An UWB Rotated Cross Monopole Antenna

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***Abstract*-Configurations of planar rotated cross monopole antennas have been investigated. The rotated cross patch comprises a vertical microstrip and three rectangular patches (area A, B, and C). By rotating the horizontal patches (area B and C), the bandwidth of the antenna can be significantly enhanced. The effect of the rotated angle of B and C on the bandwidth has been studied. The measured results show that The bandwidth of impedance bandwidth (10-dB reflection coefficient) is as wide as 6.97 GHz (2.29–9.26 GHz) or about 120.6% . which is about two times that of the corresponding conventional cross monopole antenna. The proposed antenna has a ultra-wide bandwidth which can cover DECT/IMT-2000/3G/UMTS/2.45-GHz/5.2-GHz/5.8-GHz ISM band (WLAN, IEEE 802.11b and g)/ Bluetooth/ZigBee 2.4 GHz/2.5-GHz WiMAX/3.5-GHz WiMAX bands.**

Index Terms—rotated monopole antenna, ultra-wideband.

I. INTRODUCTION

With the rapidly development of wireless communication, the multiband antenna has become a hot area. Covering multiband using only one antenna becomes a challenging issue. One of the solutions is using wideband antenna. Planar monopole antennas usually have these advantages at the price of relatively narrow bandwidth, which might not be wide enough to support modern digital wireless communication systems. To get a wideband monopole antenna, different methods have been proposed, such as multilayer structures [1] or parasitic elements [2]. In addition, beveling the rectangle of the monopole also can improve the impedance bandwidth to 6:1 for VSWR=2 [3]. In [4], a planar cross monopole antenna was investigated. The cross-shaped patch comprises vertical microstrip and two rectangular patches. The antenna exhibits a wide impedance bandwidth of over 70%. In[5], a printed antenna composing of a trapezoid ground plane and an elliptical monopole patch was proposed. The antenna has a measured impedance bandwidth from 1.02 GHz to 24.1 GHz with a VSWR = 2. To get wide operation band, the author In [6] proposed a printed wide-slot antenna fed by a microstrip line with a rotated slot for bandwidth enhancement, the measured impedance bandwidth, defined by 10 dB return loss, can reach an operating bandwidth of 2.2 GHz at operating frequencies around 4.5 GHz.

In this paper, an ultra-wideband rotated cross monopole antenna was presented. The antenna has wide operation and width of 6.97 GHz (2.29–9.26 GHz) or about 120.6% for return loss=10dB, which can cover DECT/IMT-2000/3G/U-MTS/2.45-GHz/5.2-GHz/5.8-GHz ISM band(WLAN, IEEE-802.11b and g)/Bluetooth/ZigBee/2.4-GHz/2.5-GHz WiMAX-/3.5-GHz WiMAX bands. By rotating the two patch of the antenna (area A and B), the impedance bandwidth of proposed cross monopole antenna can be significantly enhanced.

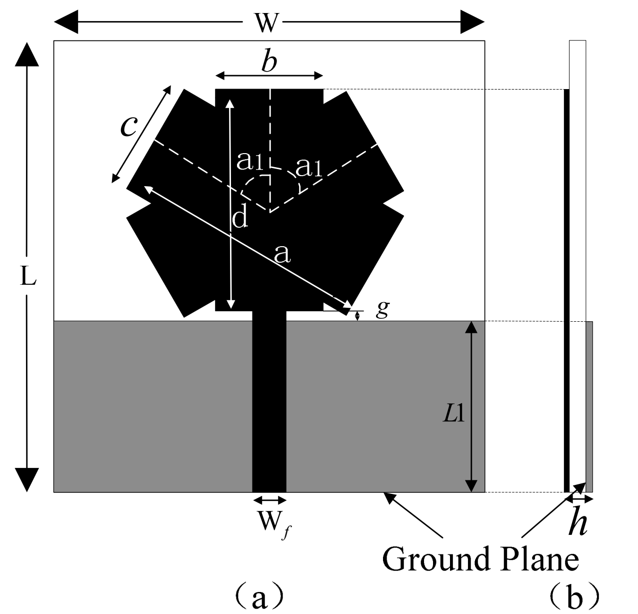

Figure 1 Geometry of the proposed antenna: (a) top view, (b) side view

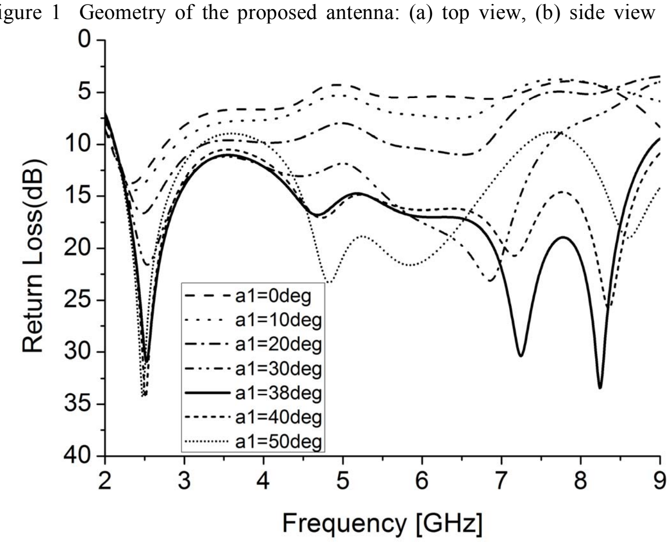

Figure 2 Simulated return loss against frequency for the proposed antenna with various a1, W=L=50mm, L1=15mm, a=9mm, b=9mm, c=13mm, d=28mm, g=0.5mm

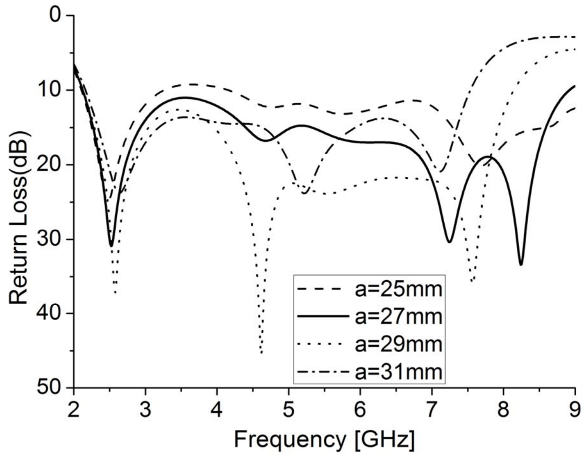

Figure 3 Simulated return loss against frequency for the proposed antenna with various a, W=L=50mm, L1= 15mm, , b=9mm, c=13mm, d=28mm, g=0.5mm, a1= 38°

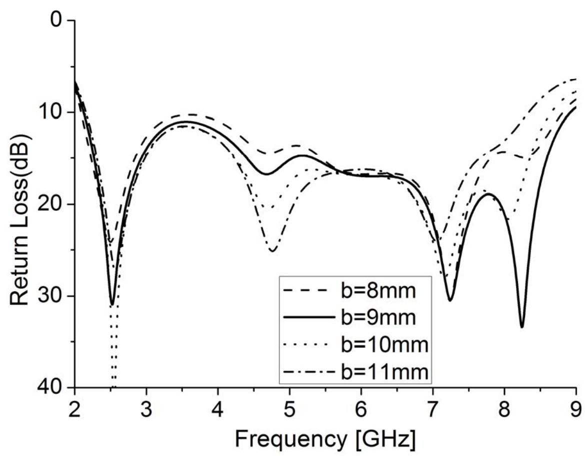

Figure 4 Simulated return loss against frequency for the proposed antenna with various b, W=L=50mm, L1=15mm, a=9mm,, c=13mm, d=28mm, g=0.5mm, a1= 38°

II. ANTENNA DESIGN AND EXPERIMENT RESULTS

A. ANTENNA DESIGN

The geometry of the proposed rotated cross monopole antenna is shown in Fig.1. The rotated cross monopole antenna can be easily printed on dielectric substrate. It is constituted of rotated cross-shaped planar monopole fed by 50- microstrip line and a ground plane. The rotated cross patch is consisting of three parts-the vertical rectangular patch (A) and two rotated rectangular patches (B and C) , which has a rotated angle of a1. The vertical rectangular patch (A) acts as a radiator as well as feed for the cross patch antenna. The rotated monopole radiator and 50 Ω -microstrip feed line are printed on the same side of the dielectric substrate while the ground plane locates on the other side. To simplify the design, the part B and C have the same dimensions of $a \times c$. The size of the patch A is $b \times d$ and the whole antenna is fed by a 50-Ω microstrip line with a width of W_f. The proposed antenna is printed on an FR4 substrate with a thickness of 1.6mm and a relative permittivity of 4.4, which has a dimension of W× L.

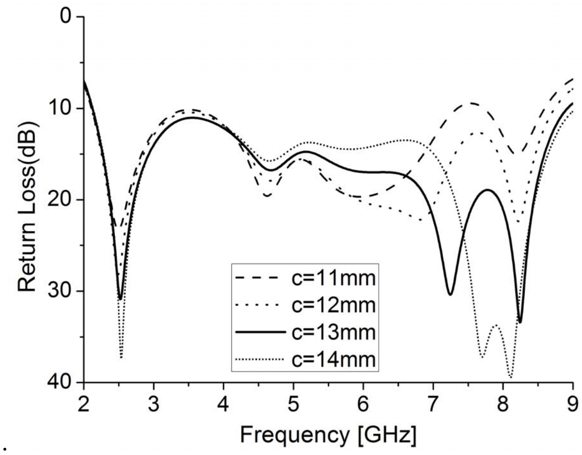

Figure 5 Simulated return loss against frequency for the proposed antenna with various c, W=L=50mm, L1 = 15mm, a=9mm, b=9mm, d=28mm, g=0.5mm, a1= 38°

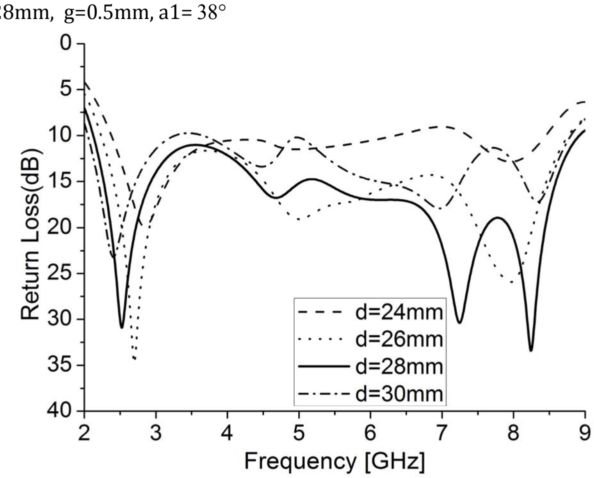

Figure 6 Simulated return loss against frequency for the proposed antenna with various d, W=L=50mm, L1=15mm, a=9mm, b=9mm, c=13mm, g=0.5mm, a1= 38°

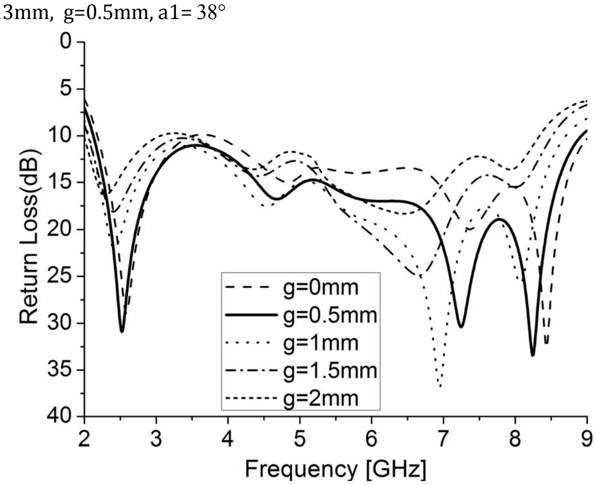

Figure 7 Simulated return loss against frequency for the proposed antenna with various g, W=L=50mm, L1=15mm, a=9mm, b=9mm, c=13mm, d=28mm, a1= 38°

The dimension of ground plane for the proposed antenna is W×L1. The feed gap width between the ground plane and the feed point is g.

B. PARAMETER STUDY

In order to understand the effects of various parameters and to optimize the performance of the final design, a parameter study is carried out in this section. The whole Simulation is carried out using CST, a commercial electromagnetic simulator based on Finite Difference Time Domain (FDTD).

In this antenna, the most critical parameter is the rotated angle of the horizontal patch. It has a significant effect on the return loss. Fig.2 shows the simulated reflection coefficient for the reference antenna with different a1. It shows that that the return loss varied significant as different a1. The return loss decreases to 10dB gradually as a1 increases. When a1is larger than 40 ° , the return loss become large. To get a wide operation band, we chose the a1 as 38°. The bandwidth of impedance bandwidth (10-dB reflection coefficient) is as large as 6.97 GHz (2.29–9.26 GHz). Fig.3-6 show the return loss with different a, b, c, and d. It is from the simulated results shown that a and d have significant effect on the bandwidth of the rotated monopole antenna. The width of the rotated rectangle patches b and c only has effect on the impedance of the antenna at the high band. At the low band operation, the antenna has a stable return loss which varies little as b and c have different value. The width of the gap between the ground plane and the feed point ,g, also has effect on the bandwidth of the antenna. Fig. 7 shows the return loss of the antenna with different g. As the g become larger, the impedance match at the high band becomes worse, meanwhile, the resonant frequency shifts to a little lower frequency.

III. SIMULATED AND M EASURED RESULTS

The prototype of the proposed antenna with optimal geometrical parameters as shown in Fig. 1 is constructed and measured. The antenna proposed here is fabricated on commercially available FR4 substrate with h=1.6mm, ε =4.4. The geometric dimensions of the proposed antenna are as follows: W=L=50mm, L1=15mm, a=9mm, b=9mm, c=13mm,d=28mm, g=0.5mm, a1= 38^o . The antenna was fabricated and the photograph of it is shown in Figure 8. The return-loss performance was measured using Agilent Vector Network Analyzer. Fig.12 shows the simulated and measured return loss of the proposed antenna. The measured results show that the bandwidth of impedance bandwidth (10-dB reflection coefficient) is as large as 6.97 GHz (2.29–9.26 GHz) or about 120.6%. A little difference between the simulated and the measured results can be observed, the measured resonant frequency of the antenna shifts to the high frequency There may be because the substrate that we used is commercial available and the permittivity is not strictly accurate.

Fig.9-11 give the simulated radiation patterns at 2.4GHz, 3.5GHz and 7GHz. It seen that at the low band ,the proposed antenna has a monopole-like patterns. A good omnidirectional radiation pattern is obtained. It is also noted that radiation patterns are in symmetry with respect to the antenna axis since the proposed antenna's structure is symmetrical and a low cross polarization level can be observed at the whole band.

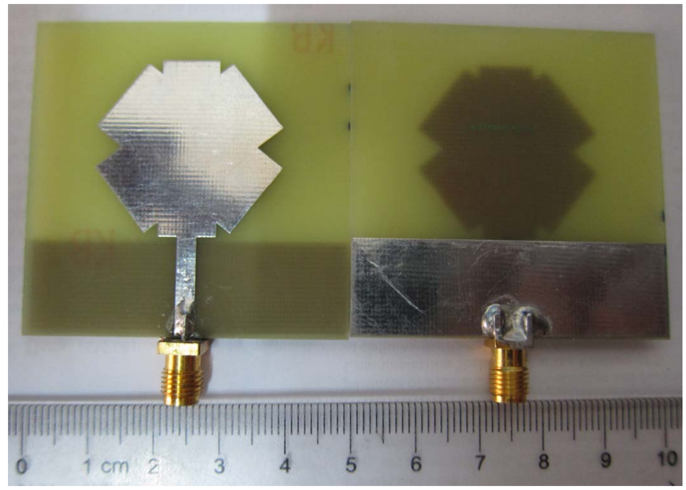

Figure 8 The prototype of the proposed antenna

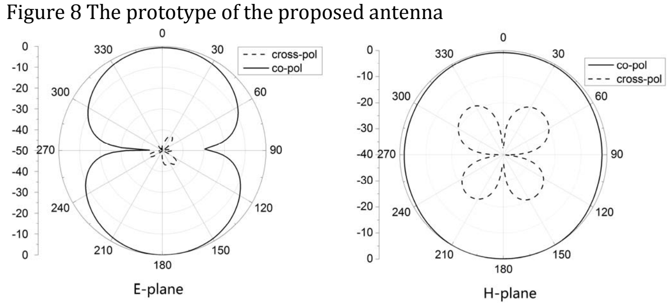

Figure 9 simulated E-plane and H-plane radiation for the antenna with a1=38° at f =2.4GHz

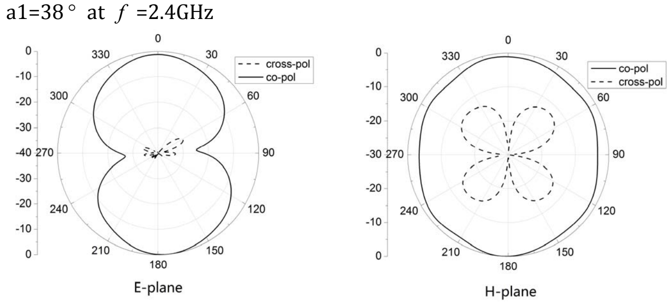

Figure 10 simulated E-plane and H-plane radiation for the antenna with a1=38° at f =3.5GHz

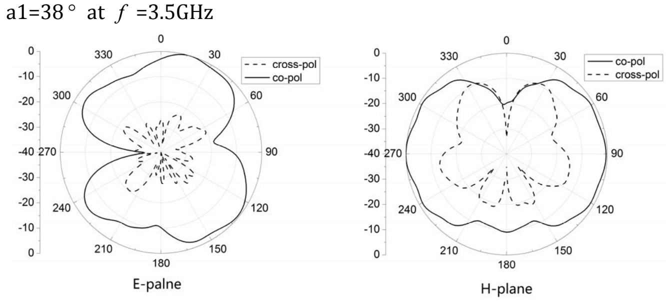

Figure 11 simulated E-plane and H-plane radiation for the antenna with a1=38° at f =7GHz

IV. CONCLUSION

A printed UWB monopole-like antenna fed by a 50-micro-strip line with rotated patches for band width enhancement has been demonstrated. By rotating the horizontal patch of the cross monopole, the bandwidth of the antenna can be significantly enhanced. Experimental results show that the impedance band width determined by 10dB return loss can reach nearly 6.97-GHz which is about two times that of the

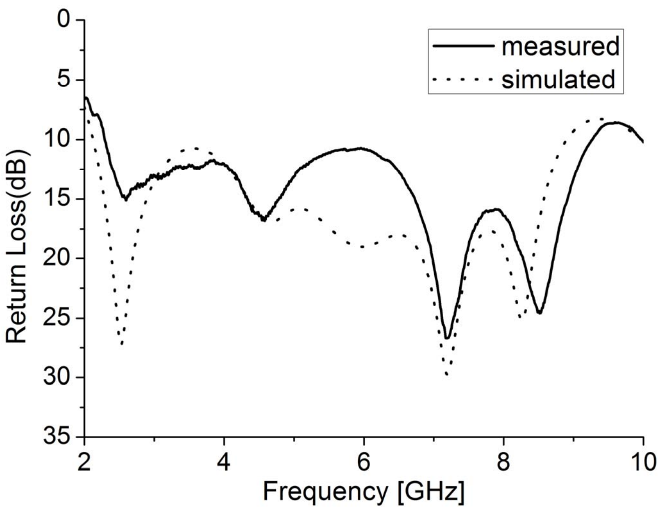

Figure 12 Measured and simulated return loss of the proposed monopole antenna

corresponding conventional microstrip-line-fed cross monopole. The antenna can cover DECT/IMT-2000/3G/UMT-/2.45-GHz/5.2GHz/-5.8GHz ISM band (WLAN, IEEE 802.11b and g)/ Blue-tooth/ZigBee 2.4 GHz/2.5-GHz WiMAX/3.5-GHz WiMAX bands . Moreover, the proposed antenna possesses nearly omni-directional radiation characteristics at the low band and low cross polarization level can be observed at the whole band

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