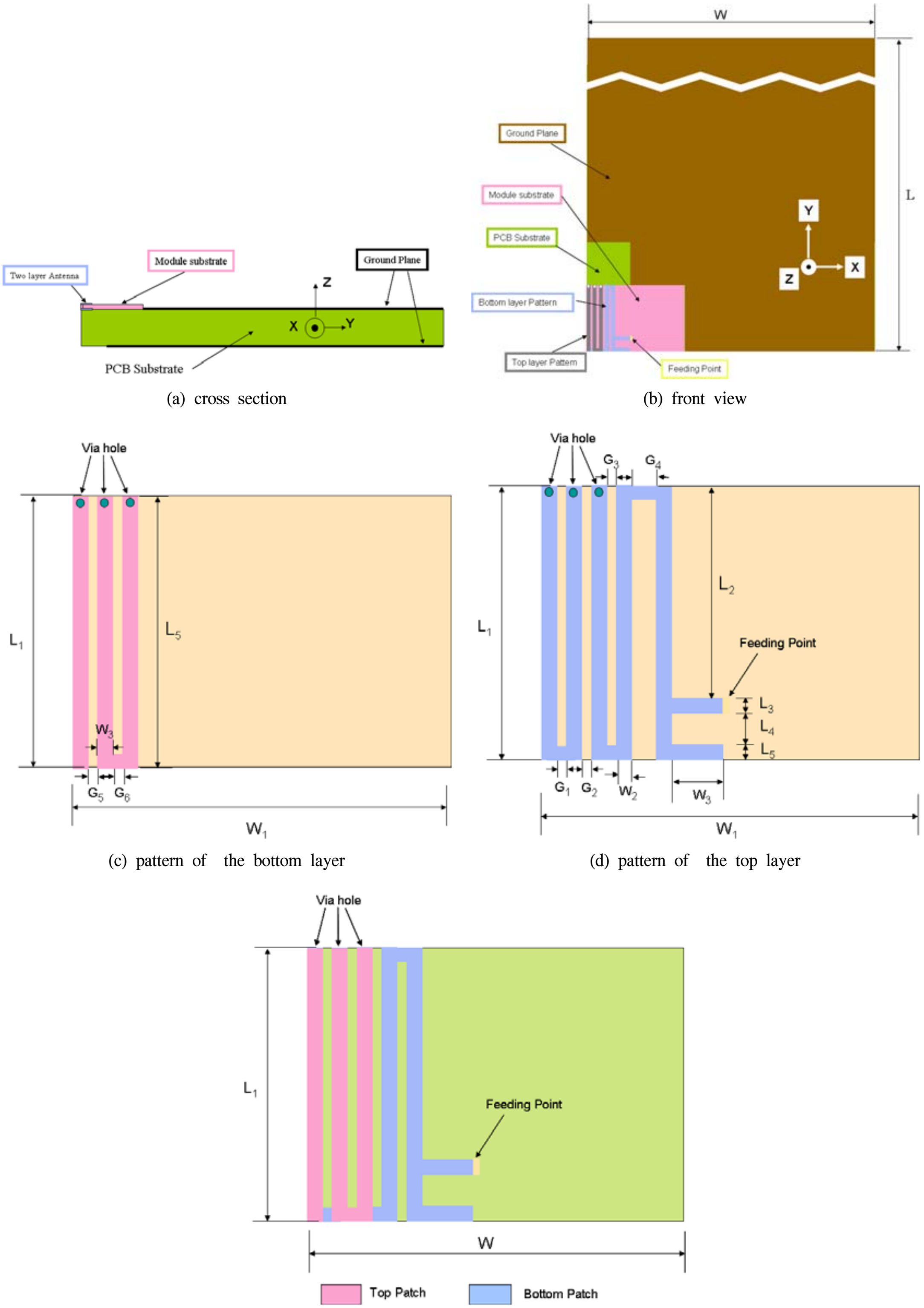
In this paper, we propose a compact antenna with a two-layer geometry for Bluetooth applications. The meander-type patch antenna here is positioned top and bottom layer in the module substrate. Through the proper selection of the parameters of the gap of the lines, line length and width of the top and bottom layers, good performance was obtained with the proposed antenna. The results of the experiment that were conducted on the antenna's impedance bandwidth, radiation pattern, and gain are discussed in detail below.

Ⅱ. Antenna Design

The schematic configuration of the proposed antenna design with a two-layer structure is shown in Fig. 1. Figures 1(a) and 1(b) show the cross-section and front view, respectively. The main radiator of the proposed compact antenna shown in Figure 1(a) and (b) occupies a small volume of 2.5mm´6.55mm´0.4mm and is fabricated on an FR4 substrate that have a relative dielectric constant 4.4. The system ground plane in the study is printed on a 1.2-mm-thick FR4 substrate with dimensions of $50´80mm^2$,whichisareasonablesizethatispracticalform obilephones.The total size of a 0.4-mm-thick FR4 module device is $11.25´6.55mm^2$. Also, the proposed antenna, which is printed on top and bottom of the module surface, is mounted at the bottom left corner of the system ground plane for Bluetooth operation. The proposed antenna consists of a lower pattern in the bottom layer, an upper pattern in the top layer, and three via for connecting the two layers. By connecting the two patterns on the top and bottom layers by three via, the resonant length of the proposed antenna is extended and then the size of the proposed antenna is reduced. Moreover, the proposed antenna is printed on the non-ground portion of the system ground plane for Bluetooth operation. The non-ground portion, whose area is 5.15mm´8.5mm, is taken of the PCB board for the radiation of the Bluetooth band. The proposed antenna is then small enough to be embedded on module devices.

Figures 1(c) and 1(d) show the pattern of the top and bottom layers, respectively. The proposed patch antenna for the top and bottom layers consists of a meander-type line. Figure 1(e) shows the proposed antenna design, which adds up the pattern of the top and bottom layers. Moreover, the feeding point is located on the bottom right corner in the bottom layer of the module substrate. For feeding the antenna, a 50Ω coaxial line is used. Full-wave commercial EM software with the capability of simulating finite substrate and finite ground structure, HFSS[9], was used in optimizing the geometric parameters of the proposed Bluetooth antenna. Therefore, the dimensions of the proposed antenna are set as follows: L=80mm; L_1=6.55mm; L_2=5mm; L_3=0.35mm; L_4=0.85mm; L_5=0.35mm; W=50mm; W_1=11.5mm; W_2=0.35mm; W_3=2.5mm; W_4=2.3mm; G_1=0.1mm; G_2=0.1mm; G_3=0.15mm; G_4=0.25mm; G_5=0.1mm; G_6=0.15mm.

From the simulation results, the total length of the proposed antenna has a resonant path of about 0.43λ. Using the meander-type line that is longer than the conventional resonant length at 2.4GHz, which introduces additional inductance to compensate for the capacitive coupling arising between the lines, improved impedance matching can be obtained.



(a) cross section

(b) front view

(c) pattern of the bottom layer

(d) pattern of the top layer

(e) add up the pattern of the top and patter layer

Fig. 1. Configuration of the proposed compact antenna with a two-layer structure

Ⅲ. Measurement

We manufactured and experimentally tested the proposed Bluetooth antenna. The return loss and the radiation pattern of the proposed antenna were measured using an Agilent Technologies E8362B Vector Network Analyzer/receiver in an anechoic chamber. The return loss of the proposed antenna is shown in Figure 2. It is clear that the antenna has Bluetooth characteristics with a bandwidth range of 2.4－2.484GHz assuming a -7.5dB return loss reference. In this figure, the red and blue lines represent the return loss of measured data and simulated data, respectively. The results show satisfactory agreement between the measurement and simulation obtained from Ansoft HFSS. Based on the -7.5dB return loss bandwidth, which is acceptable for Bluetooth applications, the impedance bandwidth is about 220 MHz (2.34－2.56 GHz), which covers the whole Bluetooth band (2.4－2.483 GHz).

The far field radiation patterns of the proposed antenna have been obtained in Figure 3. From the results, comparable E_Θ and E_ϕ components are seen, especially in the y－z plane (the elevation plane) and z－x plane (the azimuth plane). Similar radiation patterns for other frequencies over the operating band were also seen. In this radiation pattern, the red and blue lines represent the radiation pattern of E_Θ and E_ϕ at 2.44 GHz, respectively. We found that omni-directional behavior, especially in the z－x plane, is nearly revealed.

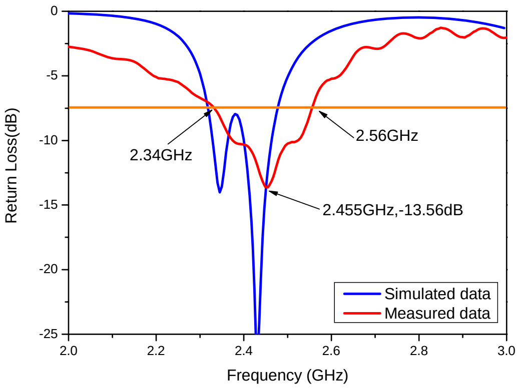
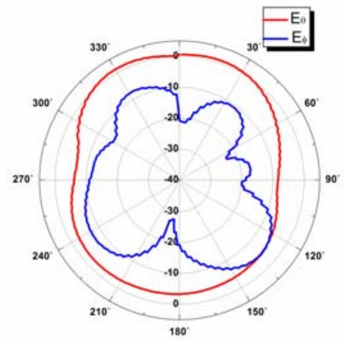
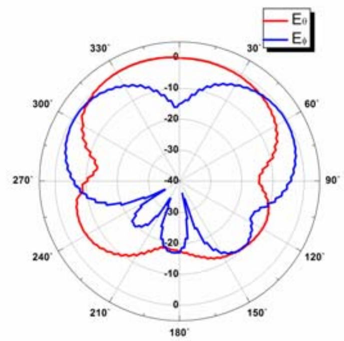


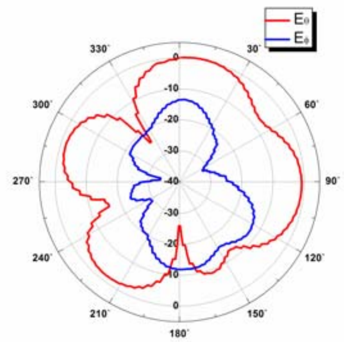
Fig. 2. Simulated and measured return loss vs. frequency for the proposed antenna



(A) X-Z Plane



(B) Y-Z Plane



(C) X-Y Plane

Fig. 3. Radiation Patterns Of The Proposed Compact Proposed Antenna At The 2.44Ghz: (A) X－Z Plane, (B) Y－Z Plane, And (C) X－Y Plane

Gain variations with the proposed antenna with the operating frequency was also simulated (Ansoft HFSS) and measured. The results are shown in Figure 4. In the gain results, the red and blue lines represent the gain of measured data and simulated

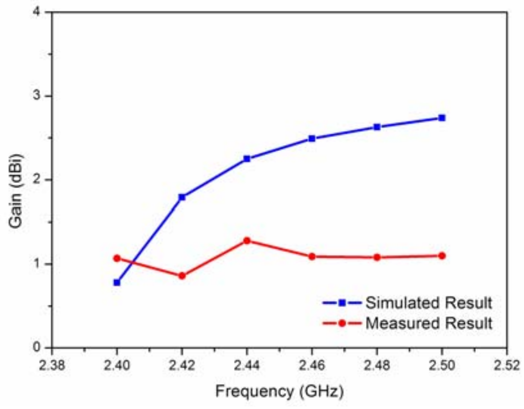


Fig. 4. Simulated and measured proposed compact antenna gain for Bluetooth frequencies.

data at the operating band, respectively. The measured gain is between 0.86dBi and 1.28dBi for the frequency range of 2.4–2.5GHz, and is slightly lower than the simulated one. The antenna gain had a peak value of 1.28 dBi at 2.44 GHz. At 2.44 GHz, the maximum gain on the x–z plane was 1.28 dBi, and on the y–z plane, 0.5 dBi.

4. Conclusion

A compact antenna for Bluetooth applications has been proposed and successfully tested. Using the meander-type line with a two-layer structure and shorted-strip line, the proposed antenna is designed. Optimization of the various parameters of the proposed antenna can be performed using commercial EM software. The proposed compact antenna is then small enough to be embedded on the module devices. Experimental results show that by choosing suitable combinations of these parameters, good impedance bandwidth and stable radiation patterns and gains can be obtained. This proposed antenna has an impedance bandwidth (S_{11}=-7.5dB) of 220 MHz (2.34–2.56 GHz). Within this impedance bandwidth, broadside radiation patterns are observed and exhibited. Also, the measured peak gains, with gain variations of less than 0.42dBi, are obtained at 0.86–1.28dBi. The proposed antenna is a good candidate for Bluetooth applications.

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