A Novel Dual-band Patch Antenna for Zigbee System

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Abstract

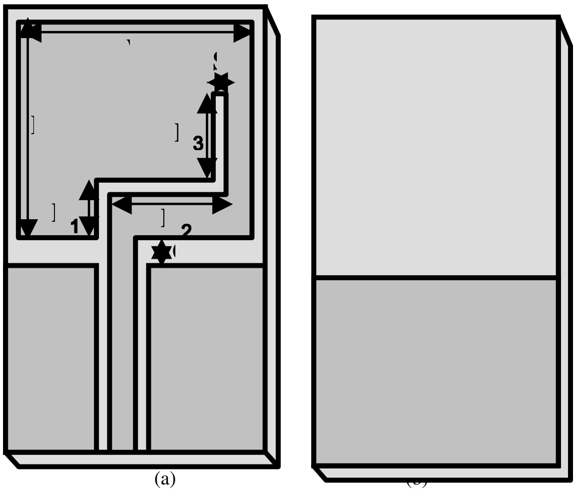
In this paper, a novel dual-band patch antenna having a chair-shaped slot is designed, fabricated, and measured for Zigbee system. The proposed antenna is designed to operate from 868 to 928 MHz(lower-frequency band) and 2.45 GHz (upper-frequency band). The lower-frequency band(868~928 MHz) can be controlled by adjusting the length of a chair-shaped slot and the upper-frequency band(2.45 GHz) can be controlled by the size of the radiation patch. It is designed to work on a substrate FR-4 of thickness 0.762 mm and relative permittivity 4.4. Details of the proposed antenna design and the measured results are presented and discussed.

1. INTRODUCTION

A Zigbee system is standard technology for home automation and data network that have low transmission speed. It can control electric lamp, home security system, and VCR ON/OFF in home anywhere by operation of button one. The system has low electric power and low cost and data rate is 250 kbps within a radius 30m [1-2]. Recently, several dual band antennas for Zigbee system were developed [3-4]. The dual-band antennas are small and have a good dual band characteristics but antenna structure is very complicated.

In this paper, we have proposed a compact dual-band simple structure antenna for Zigbee system. The antenna is patch antenna having a chair-shaped slot. The antenna used CPWG(coplanar waveguide with ground) structure which is less sensitive in impedance change and easy to be integrated with other RF circuits [5]. The lower-frequency band is 868~928 MHz and the upper-frequency band is 2.45 GHz. The lower-frequency band(868~928 MHz) can be controlled by adjusting the length of a chair-shaped slot and the upper-frequency band(2.45 GHz) can be controlled by the size of the radiation patch.

2. ANTENNA DESIGN AND MEASURED/SIMULATED RESULTS



(a) (b)

Fig. 1: Geometry of the proposed dual-band antenna
(a) Top view, (b) Bottom view

Figure 1 shows the geometry of the proposed dual-band antenna for Zigbee system. As shown, the antenna is fed by a CPWG line. It is printed on the FR-4 substrate with 0.762 mm and relative permittivity 4.4, respectively. The size of the substrate is 30 * 30 mm^2. The proposed antenna consists of a rectangular patch (23 * 26 mm^2), a chair-shaped slot (L_1: 7 mm, L_2: 18 mm, L_3: 15 mm, S: 2 mm), and a CPWG feed line. The design procedure of the proposed dual-band antenna is as follows. Firstly, we have designed the antenna operating in the higher-frequency band(2.4 GHz) by using the rectangular patch(L*W) and secondly, lower-frequency band (868~928 MHz) by inserting a chair-shaped slot on the radiation patch.

The commercial software Ansoft HFSS [6] has been used for the simulation of the dual-band antenna. The proposed antenna was constructed and studied. The antenna was measured using an Anritsu Vector Network Analyzer (37397C) in an anechoic chamber. Figure 2 shows the measured and simulated return loss of the proposed antenna. The measured results agree well with the simulated results. For comparison, we have used two commercial software Ansoft HFSS and Microwave Studio of CST. The impedance

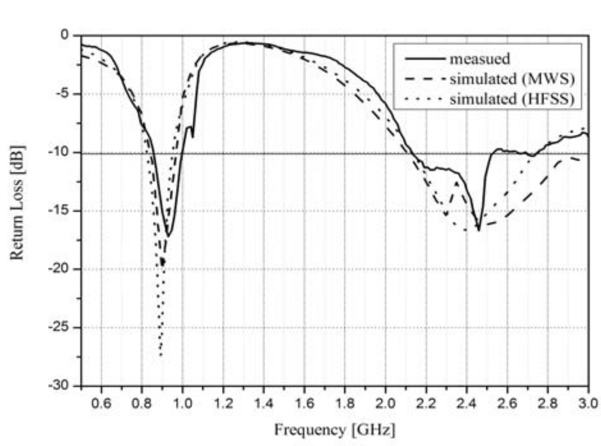


Fig. 2: Measured and simulated return losses for the proposed antenna

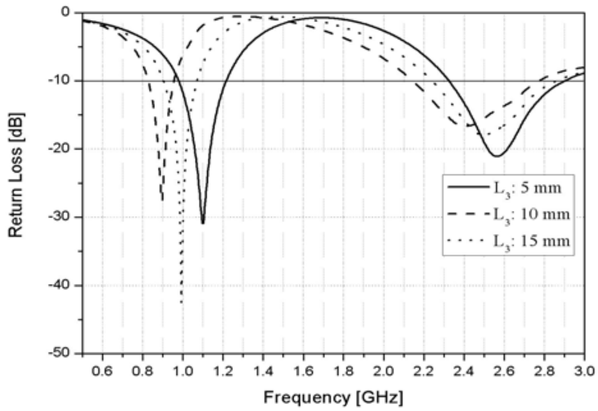


Fig. 3: The effects of the chair-shaped slot length (L_3) on the return loss

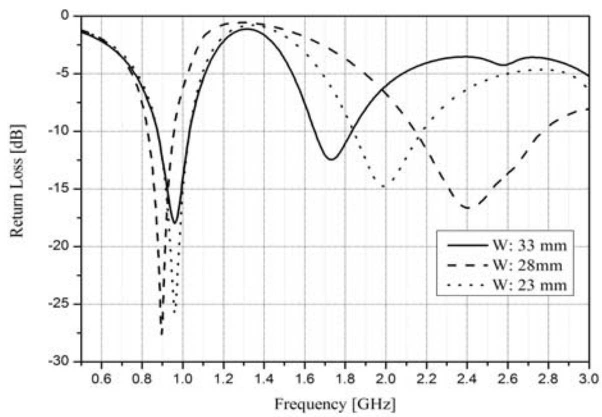
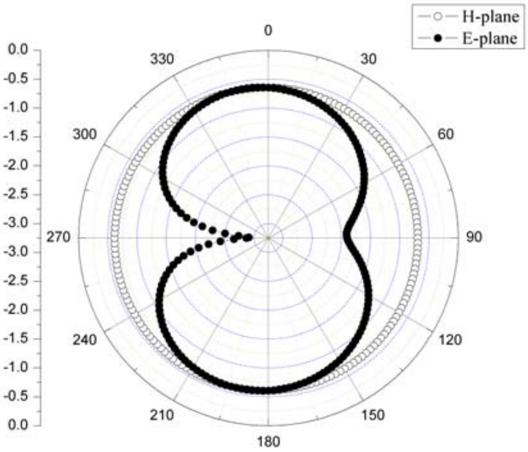
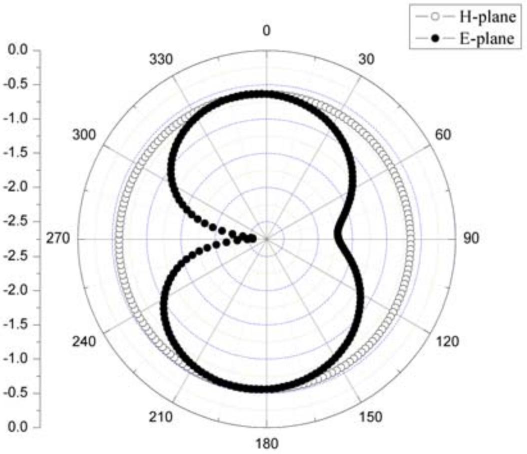


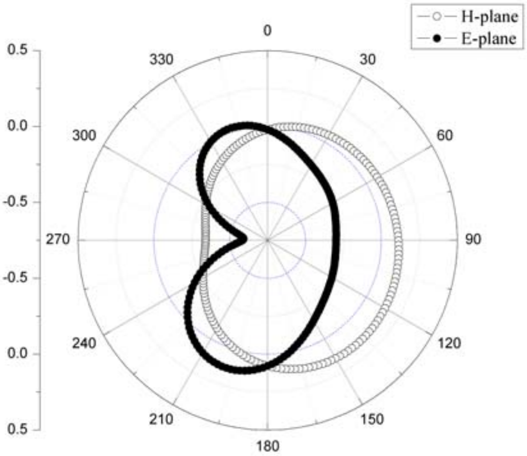
Fig. 4: The effects of the size of the radiation patch (W) on the return loss



(a)



(b)



(c)

Fig. 5: Simulated radiation patterns at
(a) 868 MHz (b) 915 MHz (c) 2.45 GHz

bandwidth of the antenna for S_{11} < -10dB was found to be 15.6 % and 17.2 % at each frequency bands. As can be seen from the figure, the proposed antenna can cover the Europe (868 MHz), the United States of America (902 ~ 928 MHz), and world wide (2.45 GHz) frequency band.

The effects of the chair-shaped slot length (L_3) on the return loss are shown in Figure 3. From the figure, the length(L_3) of a chair-shaped slot has effect on the lower-frequency band but negligible effect on the upper-frequency band, which is a good feature because the dimensions of determining the lower-frequency band do not affect on the upper- frequency band. As the length of a chair-shaped slot (L_3) increases, the lower resonant frequency decreases. The effects of the radiation patch size on the return loss are shown in Figure 4. The change of radiation patch size (W) has negligible effect on the lower- frequency band. It changes only upper-frequency band characteristics.

TABLE 1. SIMULATED ANTENNA GAIN ACROSS THE PROPOSED ANTENNA

	Frequency [MHz]		
	868	915	2450
Gain [dBi]	-0.64	-0.63	0

Figure 5 is the simulated radiation patterns at 868 MHz, 915 MHz, and 2.45 GHz. The simulated antenna gain across the operating frequency band is shown in Table 1. A peak antenna gain is about 0dBi at about 2.45 GHz, and the gain variations are less than about 1dBi for the operating frequency bands. Figure 6 shows the photograph of the PCB integrated antenna including other RF circuits.

Fig. 6: The photograph of the proposed antenna

3. CONCLUSION

In this paper, a novel dual-band patch antenna with a chair-shaped slot is proposed for the Zigbee system. The proposed antenna is compact, and easy to manufacture, and simple in structure. The impedance bandwidth of the antenna was found to be 15.6 % and 17.2 % for the lower- and upper-frequency band. The effects of the chair-shaped slot and radiation patch size on the operating frequency were investigated. We presented the simulated radiation patterns and antenna gain at 868 MHz and 915 MHz and 2.45 GHz. From the above results, the proposed dual-band antenna can be used for the PCB integrated Zigbee system.

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