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SRR Loaded UWB Monopole Antenna with WiMAX and WLAN Notch

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***Abstract*— This paper presents a compact sized coplanar waveguide fed (CPW) printed circular monopole antenna for ultra wideband (UWB) communications having WiMAX and WLAN frequency notch. The proposed antenna achieved dual frequency notching by loading circular split ring resonator (SRR) on a low cost FR4 Epoxy substrate. The electromagnetic inductive coupling of the SRR with the CPW provides the frequency notch. The antenna's return loss and VSWR plots are presented here to confirm the notching.**

***Index Terms*—CPW feed, Monopole antenna, UWB, SRR, WiMAX, WLAN**

I. Introduction

Communication systems have increased the demand for cost effective, compact antennas with interference reduction capabilities. According to federal communication commission (FCC) rules, from 2002 onwards the 3.1 - 10.6 GHz band is allocated to the ultra wideband (UWB) applications [1]. UWB technology has several advantages like very wide bandwidth ranging from 3.1 to 10.6 GHz compared to most of the existing wireless communication standards and low cost, simple RF circuitry, high data rates and low average radiated power. To reduce interference between ultrawideband (UWB) systems and other narrow band systems, several designs are available in open literature. Notch characteristics achieved by changing the shapes of radiator with various types of slot or by parasitic loading [2]–[6]. Several design configurations include triple notch frequencies [7], double notch frequencies [8] and single notch frequencies [9] achieved using various design configurations employed within printed planar monopole antennas. Other design configurations are dual-frequency notch and wideband notch filtering by loading SRR pair on the back side of CPW-fed monopole antenna [10]-[11].

This paper presents a simple method to design a frequency notched UWB antenna by loading single ring dual SRRs on the back side of a CPW fed printed circular monopole antenna. The single ring SRRs are placed symmetrically on the opposite surface of the printed planar monopole antenna along the signal line which results in a notch frequency. Resulting notch frequency changes in accordance with the dimensions of circular SRRs. Propagation of electromagnetic (EM) signals, with their magnetic fields along the axes of the SRR's, interacts with the SRRs, and causes the SRRs to operates as magnetic dipoles. The propagating EM signal induces an electro motive force on the SRR, which in turn induces oscillating current within the circular ring SRR [12]. At a particular frequency which corresponds to the dimensions of SRR yields a resonance and prohibits signal propagation at this resonance frequency. When the excitation is given the propagating signal is rejected and reflected back, which yields a feeble radiation at the desired notch frequencies. Multiple notches can be achieved by loading multiple SRR with different geometrical dimensions.

In this paper simulated results are demonstrated as 3 different sections such as antenna with 3.5GHz WiMAX notch, antenna with 5.5GHz WLAN notch and by combining these two in a single printed circular monopole antenna giving dual frequency notch. Here we proposed frequency notching technique using circular single ring SRR, which yields a notching at a single frequency [13]. In most of the previous methods described earlier, where most of the modifications and incorporations are on the ground plane or radiator. The simplicity of our design is that here there is no need of varying the shape of radiator and ground plane and it can also be employed in any CPW-fed planar monopole UWB antenna.

II. ANTENNA CONFIGURATIONS

Schematic of the proposed antenna with dual frequency notch is shown in Fig.1. The proposed antenna is fabricated on FR4 Epoxy material having relative permittivity, $\varepsilon r=4.4$, $\tan\delta=0.02$, and thickness $h=1.6mm$. The circular uwb monopole having radius R=12.5mm is fed by a CPW consisting of ground planes having widths W_1= 22mm and W_2=22mm, length $Ls=29.4mm$ and a signal line having length $Ls+t$= 29.6 and width $S=5mm$. The slots between the signal line and ground planes have width $Sg=0.5mm$. Antenna loaded with two circular shaped single ring split ring resonators, shown in Fig. 1(c), where r is the radius of the SRR, conductor width w and the split gap g. Circular shaped single ring SRRs of two different dimensions are printed on the opposite surface of a CPW separated by the substrate height, as shown in Fig. 1(b). A single ring SRR is shown in Fig. 1(c) having dimensions r_i, which is radius of SRR, conductor thickness w_i, and split gaps g_i, where i=1,2, corresponding to the SRR 1 and 2, respectively. Where r_1=7.2mm, width w_1=0.5mm and split gap g_1=0.5mm, the SRR corresponds to 3.5GHz WiMAX and r_2=5mm, width w_2=0.5mm and split gap g_2=0.5mm, which corresponds to 5.5GHz WLAN frequency. According to the design

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equations of SRR, each SRR's resonance frequency varies which depends on its geometrical dimensions [14].

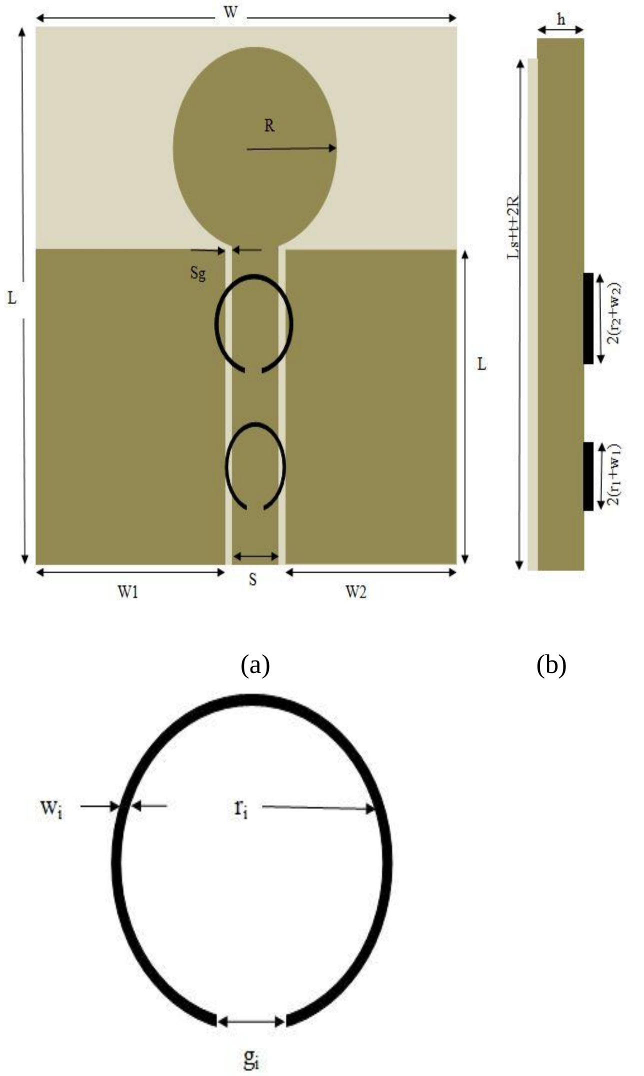

Fig. 1. (a) Schematic of a printed circular monopole fed by CPW: Top view with SRR printed in the back side (b) Side view of the printed circular monopole antenna fed by CPW loaded with SRRs (c) Schematic of circular SRR having dimensions ri, wi and gi, where *i=1,2* corresponding to SRR 1 and 2

III. RESULTS AND ANALYSIS

A CPW fed circular monopole uwb antenna without SRRs and with SRRs to obtain dual frequency notches is simulated on FR4 substrate having thickness h=1.6mm and dielectric constant εr=4.4. Here the antenna is simulated as three steps - During the first step by loading a single SRR having dimensions that corresponds to 3.5GHz WiMAX frequency, in second step by loading a single SRR having dimensions that corresponds to 5.5GHz WLAN frequency and in third by loading dual SRR to obtain dual frequency notch. The simulated results show a close corresponds with the theoretical results. The prototypes were designed and simulated using a commercial EM simulator that is HFSS.

A. Simulated return loss characteristics

Fig. 2 shows the simulated magnitude of the return loss (reflection coefficient) of the circular monopole uwb antenna without loading SRRs with design parameters described in Table I. It can be seen from the figure; the CPW fed circular monopole UWB antenna without any SRR loading operates for the entire UWB bandwidth, and have return loss less than -10db.

Fig. 3 shows the simulated magnitude of the return loss (reflection coefficient) of single SRR loaded circular monopole uwb antenna giving notches at 3.5GHz, frequency corresponds to the SRR geometric dimensions. It can be seen that, return loss is above -10db at this particular frequency. Fig.4 shows the simulated magnitude of the return loss (reflection coefficient) of single SRR loaded circular monopole uwb antenna giving notches at 5.5GHz, frequency corresponds to the SRR geometric dimensions. It can be seen that, return loss is above -10db at this particular frequency.

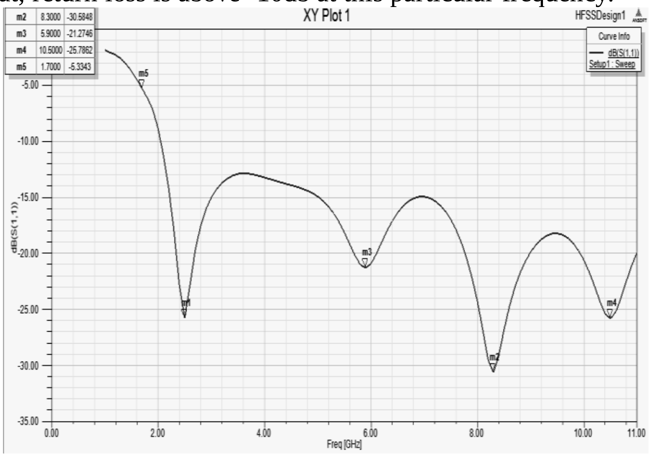

Fig.2. Simulated S11 plot of CPW Fed Circular UWB Monopole Antenna

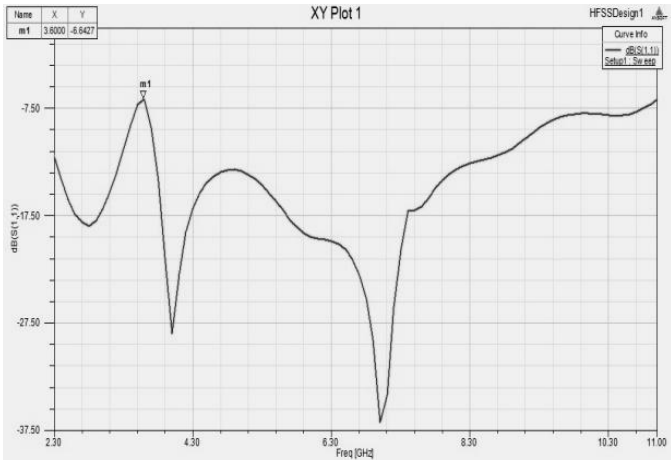

Fig.3. Simulated S11 plot of CPW Fed Circular UWB Monopole Antenna with 3.5GHz notch

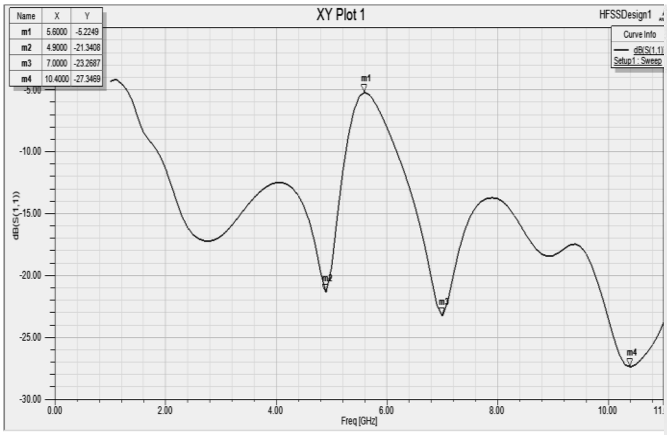

Fig.4. Simulated S11 plot of CPW Fed Circular UWB Monopole Antenna with 5.5GHz notch

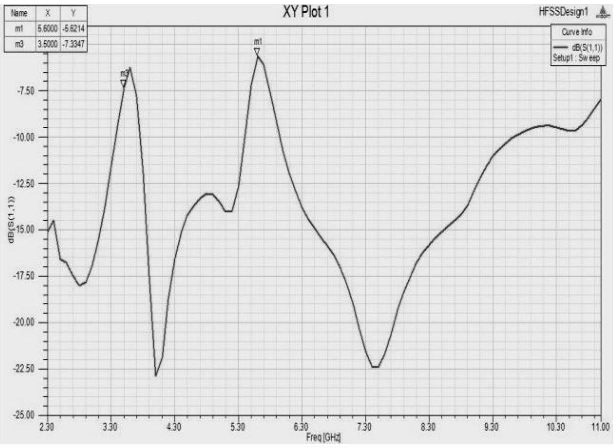

Fig.5. Simulated S11 plot of CPW Fed Circular UWB Monopole Antenna with dual frequency notch

Fig.5 shows the simulated magnitude of the return loss (reflection coefficient) of dual SRR loaded circular monopole uwb antenna giving notches at 3.5GHz and 5.5GHz.

B. Simulated VSWR characteristics

The voltage standing wave ratio (VSWR) plot of the circular monopole UWB antenna is shown in Fig.6, from which it is observed that VSWR values are less than 2 in the entire bandwidth. Fig.7 shows the VSWR plot of single SRR loaded circular monopole UWB antenna having VSWR above 2 at desired 3.5GHz frequency.

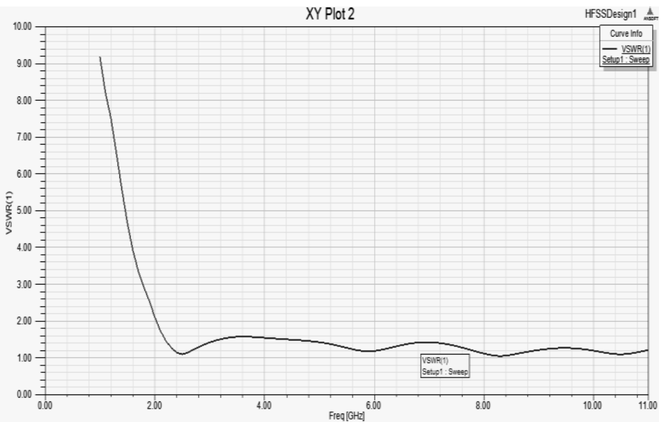

Fig.6 VSWR of CPW fed circular monopole UWB antenna

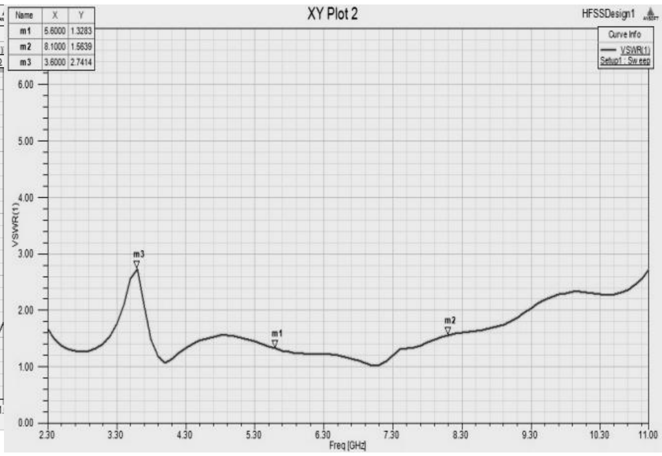

Fig.7VSWR of CPW fed circular monopole UWB antenna with 3.5GHz notch

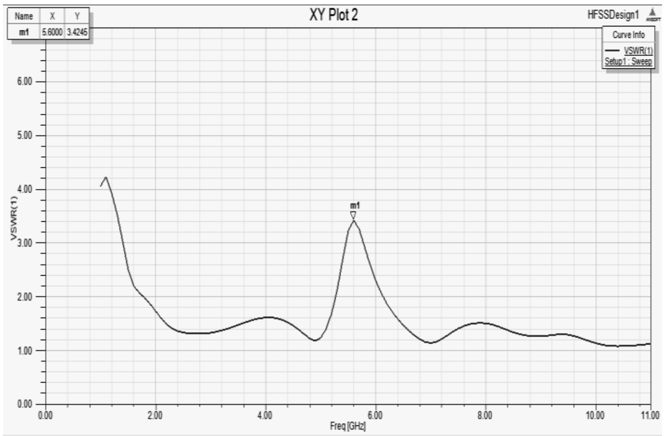

Fig.8 VSWR of CPW fed circular monopole UWB antenna with 5.5GHz notch

Fig.8 shows the VSWR plot of single SRR loaded circular monopole UWB antenna having VSWR above 2 at desired 5.5 GHz frequency. Fig.9 shows the VSWR plot of single SRR loaded circular monopole UWB antenna having VSWR above 2 at two desired notch frequencies.

C. Simulated Gain characteristics

Fig.10 shows the simulated gain plot of circular SRR loaded UWB circular monopole antenna with dual notch characteristics that is at 3.5GHz and 5.5GHz. It can be observed from the plot that at the two specified notching frequencies the gain is very low compared to other frequencies in the UWB spectrum.

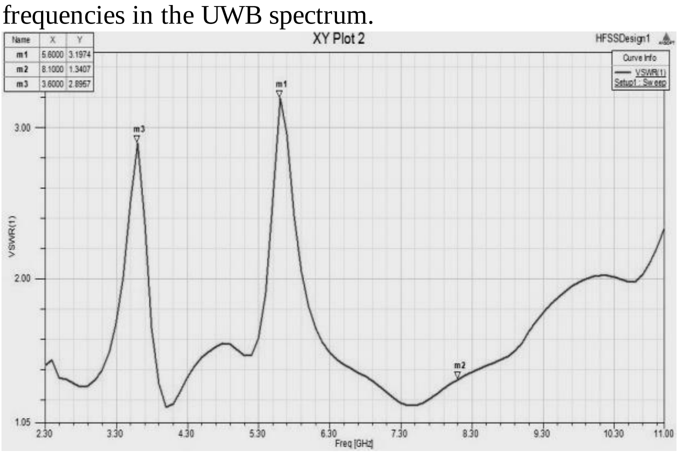

Fig.9 VSWR of CPW fed circular monopole UWB antenna with dual frequency notch

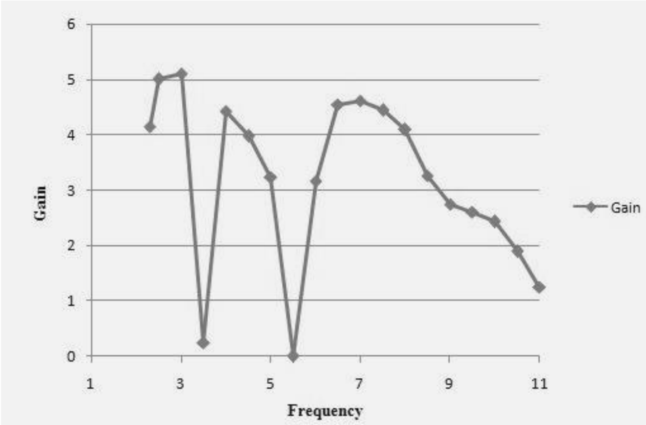

Fig.10 Gain plot of CPW fed circular monopole with dual notch

IV. CONCLUSION

A CPW fed circular monopole UWB antenna loaded with circular SRR's exhibiting dual frequency notch characteristic has been proposed and presented here. The configuration works with accurate lacing of the SRR on the opposite surface of the CPW feed line. The electromagnetic inductive coupling between the SRR and the feed line at its resonance frequency produce the desired frequency notching. The antenna dimensions and the SRR dimensions are independent of each other. The notch frequency can be varied to the desired value by varying the SRR dimensions based on the design equations.

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