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A Dual Polarization Bow-Tie Slot Antenna For Broadband Communications

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ABSTRACT
A dual polarization bow-tie slot antenna for broadband communications is proposed in this paper. This antenna consists of two bow-tie slot antennas which is perpendicular to each other and with coplanar waveguide (CPW)-fed. The proposed antenna has a very simple antenna structure and wide impedance bandwidth (~ 400% for ∣S11 ∣and ∣S22 ∣≧ 10dB) which can cover the 1.5 ~ 6 GHz frequency band for Global Positioning System (GPS, 1575MHz) and dual ISM band (2.4GHz and 5.8GHz) applications. Good isolation between the two input ports (∣S21 ∣≧ 20dB) is also achieved at the operating band. The radiation pattern and efficiency of the proposed antenna are also measured, and radiation pattern data are compared with simulation results.
KEYWORDS *- Broadband, dual polarization, isolation, slot antenna.*

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I. INTRODUCTION

With rapid progress in wireless communication systems, the demand to enhance the information accessibility and wideband utility has become major importance in wireless technology. An efficient way to increase the capability is the employment of polarization diversity, and thus the dual-polarized antennas have gained more and more popularities. In [1], a tri-polarization antenna was proposed, but isolation between some ports were not sufficient and were hence unacceptable in high-performance applications. Several papers have been published [2]–[3] to improve isolation in similar antenna applications. However, the antennas of the bandwidth are still not wide enough for modern wireless communication systems. To have wider bandwidth and simple planar antenna configuration, bow-tie dipole and slot antennas are good candidates [4]–[5]. To enhance the bandwidth of CPW-fed bow-tie slot antennas, some techniques have been proposed, including the use of a tapered metal stub to achieve impedance matching, the use of inductive coupling, and the adjustment of slot flare angle to enhance bandwidth.

To meet the specification of wide bandwidth, simplicity, and high isolation, a dual-polarization CPW-fed bow-tie slot antenna is proposed in this paper. The proposed design is brought by the embedded slot with a pair of stubs and combined two antennas at the scattered CPW feeding on left and right both sides, the horizontal and vertical polarization of slot antenna are excited by the 0^o and 90^o directional rotation of different CPW feed line. Measured performance of the developed antenna includes -10dB reflection coefficient, with the bandwidths of 4.7 GHz (461%) and 4.74 GHz (476%) for the dual polarization. The isolation between two ports in the WLAN band is better than -23.1dB (2.4GHz) and -37.1dB (5.8GHz).

II. ANTENNA STRUCTURE AND DESIGN

Fig. 1 shows the configuration of the proposed antenna. The overall dimensions of the antenna are 190 x 100 mm2. The antenna is made of FR4 ($\varepsilon r = 4.4$, $\tan\delta = 0.02$), its thickness is 1.6mm. A 44 x 38 mm2 the embedded triangle slot with a pair of stubs, it combined two antennas and scattered feeding on left and right both sides. The CPW-fed line is designed to be 50Ω (L3 = 3.2mm), gap spacing (S1 = 0.2mm) and taper to the CPW of signal strip length should be 0.175λ (W2 = 35mm) that parameter is determined by the required band of the lowest frequency. Etched in the left side, the antenna serves as the vertical polarization radiation. The CPW is fed in port 1. In the right side, antenna rotates 90^o to cover the horizontal polarization radiation. The CPW is fed in port 2.

Antenna dimensions of L (= 0.5λ) and W (= 0.4λ) are determined by the lowest frequency of desired band, $\theta = 40^o$ and S3 = 0.5mm are proposed for impedance matching. To ensure isolation between two antennas distance, D (= 10mm) should be 0.05λ at the desired band of the lowest frequency. The final values of each parameter are listed in Table I.

It is well known that a pair of stubs embedded triangle slot can support wonderful reflection coefficient and utilize the CPW-fed to achieve a much wider impedance bandwidth. Owing to the slot antenna has a directional radiation, it is also suitable to be designed into a dual-polarized antenna for horizontal and vertical polarization, as shown in Fig. 2 and Fig. 3, respectively. To excite the two polarizations simultaneously, two antennas feeding by the perpendicular to each other must be used. As shown in Fig. 2 that feeding from port 1 (50Ω terminal load in port 2), a vertical polarization is excited in the left CPW structure. On the contrary, when feeding from port 2 (terminate 50Ω load in port 1), a horizontal polarization is excited in the right CPW structure, as shown in Fig. 3. The antenna is an attractive candidate for multiple band antenna applications that require polarization diversity and also for some of the MIMO systems applications.

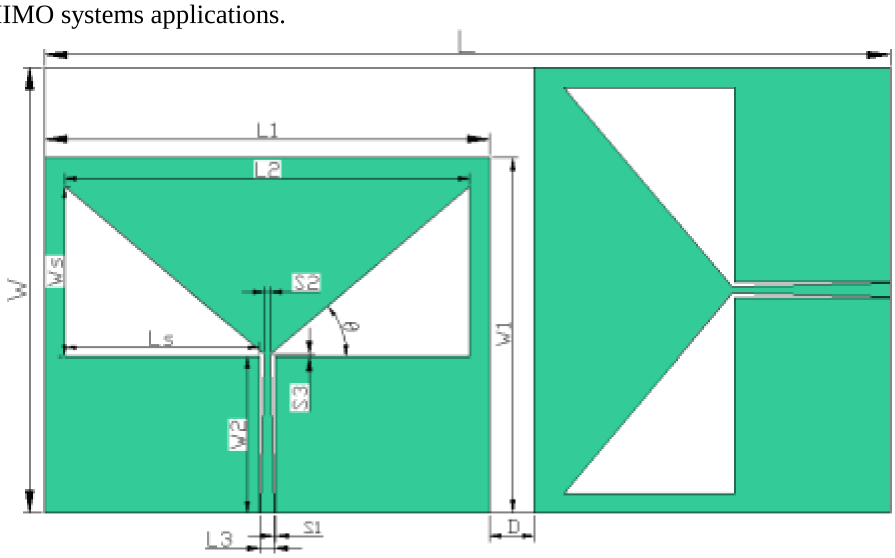


Fig. 1. Geometry and dimensions of the proposed antenna

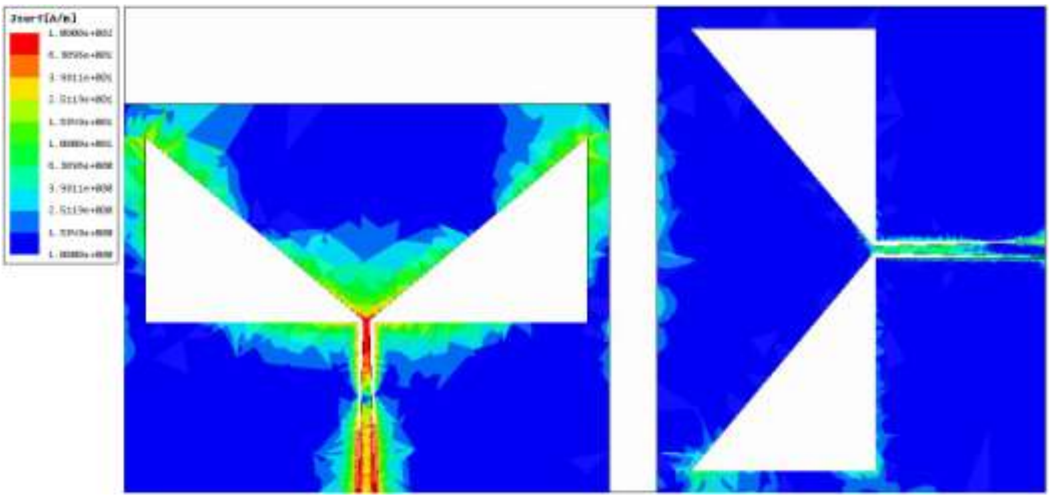


Fig. 2. Electric field magnitude in slot and CPW: feeding in port-1 (2.4GHz)

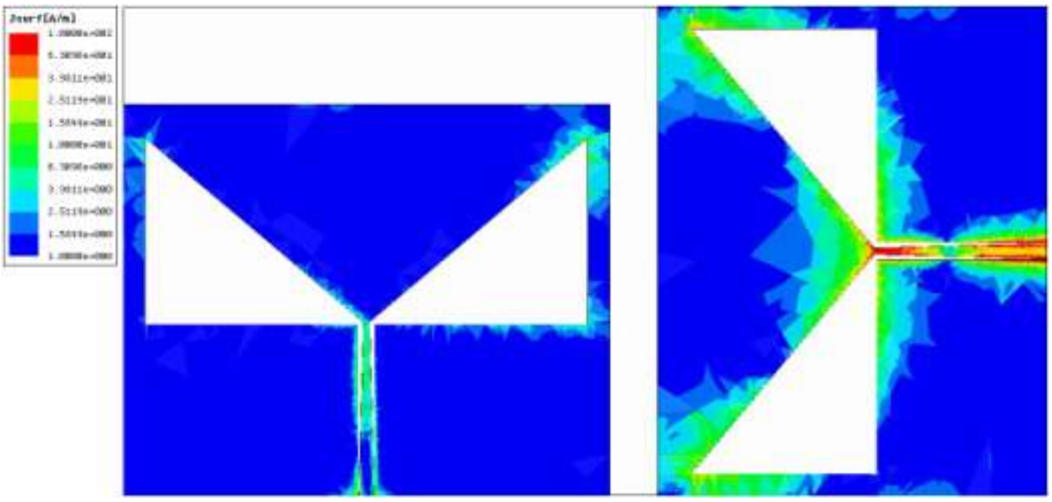


Fig. 3. Electric field magnitude in slot and CPW: feeding in port-2 (2.4GHz)

III. MEASUREMENT RESULTS

To validate the design, the S-parameters of the proposed antenna are simulated by using Ansoft High Frequency Structure Simulator (HFSS). The antenna has also been fabricated and measured. The left and right views of the antenna prototype are shown in Fig. 4.

Fig. 5 shows the measured S-parameter of the proposed antenna (solid lines) compared to the simulated ones (dash lines). As shown in the figure 5, the frequencies of the dual polarization are from 1.5 ~ 6 GHz. The bandwidths of -10 dB reflection coefficient are 4.7GHz (1.3 - 6 GHz, 461%) and 4.74 GHz (1.26 - 6 GHz, 476%) for port 1 (vertical polarization) and port 2 (horizontal polarization), respectively. Throughout the WLAN frequency band (2.4 - 2.484 GHz) and (5.15 - 5.825 GHz), the worst cases of reflection coefficient value for ports 1 and 2 are -13.4dB and -18.1dB. The isolation between two ports in the required band is lower than -20dB.

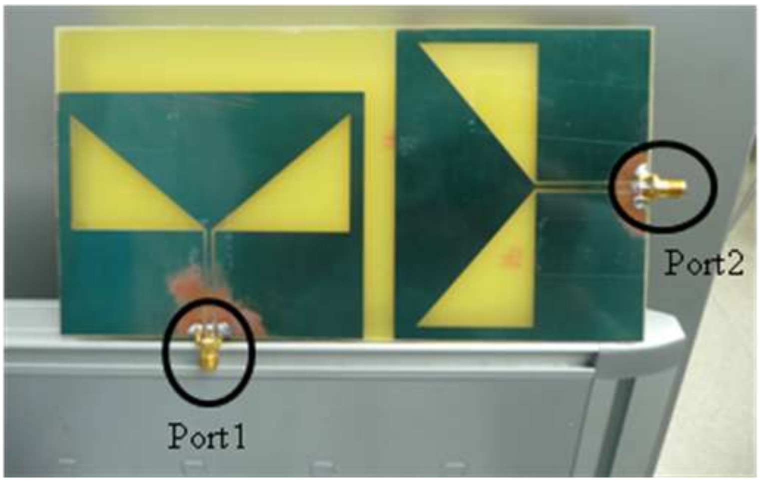


Fig. 4. Photograph of the proposed antenna

TABLE I DETAILED DIMENSIONS OF THE PROPOSED ANTENNA

Parameter	**L**	**L1**	**L2**	**L3**	**Ls**	**S1**	**S2**
Value(mm)	190	100	91.2	3.2	43.8	0.2	1.2
Parameter	**S3**	**W**	**W1**	**W2**	**Ws**	**D**	θ
Value(mm)	0.5	100	80	35	38.3	10	40^o

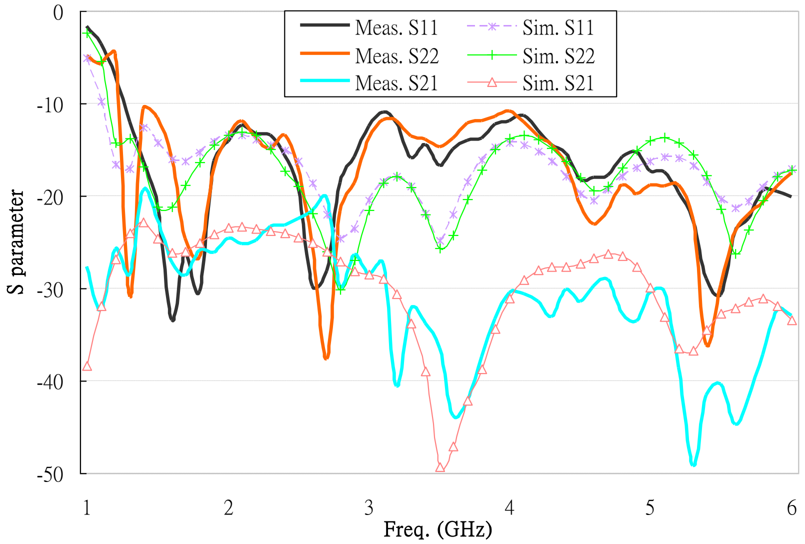


Fig. 5. Measured and simulated S-parameter of proposed antenna

When feeding from port 1 and 2, the radiation patterns of the propose antenna are shown in Figs. 6 ~ 11. For port 1, the vertical polarization is the dominant polarization. The 3-dB beamwidths are 80^o and 60^o in E-plane (yz plane) and H-plane (xy plane) at the 1575 MHz, the same as 60^o in E- and H- at the 2400 MHz , 40^o and 20^o in E- and H- at the 5800 MHz, the cross polarization levels are lower than 5.51 and 0.43 dB in E-plane and H-plane at the 2400MHz, respectively. For port 2, the horizontal polarization case, the 3-dB beamwidths are 100^o and 120^o in E-plane (yz plane) and H-plane (xy plane) at the 1575MHz, 90^o and 60^o in E- and H- at the 2400 MHz, 50^o and 40^o in E- and H- at the 5800 MHz, the cross polarization levels are lower than 0.17 and 9.08 dB in E-plane and H-plane at the 2400 MHz, respectively. From the radiation patterns, we can observe that the port 1 and port 2 of the yz plane and xy plane are almost corresponding to the maximum of each other at the three measured frequencies. According to the results, it can be proved that the two bow-tie slot antennas are placed 90 degrees of difference can achieve good isolation and dual polarization.

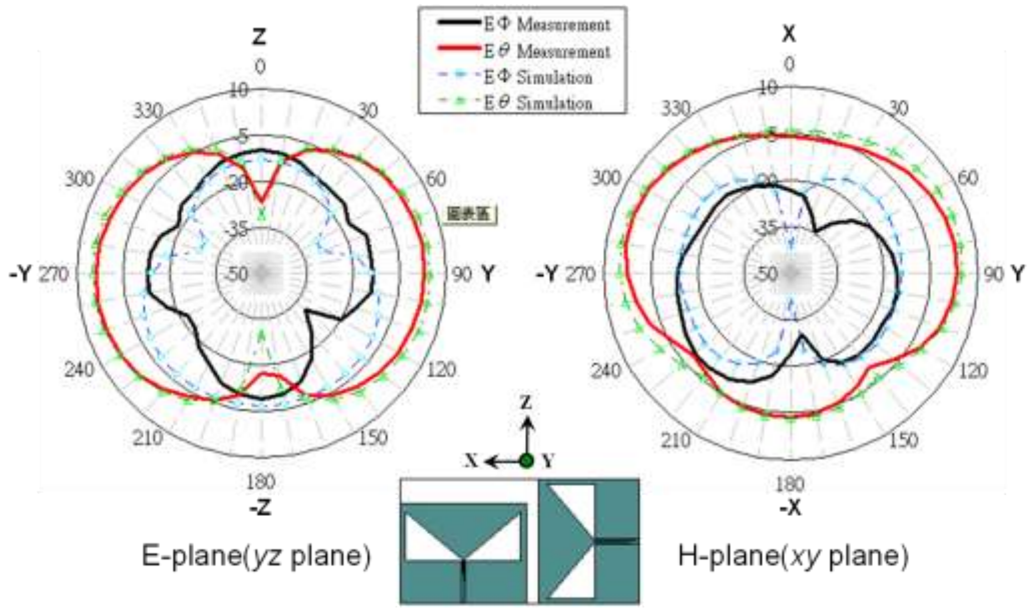
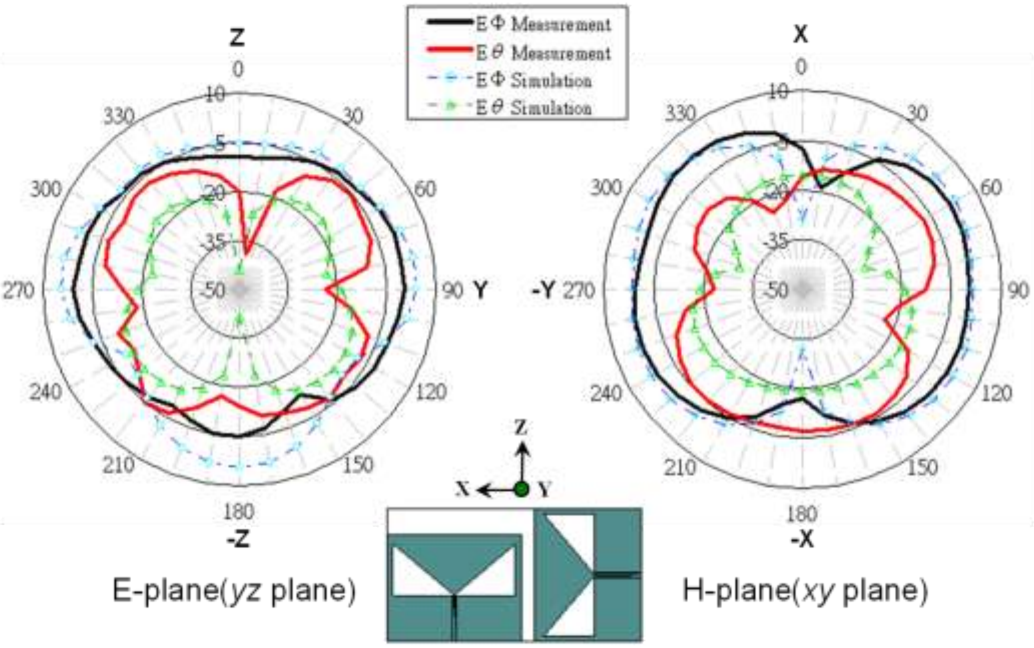
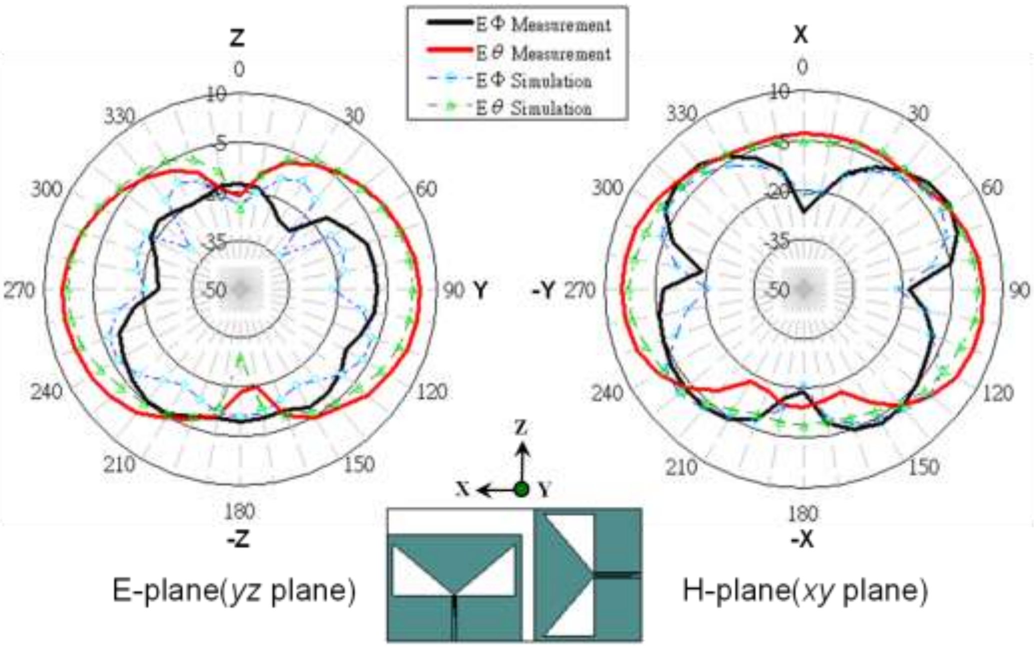


Fig. 6. Measured and simulated radiation patterns when feeding from port1 at 1.57GHz: (a) yz plane (b) xy plan



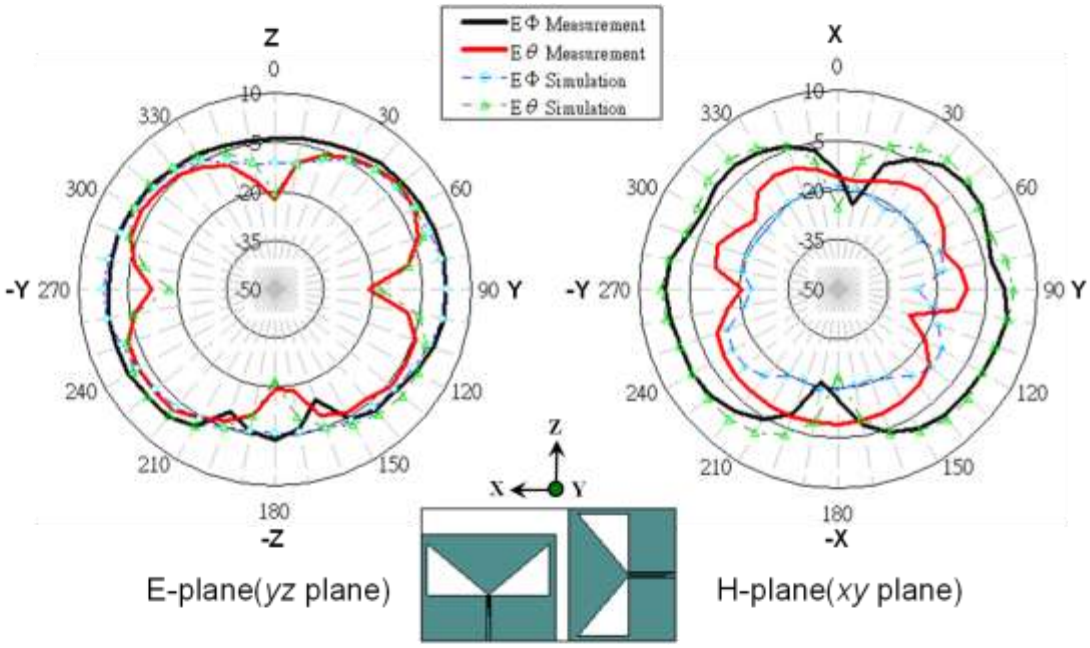
(c) (d)

Fig. 7. Measured and simulated radiation patterns when feeding from port2 at 1.57GHz: (a) yz plane (b) xy plan



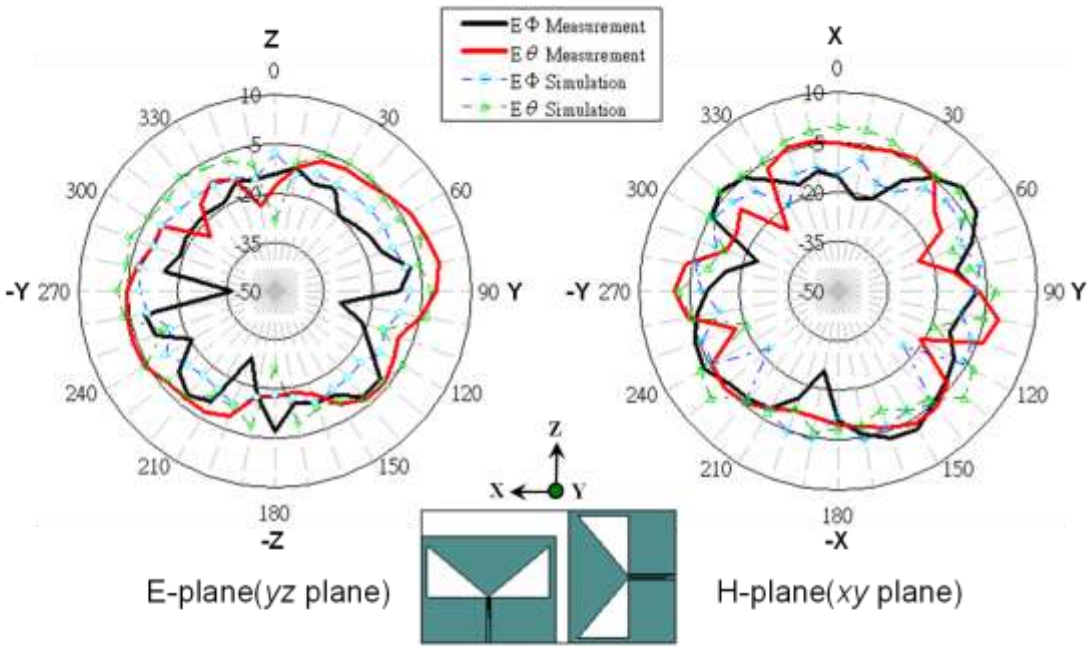
(a) (b)

Fig. 8. Measured and simulated radiation patterns when feeding from port1 at 2.4GHz: (a) yz plane (b) xy plan



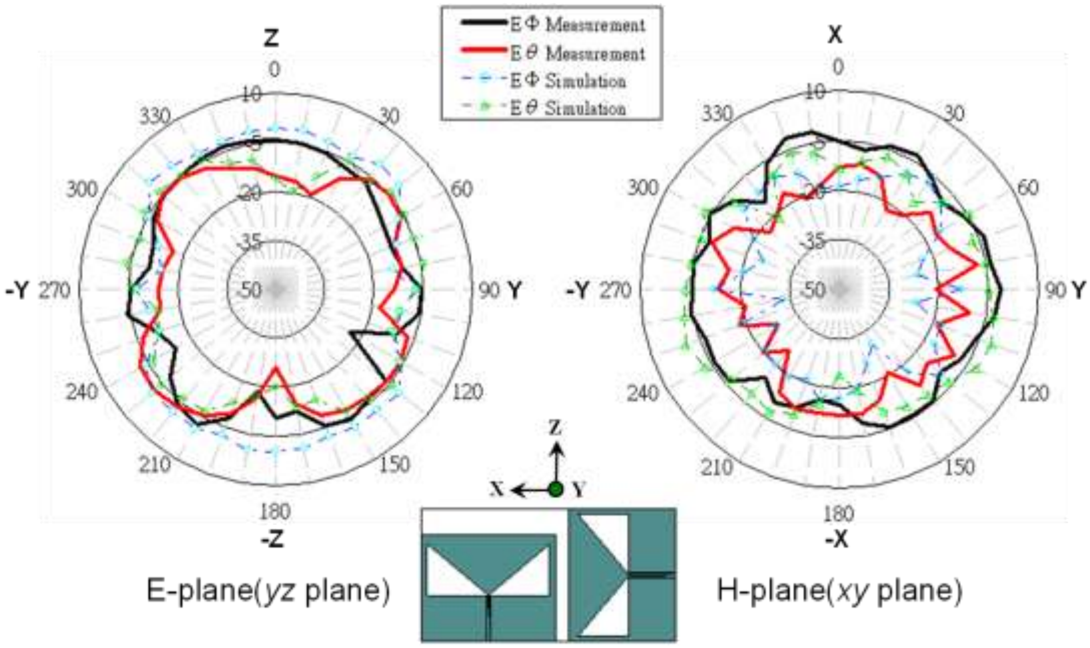
(c) (d)

Fig. 9. Measured and simulated radiation patterns when feeding from port2 at 2.4GHz: (a) yz plane (b) xy plan



(a) (b)

Fig. 10. Measured and simulated radiation patterns when feeding from port1 at 5.8GHz: (a) yz plane (b) xy plan



(c) **(d)**

Fig. 11. Measured and simulated radiation patterns when feeding from port2 at 5.8GHz: (a) yz plane (b) xy plan

The radiation efficiency and gain of the proposed antenna are also measured. The results are shown in Figs. 12 and 13, respectively. In the WLAN band of 2.4 and 5.8 GHz, the efficiency are 78.6% and 58.3% for port 1 and 80.7% and 55.2% for port 2; the peak gain are 5.84 and 4.96 dBi for port 1 and 4.74 and 3.61 dBi for port 2.

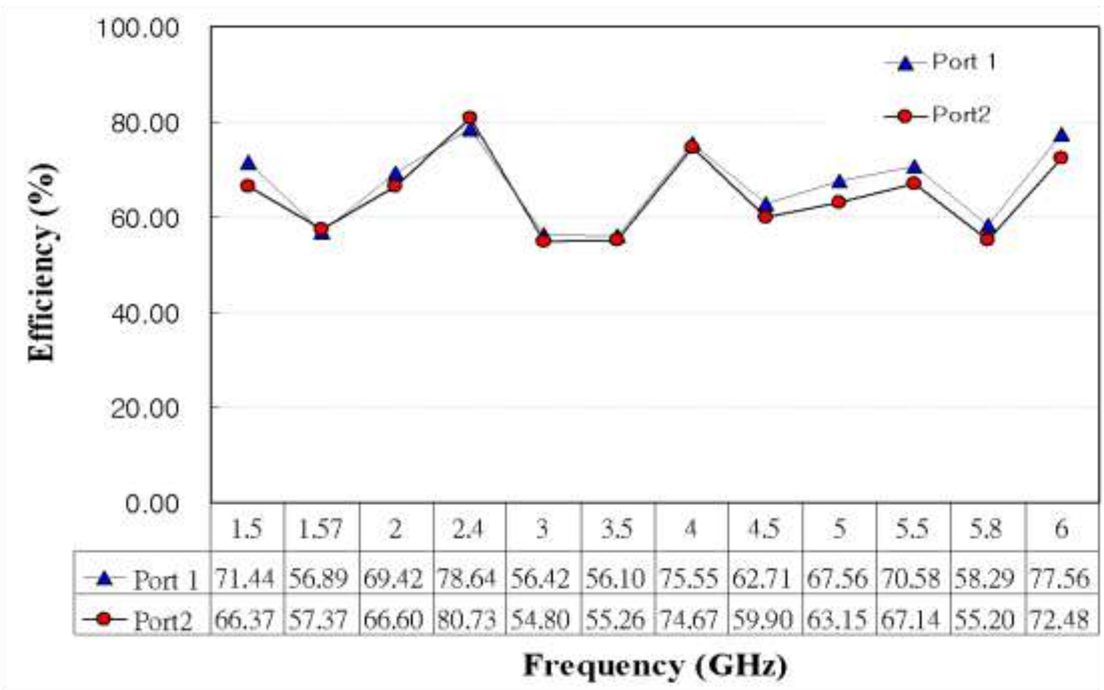
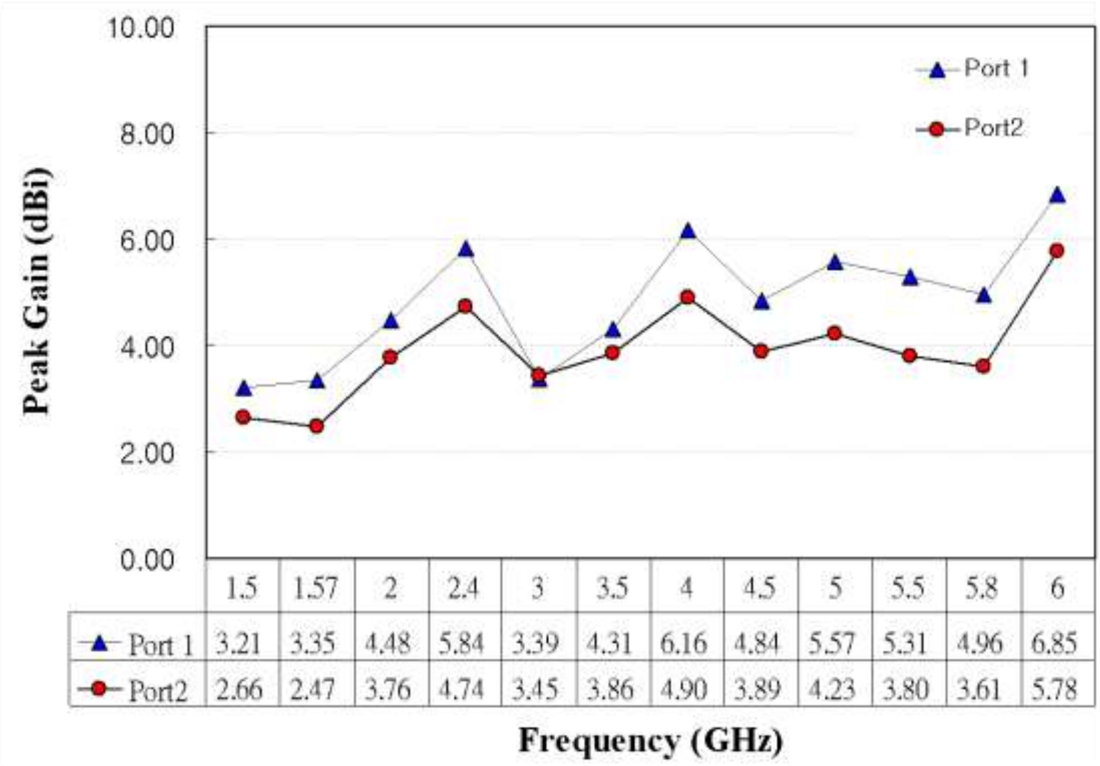


Fig. 12. Measured Radiation Efficiency of the proposed antenna



	1.5	1.57	2	2.4	3	3.5	4	4.5	5	5.5	5.8	6
Port 1	3.21	3.35	4.48	5.84	3.39	4.31	6.16	4.84	5.57	5.31	4.96	6.85
Port2	2.66	2.47	3.76	4.74	3.45	3.86	4.90	3.89	4.23	3.80	3.61	5.78

Fig. 13. Measured Peak Gain of the proposed antenna

IV. CONCLUSION

A Dual Polarization coplanar waveguide (CPW)-fed bow-tie slot antenna for broadband communications has been proposed and tested. The antenna structure is brought by the embedded slot with a pair of stubs and combined two antennas at the scattered CPW feeding on both left and right sides, it can be obtained a much wider impedance bandwidth, dual-polarization and high isolation. Measured performance of the developed antenna includes -10dB reflection coefficient, with the bandwidths of 4.7 GHz (461%) and 4.74 GHz (476%) for the two polarizations. The isolation between two ports in the required band is lower than -20dB. From simulated and measured radiation patterns, the signals received by the two ports are proved to be uncorrelated. The radiation efficiency is better than 56% and 57%, and the peak gain is better than 2.5 and 3.3dBi. Although this antenna was designed for frequency 1.5G ~ 6GHz applications, this design concept can be extended to other frequency bands of interest.

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