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CPW Feed Circular Monopole Ultra Wideband Antenna with Triple Band Notch Characteristics Using A Split Ring Resonator

Balaji.M [1], Vivek.R[2]

PG Student, Department of Electronics and Communication, GKM College of Engineering and Technology, Chennai[1]
Assistant Professor, Department of Electronics and Communication, Faculty of Engineering, MEFGI, Rajkot [2]

Abstract: In today's communication world antenna design for UWB application is one of the challenging parts. In this paper split ring resonator arrays are realized on the ground plane along the coplanar waveguide feed (CPW) of the circular monopole antenna that notches the undesired frequency like 4.5 GHz, 5.1 GHz & 7.1 GHz.The electromagnetic coupling of the SRR with the CPW yields the frequency notch. The presence of negative effective permittivity and permeability produced by the split ring resonator array etched on the ground plane and microstrip feed line leads the multiple no of notch characteristics. This paper presents the comparison of CPW feed Circular monopole antenna and SRR loaded with CPW feed Circular monopole antenna. The designed antenna is simulated using High Frequency Structure Simulator.

Keywords: Circular monopole, split ring resonator (SRR), Ultra wideband (UWB) antenna, Coplanar Waveguide feed (CPW), High frequency structure simulator (HFSS)

I. INTRODUCTION

Antenna becomes a part of electrical devices in wireless communication system after late 1888, Heinrich Hertz (1857–1894) were first demonstrated the existence of radio waves [1]. The UWB technology opens new door for wireless communication system, since the current wireless system increasing exponentially. Back from spark-gap impulse to pulse radio, UWB system plays a dominant role in communication system as the antenna is one of the wireless communications components. Recently, UWB technology with an extremely wide frequency range has been proposed for imaging radar, communications, and localized applications [2]. In 2002, Federal Communication Commission (FCC) authorized unlicensed use of UWB band ranging from 3.1 GHz to 10.6 GHz. Since then, the design of broadband antennas has become an attractive and challenging area in the research of the system design [3]. In general, the antennas for UWB systems should have sufficiently broad operating bandwidth for impedance matching and high-gain radiation in desired directions.

UWB antenna design in the recent literature, the monopole planar antenna type is widely used due to its wide bandwidth, simple structure and low cost. It has become one of the most considerable candidates for UWB applications. Several designs of monopole planar UWB antenna have been proposed [4–17]. However, some of these antennas involve complex calculation and complicated fabrication process. Therefore, we propose a simpler method to design the CPW feed circular monopole antenna UWB applications with notch characteristics.

This paper is organized as follows. In Section 2, the proposed antenna design geometry is presented. Section 3 discussed on parametric study & results analysis. In Section 4 summarizes and concludes the study.

II. PROPOSED ANTENNA DESIGN GEOMETRY

This paper describes a novel and simple method to design a frequency notched UWB antenna by loading a pair of SRRs on the opposite surface of a CPW fed circular monopole antenna. The SRRs are placed symmetrically on the back side of the printed monopole antenna which results in a notch frequency determined by the SRR's geometrical dimensions[6][11]. The suppression of the radiation at the notch frequency is due to the effect of a strong magnetic coupling of the propagating EM signal with the SRR. This coupling between the SRR and the propagating EM signal can be used to filter out undesired frequencies and avoid possible interference within the UWB (3.1 GHz to 10.6 GHz). By loading multiple SRR pairs with varying dimensions, multiple resonances can also be achieved. Fig. 1 shows the schematic of the proposed antenna. The circular

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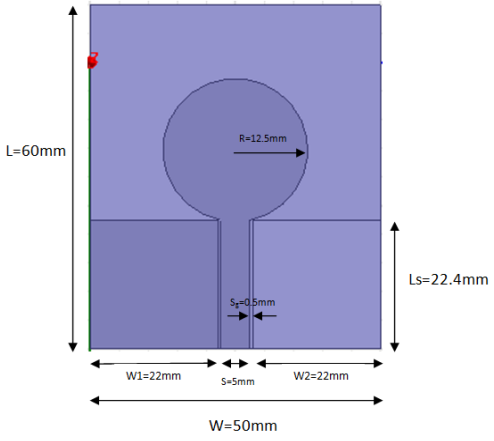
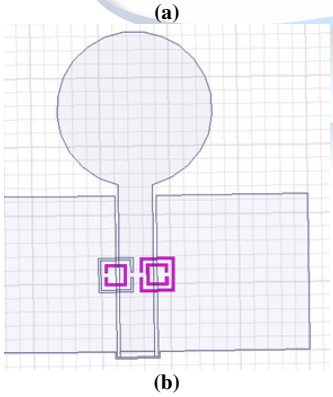
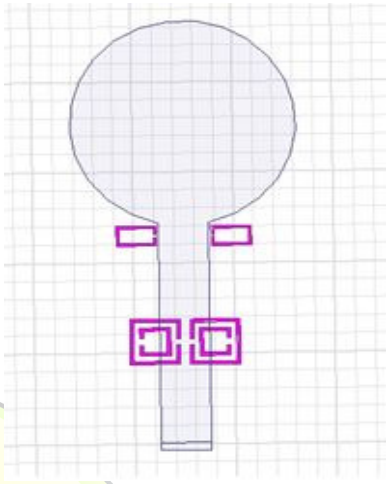
monopole of radius is fed by a CPW consisting of ground planes having widths W_1, W2and, length $L_S$and a signal line having width S and length L_S + t[13]. The slots between the ground planes and signal line have width S_g. The antenna is printed on a substrate having thickness h and dielectric constant ε_r. Two square shaped split ring resonators having dimension " a_{ext} " which is half the dimension of the side-length of the SRR, conductor thickness " C," separation between rings "D "[6][10] and split gaps " g_1 " and " g_2 " as shown in Fig. 1(c), are printed on the other side of the substrate with their centres coinciding with the slot lines of the CPW feed. Unlike in most of the previously presented designs described earlier, where most of the inclusions and slots were arranged on the radiating patch itself or the ground planes the novelty in our design is that it can be employed on any CPW fed planar monopole UWB antenna without tampering or changing the shape of the radiator or the ground plane.



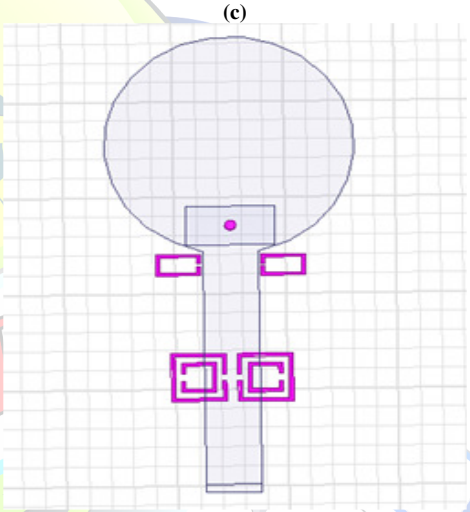
(a)



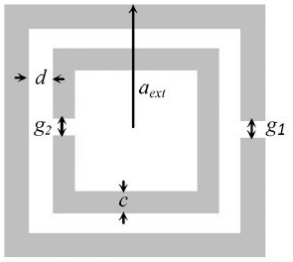
(b)



(c)



(d)



(e)

Fig.1. (a) Schematic of a CPW fed printed circular monopole antenna (b)Schematic of a CPW fed printed circular monopole antenna loaded with SRRfor single notch (c) Schematic of a CPW feed circular monopole antenna loaded with SRR with dual notch. (d) Schematic of a CPW feed circular monopole antenna loaded with SRR with triple notch (e) Schematic of Square Shape SRR

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The circular monopole antenna having diameter 25 mm is fed with a coplanar waveguide loaded with the SRR is designed with HFSS with the following parameters mentioned in the TABLE I below,

TABLE I. DESIGN PARAMETERS

No.	Designed Parameter	Antenna with SRR
1.	a_{ext}	2.5 mm
2.	c	0.35 mm
3.	d	0.6 mm
4.	g1=g2	0.7 mm
5.	Band Notch	At 4.5GHz, 5.1 GHz & 7.1 GHz
6.	Gain At Notch Frequency	-4 dB ,-5.31 dB, -3 dB

Calculation of SRR resonance frequency is given by formulae,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \quad (1)$$

The notch characteristics of the SRR loaded in the CPW feed circular monopole antenna can be calculated using the following formulae,

$$\epsilon_{reff} = \left(\frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left(1+\frac{12h}{L}\right)\right)^{-\frac{1}{2}} \quad (2)$$

Where ϵ_{reff} is the effectivedielectric constant and the ϵ_r is 4.4 as the substrate is FR4, h is 1.6 mm having height of the substrat. By using all these values ϵ_{reff} can be calculated.

$$f = \frac{c}{2L_1\sqrt{\epsilon_{reff}}} \quad (3)$$

$$L = 4w - c - 4 - d \quad (4)$$

III. Simulated Results And Analysis

A CPW fed circular monopole antenna with and without SRR'S to obtain multiple frequency notches is simulated on FR4 substrate having thickness h=1.575mm and dielectric constant ε_r=4.4.The prototypes were designed and simulated using HFSS and compared with measured results.

A. *Frequency response of CPW Fed Circular Monopole Antenna*

Figure.1 shows the frequency response of the unloaded circular monopole antenna and it is below -10db for the entire bandwidth(3.1–10.6GHz)

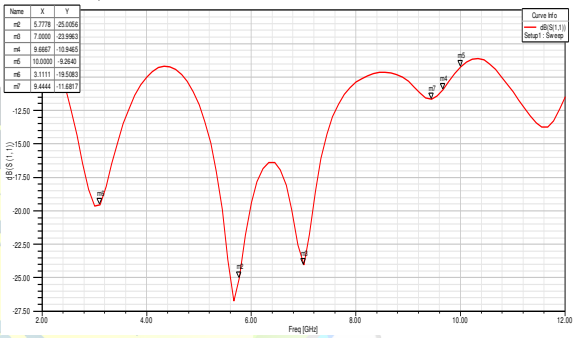

Fig .1 Simulated S_{11} Characteristics of CPW Fed Circular Monopole Antenna

B.VSWR Plot of CPW Fed Circular Monopole Antenna

The voltage standing wave ratio (VSWR) plot of the unloaded circular monopole antenna in Fig.2 is shown from which it is observed that VSWR values is less than 2 in the entire bandwidth

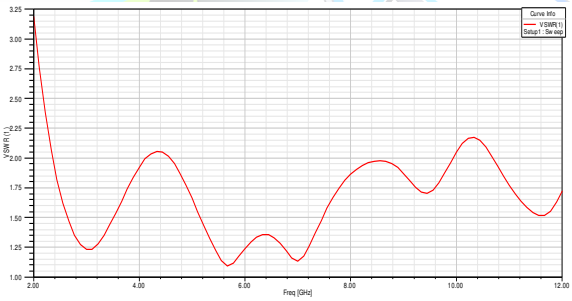

Fig.2 Voltage Standing Wave Ratio for CPW Fed Circular Monopole Antenna

C .Frequency Response of SRR Loaded with CPW Fed Circular Monopole Antenna.

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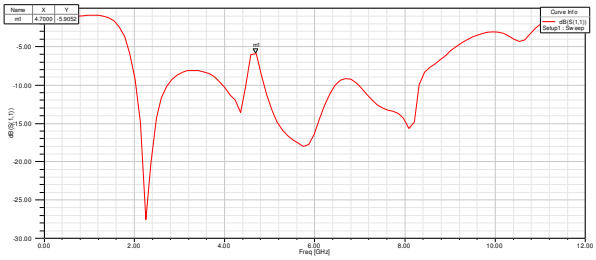

Fig .3 Simulated S_{11} Characteristics of SRR loaded with CPW Fed Circular Monopole Antenna

Figure.3 shows the simulated S_{11} characteristics of square shaped SRR loaded circular monopole antenna. The current oscillating between the SRR's exhibit filter characteristics which is determined by SRR's geometry and notches the desired frequency. In the above figure a frequency notch has been obtained at 4.5GHz which is determined by SRR's resonant frequency.

D.VSWR plot of SRR Loaded CPW Fed Circular Monopole Antenna

The voltage standing wave ratio (VSWR) plot of the SRR loaded circular monopole antenna in Fig.4 is shown , from which it is observed that VSWR values is less than 2 for the entire bandwidth except at notch frequency 4.5GHz

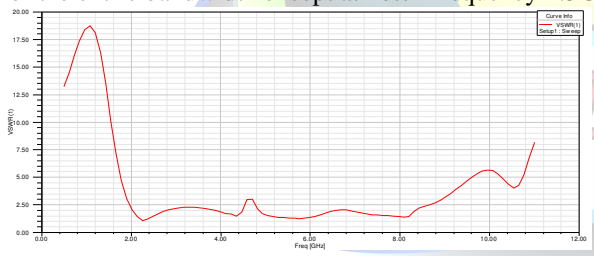

Fig.4 Voltage Standing Wave Ratio for SRR Loaded CPW Fed Circular Monopole Antenna.

E .Frequency Response of SRR Loaded Antenna to obtain dual notch

Similarly another pair of SRR is loaded on the back side of the circular monopole antenna. It exhibits similar filter characteristics and the desired frequency is notched from being generated.

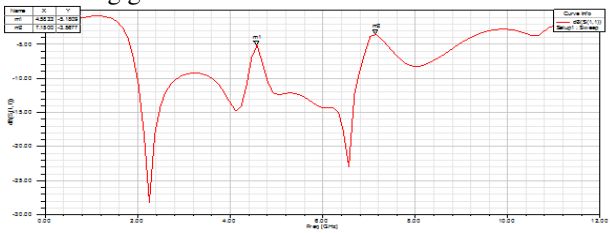

Fig .5 Simulated S_{11} Characteristics of SRR loaded with CPW Fed Circular Monopole Antenna with dual notch frequency

F.VSWR plot of SRR Loaded CPW Fed Circular Monopole Antenna with Dual Notch

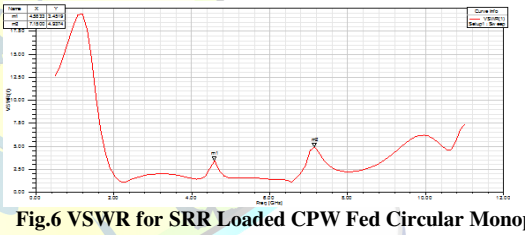

Fig.6 VSWR for SRR Loaded CPW Fed Circular Monopole Antenna with Dual Notch.

The voltage standing wave ratio (VSWR) plot of the SRR loaded circular monopole antenna in Fig.6 is shown , from which it is observed that VSWR values is less than 2 for the entire bandwidth except at notch frequency 4.5GHz and 7.1GHz.

G .Frequency Response of SRR Loaded Antenna to obtain triple notch

Figure.7 shows the simulated S_{11} characteristics of square shaped SRR loaded circular monopole antenna. The current oscillating between the SRR's exhibit filter characteristics which is determined by SRR's geometry and notches at the desired frequencies. In the above figure a frequency notch has been obtained at 4.5GHz, 5.1 GHz and 7.1 GHz which are determined by SRR's resonant frequency.

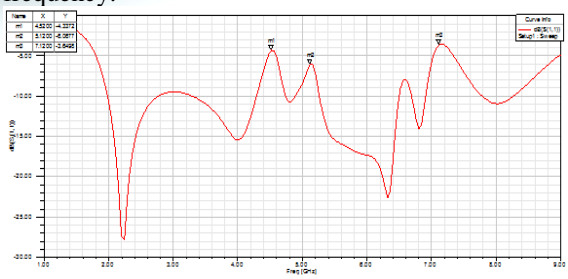

Fig .7 Simulated S_{11} Characteristics of SRR loaded with CPW Fed Circular Monopole Antenna with triple notch frequency

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H. VSWR plot of SRR Loaded CPW Fed Circular Monopole Antennawith Triple Notch

The voltage standing wave ratio (VSWR) plot of the SRR loaded circular monopole antenna in Fig.8 is shown , from which it is observed that VSWR values is less than 2 for the entire bandwidth except at notch frequency at 4.5GHz ,5.1 GHz and 7.1GHz.

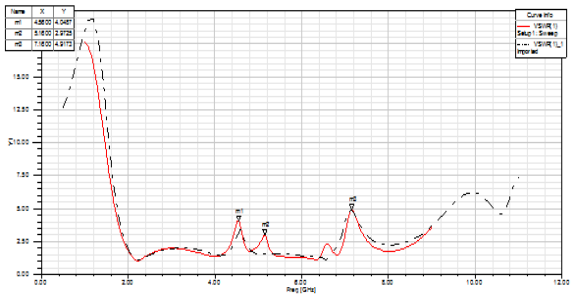

Fig.8 VSWR for SRR Loaded CPW Fed Circular Monopole Antenna with Triple Notches

I. Gain Plot of SRR Loaded Monopole Antenna with Triple Notch

Fig.9 shows the simulated plot of gain with triple notch characteristics i.e., 4.5 GHz, 5.1 GHz, and 7.1 GHz from the entire bandwidth of 3.1 GHz to 10.5 GHz.

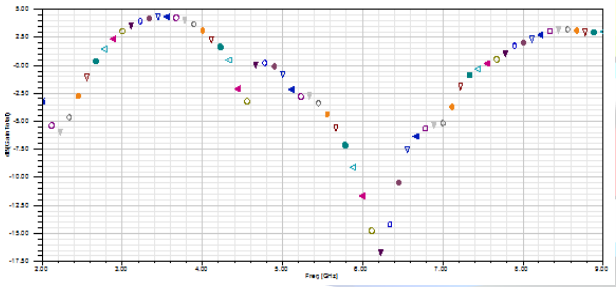

Fig.9 Gain Plot for CPW Fed Circular Monopole with Triple Notches

IV. CONCLUSION

The antenna has been designed using HFSS13.0 of 1.575 mm thickness with copper as the conducting material. The notch characteristic has been obtained for the designed antenna at three different frequencies i.e., 4.5 GHz, 5.1 GHz & 7.1 GHz. A compact CPW fed circular monopole loadedSRR with a frequency notch characteristic hasbeen proposed. The configuration works with precise positioning of the SRR on the back side of the CPW. The electromagnetic coupling between the CPW and the SRR's resonance frequency yields the desired notch. Since the antenna design and the SRR dimensions are independent of each other, the notch frequency can be customized to the desired value by changing the SRR dimensions.

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