논문 08-33-10-05 한국통신학회논문지 '08-10 Vol. 33 No. 10

블루투스 용 미앤더 형 적층구조를 가진 패치 안테나의 구현

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Design of a Compact Antenna with Meander-Type Stack Structure for Bluetooth Application

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요 약

This paper was proposed and experimentally studied about compact meander-type antenna with stack geometry. The prototype consists of a lower meander-type patch at the bottom layer, an upper meander-type patch at the top layer, and a via that connects the two layers. It is investigated that the effect of lengths and widths of the meander-line at the top and bottom patch antennas for Bluetooth application. From the results of the experiment, the measured impedance bandwidth, defined by VSWR 1:3, can reach an operating bandwidth of 105MHz (2.395-2.499GHz). Also, the antenna radiation patterns and gains within the operating band were measured and studied

Key Words : Antenna, Meander-Type Antenna, Two-Layer Structure, Bluetooth Operat

ABSTRACT

본 논문은 적층 구조를 가진 미엔더 형 안테나를 제안하고 실험하였다. 제안된 안테나의 아래층은 저주파수용이고 위층은 고주파수용으로 구성되었으며, 구멍을 뚫어서 연결하였다. 아래층과 위층 패치의 미엔더 폭과 길이가 블루투스 용으로 적용할 수 있도록 구해졌다. 실험 결과로부터 정재파비가1:3인 조건에서 임피던스 대역폭 105㎒ (2.395-2.499㎓)이 구현되었다. 또한 동작 대역폭 내에서의 원하는 방사 패턴과 이득이 구현되었다.

Ⅰ. Introduction

Bluetooth have been the subject of much hype and media attention over the last couple of years. Itis a low cost, low power, short-range radio technology, originally developed as a cable replacement to connect devices such as mobile phones, headsets, PDAs, portable computers, digital cameras, and printers. This may sound relatively innocuous but by enabling standardized wireless communications between any electrical devices, Bluetooth has created the notionof a Personal Area Network, a kind of close range wireless network that is aboutto revolutionize the way people interact with the technological environment. Undoubtedly, Bluetooth-based communication capability will play an important role in current and future consumer electronics.

As commonly known, a conventional micro-strip antenna attracts low profile bandwidth but repulses large lateral-size and narrow impedance bandwidth.

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논문번호 : 08058-0905, 접수일자 : 2008년 9월 5일

In the literature, several techniques are utilized to reduce the resonant length of these patch antenna: increasing the dielectric constant of the substrate material [1]-[3], inserting the slot [4], the addition of a shorting wall between the conducting patch and the ground plane [5], the addition of a shorting in between the conducting patch and the ground plane [6],using the a resistive loading [7], and inverted double-L type [8]. As the increasing the dielectric constant of the substrate will decrease the resonant length of the patch. However, this technique decreases the already narrow impedance bandwidth of the patch antenna. Size reduction has been shown that by placing a shorting wall along the null in the electric field acrossthe center of the patch, the resonant length can be reduced by a factor two, reducing the area occupied by the patch by a factor of four. Other techniqueto reduce the resonant length is adding a shorting pin in close proximity to the probe feed. The shorting pin is capacitively coupled to the resonant circuit of the patch. And it has been shown that a suitable placed shorting pin can reduce the resonant length. Others methodof size reduction is using the resistive loading and two shorting pin, respectively.

Using these methods, many studies have been made to reduce antenna size for Bluetooth application [9]-[15], thus the following antennas have been developed: the Inverted-F type [9], the Meander line type [10], Small chip-type [11], EBG-assisted slot type [12], the Hilbert-type [13], two-layer patch type [14], and watch type [15]. The current design trend is to implement Bluetooth technology in small integrated circuits. The available Bluetooth antenna designsstill require a relatively large space. Antennas used for Bluetooth applications therefore need to be small in order to be integrated with the system.

In this paper, we propose compact antenna with meander-type stack structure for Bluetooth application. The patch antennas are positioned at the top and bottoms layer of the module substrate. By connecting the two patches using the via, the size of the proposed antenna is reduced. By properly selecting line length and width parameters of the top and bottom layers, respectively, it can be expected that the coupling between top layer and bottom layer can be controlled more effectively, thus, operation of the proposed stack geometry compact antenna for Bluetooth application becomes possible. The results of the experiment that wereconducted 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 for meander-type compact Bluetooth antenna with stack structure is shown in Fig. 1. The system ground plane in the study is printed on a 1.2-mm thick, $5080mm^2$ FR4 substrate, which is a reasonable size for practical mobile phones. The proposed antenna and module substrate are mounted at the lower left corner of the system ground plane in order to operate Bluetooth. The proposed antenna is located on a 0.4-mm thick, $99mm^2$ FR4 substrate. Also, the proposed compact antenna is based on a meander line at the top and bottom layers in the module substrate. The antenna consists of a lower patch at the bottom layer, an upper patch at the top layer, and a via that connects the two layers. The main radiator of the proposed compact antenna shown in Figure 1(a) occupies a small volume 1.2mm6.4mm0.4mm and is fabricated on an FR4 substrate that has a relative dielectric constant 4.4. The proposed antenna is then small enough to be embedded on the module devices.

Figures 1(b) and 1(c) show our proposed antenna structure and pattern on each layer. In this design, the patch antenna at the top and bottom layers is composed of a meander line type. The feed point is located atthe top layer of the module substrate to connect with the module output terminal. Two layers are connected by a via hole trough the FR4 substrate. The via hole is located at the bottom left top of the module substrate. A full-wave commercial EM software capable of simulating finite substrate and finite ground structure, HFSS [16], was used to optimize the geometrical parameters

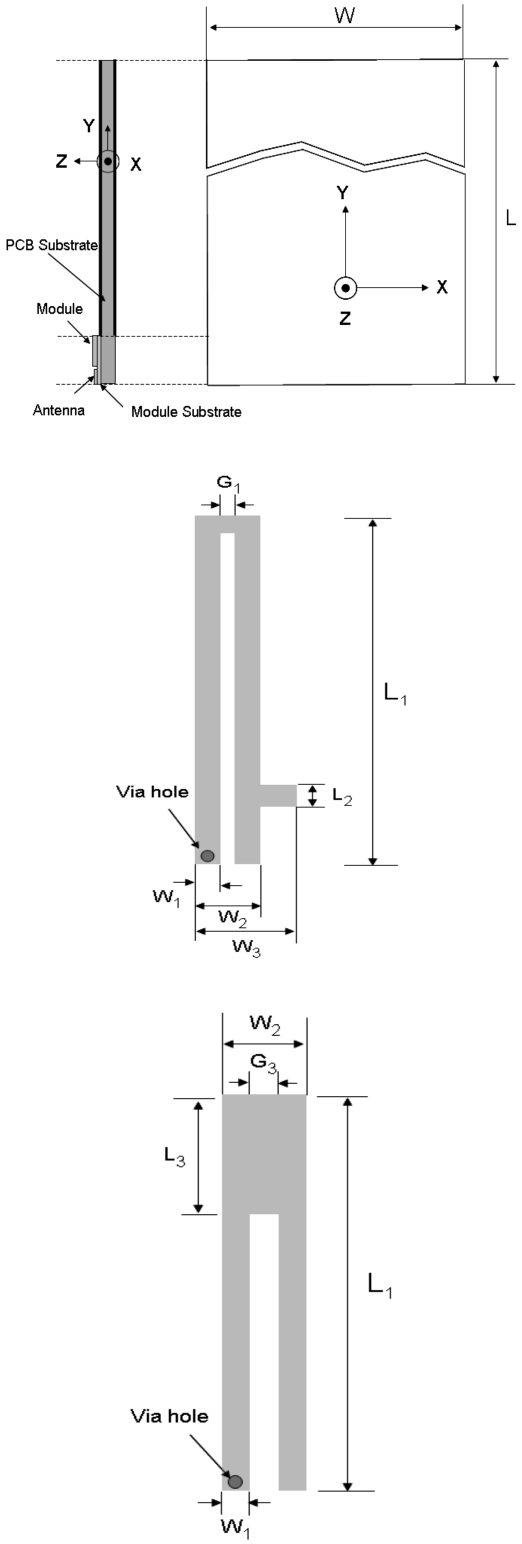


Fig. 1. Configuration of the proposed compact antenna with stack structure

(lines, lengths, gaps) of the proposed Bluetooth antenna. Therefore, the dimensions of the proposed antenna are as follows: L = 80 mm; L1 = 6.4 mm; L2 = 4.9 mm; L3 = 0.4 mm; L4 = 1.8 mm W = 50 mm W1 = 0.4 mm; W2 = 1.0 mm; W3 = 1.45 mm; W4 = 1.2 mm G1 = 0.2 mm and G2 = 0.4 mm.

Ⅲ. Measurement

Figure 2 shows the simulated and measured return loss for the proposed antenna. Based on the simulation results, the proposed compact Bluetooth antenna with module is fabricated and measured using an Agilent Technologies E8362B Vector Network Analyzer, with far-field patterns and gain within a compact range, taken from the Samsung Electro-Mechanics. The results show satisfactory agreement between the measurement and simulation obtained from Ansoft HFSS. The cured trend is behaved well over the whole operating bands. Based on the 7.5 dB return loss bandwidth, which is acceptable for Bluetooth applications, the impedance bandwidth was about of 105 MHz (2.3952.449GHz), covering the whole Bluetooth band (2.4 -2.483 GHz)

Figure 3 plots the measured radiation pattern at 2.44 GHz. From the results, comparable EΘ and Eϕ components are seen, especially in the y-z plane (the elevation plane) and z-x plane (the azimuth plane). This characteristic is a merit for practical applications in a complex wave propagation environment. Similar radiation patterns for other frequencies (2.4GHz,

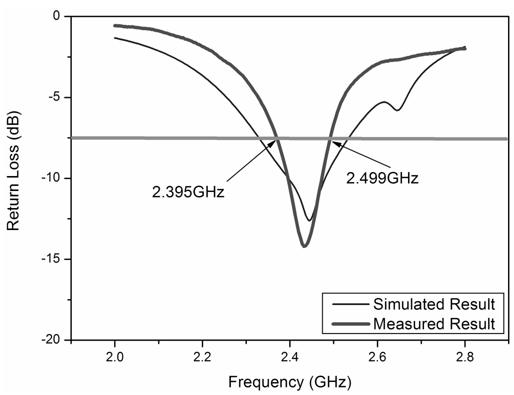
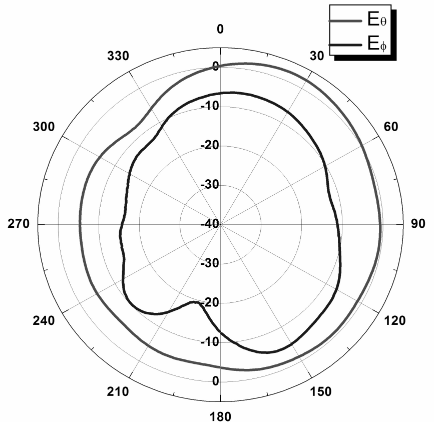
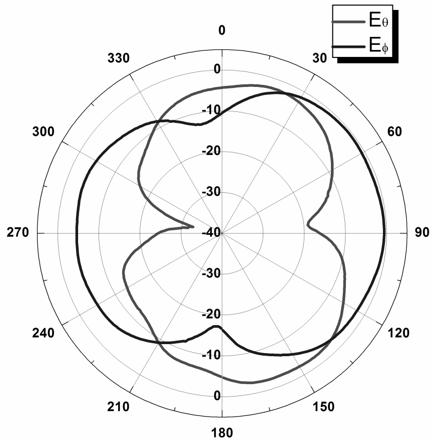


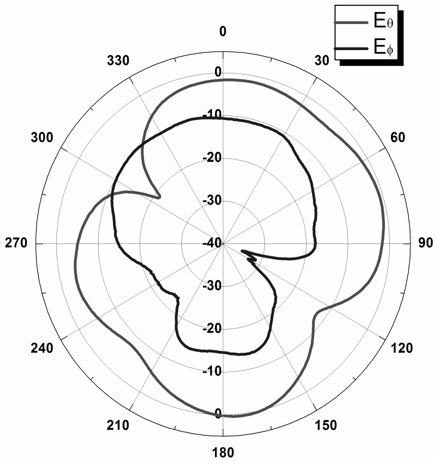
Fig. 2. Simulated and measured return loss vs. frequency for the proposed compact antenna



(a) x-z plane



(b) y-z plane



(c) x-y plane

Fig. 3. Radiation patterns of the proposed compact antenna for the Bluetooth band: (a) x-z plane, (b) y-z plane, and (c) x-y plane

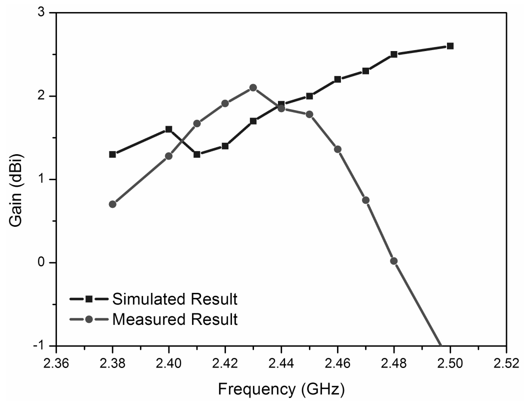


Fig. 4. Simulated and measured proposed compact antenna gain for Bluetooth frequencies

2.48GHz) over the operating band were also observed. In this radiation pattern, the red and blue lines represent the radiation pattern of EΘ and Eϕ at 2.44 GHz, respectively.

Fig. 4 shows the simulated (Ansoft HFSS) and measured the proposed antenna gain for operating frequencies. Measured gain varies in a small range of about 0.02 to 2.10 dBi for frequencies across the operating bandwidth. The antenna gain had a peak value of 2.10 dBi at 2.43 GHz. At 2.44 GHz, the maximum gain on the x-z plane was 1.85 dBi, and on the y-z plane, 1.47 dBi.

Ⅳ. Conclusion

A compact antenna with meander-type of stack geometry has been proposed for Bluetooth application, and a prototype is successfully implemented. In order to achieve the best performance, optimization of the various parameters of the proposed antenna can be performed using a full-wave commercial EM software capable of simulating finite substrate and finite ground structure, HFSS. From the simulation results, the size of the proposed compact antenna on module substrate is only 2.3mm6.4mm0.4mm. The proposed antenna is then small enough to be embedded on module devices. Experimental resultsshow that by choosing suitable combinations of these parameters, good impedance bandwidth and stable radiation patterns can be obtained. This proposed antenna has an impedance bandwidth (Return Loss

= -7.5dB) of 105 MHz (2.3952.499GHz). Within this impedance bandwidth, broadside radiation patterns are observed and exhibited. Also, the measured peak gains, with gain variation less than 2.08 dBi, are obtained of 0.02-2.10 dBi. The proposed antenna is a good candidate for Bluetooth applications.

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