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An Extremely Wideband Printed Monopole Antenna with Dual Notched Stop Bands

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ABSTRACT:This paper proposes a design of an extremely wideband printed monopole antenna with dual notched stop bands for worldwide interoperability for microwave access (WiMAX) and wireless local area networks (WLAN). The individual notch frequencies are controlled by the individual split ring resonators (SRRs) and central notch frequency is determined by the individual SRRs physical dimensions. Predicted extremely wide impedance bandwidth of antenna is 2.67-22 GHz, for VSWR < 2 with two notched stop bands 3.36-4.10 GHz and 5.15-6.20 GHz, for VSWR > 2 is achieved for rejecting WiMAX (3.3-3.69 GHz) and WLAN (5.15-5.825 GHz) band signals. Significant gain reduction over the notched stop bands and nearly omnidirectional radiation patterns over operating frequencies is also analysed.

KEYWORDS: Extremely wideband antenna, notched stop band, split ring resonator, WiMAX, WLAN.

I.INTRODUCTION

The design of products capable of operating in different frequency bands for wireless communication systems has been drawn much attention in both the researchers and academicians. There are some narrow bands exists in the wireless communication systems. The narrow band communication systems are WiMAX (3.4-3.69 GHz) and WLAN (5.15-5.825 GHz). The microwave printed monopole antennas are preferred for wireless communication systems that can operate on multiple frequency bands [1]. To overcome the problems of electromagnetic interference, various printed monopole antennas with notched stop bands have been designed and investigated. Several design techniques proposed in open literature describe extremely wide band antennas with notched stop bands achieved by employing different modifications with slots on radiating patch or on ground plane such as split ring resonators (SRRs) [2]-[5], slot-type SRR [6] and combinations of them.

This paper describes the design of an extremely wideband printed monopole antenna with dual notched stop bands by loading complementary co-directional SRRs on radiating patch with microstrip feed line is presented. The wideband performance is achieved by modifying ground plane structure in respect of beveling edges and inserting square slot on it. By adjusting the dimensions and locations of the square slot and beveled edges, an enhanced impedance bandwidth is achieved. The stop band for WIMAX and WLAN is achieved by inserting complementary co-directional SRR in the radiating patch. By adjusting the size and location of the SRRs, the central notched stop band frequency can be controlled. The wideband performance is achieved by modifying ground plane structure in respect of beveling edges and inserting square slot on it. By adjusting the dimensions and locations of the square slot and beveled edges, an enhanced impedance bandwidth is achieved. The simulation of the proposed structure is carried out by using a commercially available software package CST Microwave Studio [7].

II.ANTENNA DESIGN

Fig. 1 shows a schematic diagram of the proposed extremely wideband printed monopole antenna with loading of SRRs. The antenna is printed on a glass epoxy FR-4 dielectric substrate with relative permittivity (ε_r) of 4.4, thickness of 1.6 *mm*, and loss tangent ($tan\delta$) of 0.02. The radiating element and microstrip feed line of width 'W_f' are printed on the top side of the substrate and modified partial ground on bottom side to achieve 50 *ohm* characteristic impedance.

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The gap between the radiating patch and modified ground plane is an important parameter to control the impedance bandwidth and provide good impedance matching circuit which can lead to wideband multi-resonance characteristics of the input impedance at lower edge of the radiating patch and it contributes the radiation. The outer and inner radiuses of the inner co-directional SRR are denoted with *'or2'* and *'ir2'*, respectively. The outer and inner radiuses of the outer co-directional SRR are denoted with *'or1'* and *'ir1'*, respectively. The complementary co-directional SRRs is etched in the radiating patch to achieve dual notched stop bands for the WiMAX and WLAN to prevent the interference between them. The complementary co-directional SRRs behaves as a quasi-resonance circuit and it provides the distributed capacitance between concentric rings and overall inductance. However, at the resonance frequency antenna radiation is very poor due to the strong magnetic coupling with SRR contributing to the frequency notch. Thus coupling between SRR and propagating EM signal with small size of complementary co-directional SRRs, it provides the strong signal rejection performance to filter out WiMAX and WLAN band signals to avoid interference, when it placed close to feed line. The dimensions of the designed printed monopole antenna after optimization are listed in Table 1.

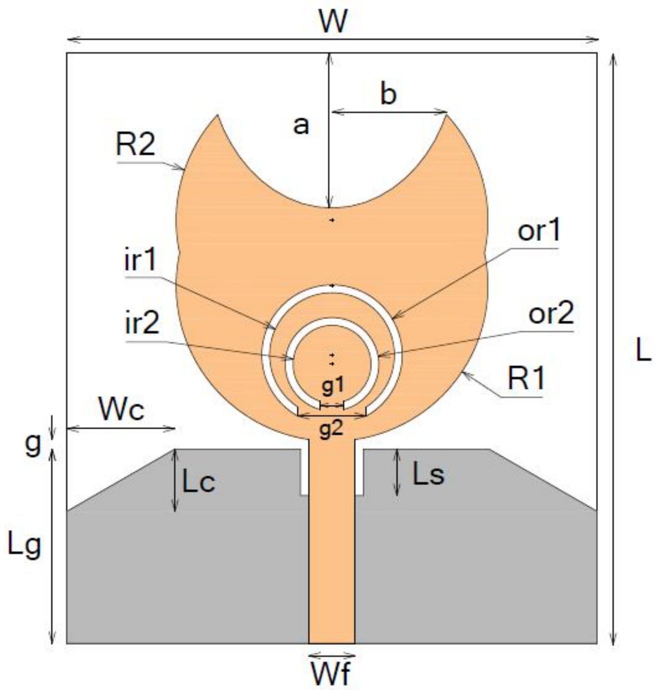

Fig. 1 Schematic of the proposed dual notched extremely wideband printed monopole antenna with complementary co-directional SRRs.

Table 1 Dimension of the proposed antenna [mm]

L	W	R1=R2	a	b	ir1	or1	ir2
38	34	10	10	8	3	2.5	4
or2	Wf =Ls	Lc	Wc	Lg	g	g1	g2
4.5	3	4	6.93	12.5	0.6	1.5	4.4

III.RESULTS AND DISCUSSION

In this section, simulation results of an extremely wideband printed antenna with dual notched stop bands are presented. Fig. 2 shows the simulated reflection coefficient (S11) characteristics against frequency of the unloaded complementary co-directional SRRs printed monopole antenna and that loaded with complementary co-directional SRRs. As can be seen from Fig. 2, the simple microstrip line fed printed monopole antenna without loading complementary co-directional SRRs operates from 2.77 GHz to 22 GHz with resonance dip at 3 GHz frequency. The complementary co-directional SRRs loading contribute dual notches at 3.9 GHz and 5.7 GHz. The first notch at 3.9 GHz is due to the outer complementary SRR with larger dimension whereas the second notch at 5.7 GHz is due to the inner complementary SRR with smaller dimension. It is observed that the impedance bandwidth of the proposed

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antenna is from 2.67 GHz to 22 GHz for VSWR < 2 with dual notched stop bands 3.36-4.10 GHz and 5.15-6.20 GHz is achieved, for VSWR > 2, for rejecting WiMAX and WLAN band signals, respectively. The central notch frequency of individual SRRs is determined and controlled by the geometrical dimension of individual SRRs.

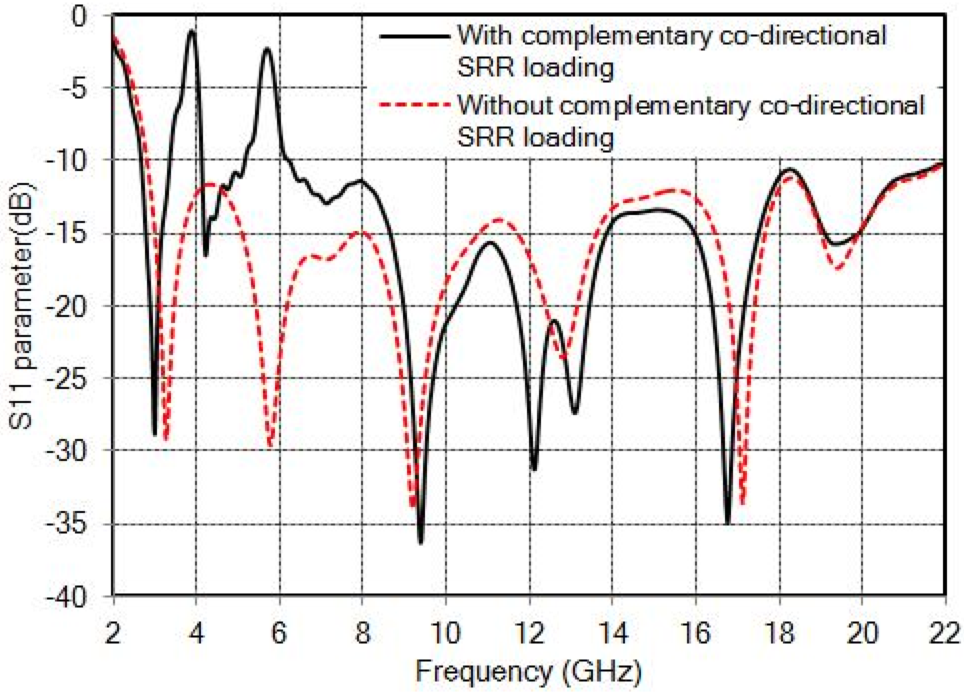

Fig. 2 Simulated S11 characteristics of the proposed dual notched extremely wideband printed monopole antenna with and without complementary co-directional SRR loading.

To understand the operation mechanism of the complementary co-directional SRRs simulated surface current distribution at notched frequency 3.9 GHz and 5.7 GHz of the proposed antenna is shown in Fig. 3 (a) and (b), respectively. When the antenna is working at the central notched band frequency at 3.9 GHz, the outer complementary SRR behaves as a separator as shown in Fig. 3 (a), which almost has no relation to the other band-notches. Similarly, the inner complementary SRR operates as a second separator for the central notched band frequency at 5.7 GHz as shown in Fig. 3 (b). It can be seen from figure that the surface currents are highly concentrated around the outer and inner complementary SRRs at 3.9 GHz and 5.7 GHz, respectively. It means that the energy is stored around the individual complementary SRR and the proposed antenna does not radiate into the air. Thus, the proposed complementary co-directional SRRs loaded printed monopole antenna reject dual notched stop bands for WiMAX and WLAN bands.

The simulated realized gain characteristics against frequency of the complementary co-directional SRRs loaded printed monopole antenna are illustrated in Fig. 4. The plot shows significantly realized gain reduction at notch frequencies. In the stop band region, the simulated results yield a gain of -5.91 dBi at 3.9 GHz and -3.41 dBi at 5.7 GHz. This result confirms that at central notch frequencies of the SRRs the antenna does not radiate into the air. The radiation patterns of the proposed antenna at four resonant frequencies i.e., 3 GHz, 9.4 GHz, 12.1 GHz, and 16.77 GHz in both E- and H-plane is illustrated in Fig. 5 (a) to (d), respectively. The E-plane co-pol radiation pattern shows bi-directional radiation pattern at 3 GHz resonant frequency. The H-plane co-pol radiation pattern shows omnidirectional pattern at 3 GHz. It can be seen that the cross-polarization is very low at lower frequencies and the value of cross-polarization increases as frequency increases and number of lobes also increases in both E- and H-plane. This is due to the increasing the horizontal components of the surface currents in the monopole which leads to cross polarization.

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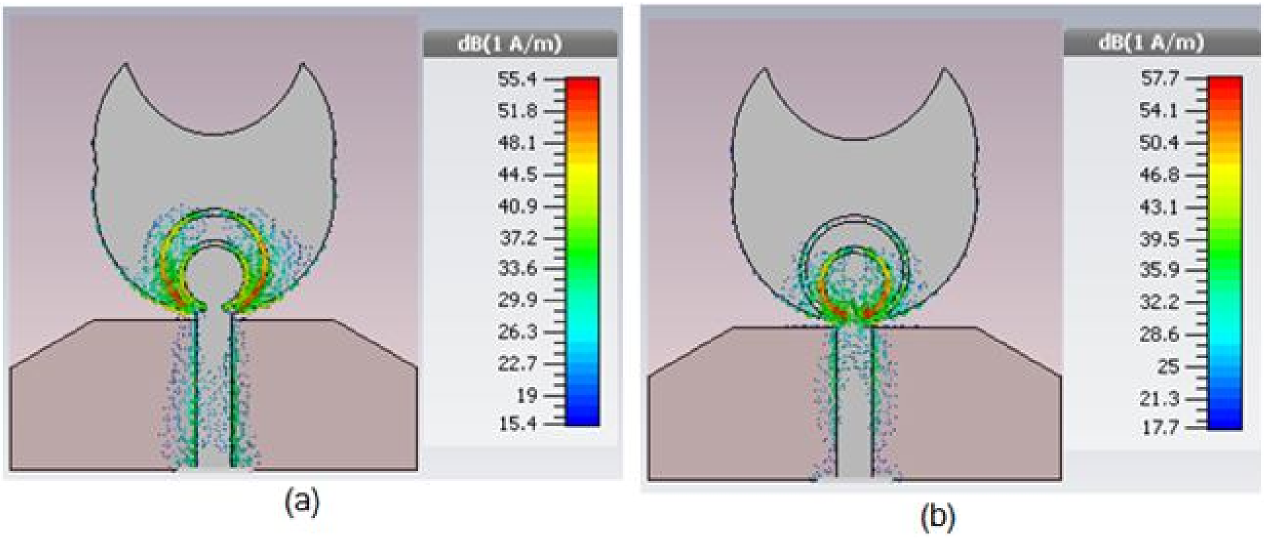

Fig. 3 Simulated surface current distributions of the proposed dual-notched extremely wideband printed monopole antenna with complementary co-directional SRR loading at (a) 3.9 GHz, and (b) 5.7 GHz.

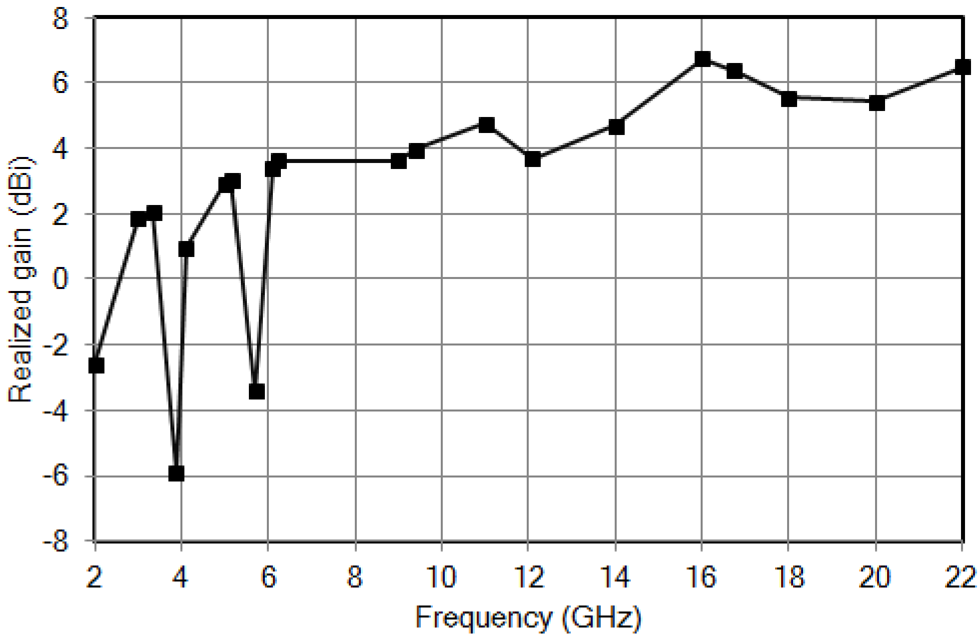

Fig. 4 Simulated realized gain characteristics of the proposed dual-notched extremely wideband printed monopole antenna with complementary co-directional SRR loading.

IV.CONCLUSION

An extremely wideband printed monopole with complementary co-directional SRRs loaded antenna for dual notched stop bands is demonstrated. The proposed antenna utilizes complementary co-directional SRRs for dual notch application. The proposed antenna is analysed with S11, surface current distribution, radiation patterns, and gain. Significantly gain reduction over the stop band is analysed. The performance of the proposed antenna proves that it is suitable for extremely wideband spectrum monitoring and multiple wireless services except WiMAX and WLAN applications. The design can be easily extended to achieve multiple notches by adding more number of SRRs.

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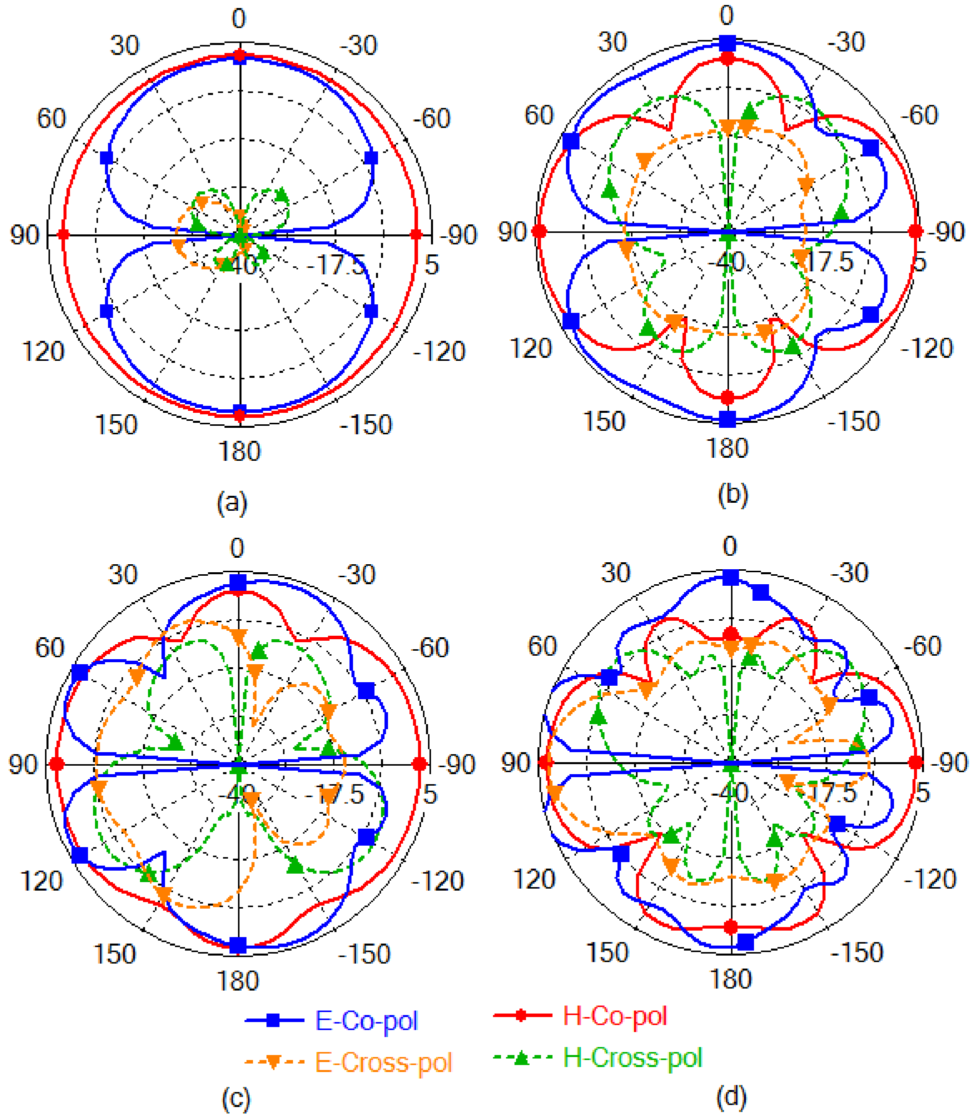

Fig. 5 Simulated radiation patterns of the proposed dual-notched extremely wideband printed monopole antenna with complementary co-directional SRR loading at four resonant frequencies (a) 3, (b) 9.4, (c) 12.1, and (d) 16.77 GHz.

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