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SRR Inspired Triple Band Notched UWB Antenna

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Abstract

In our previous paper we designed a dual band notched antenna which was having band rejection characteristics at 4 GHz (for C-band 3.7 GHz to 4.2 GHz) and at 5.5 GHz (for WLAN-band 5.15GHz to 5.825 GHz.) Now in this paper we are introducing a new band notch in previously existing dual band notched antenna to convert it into a triple band notch antenna by etching out Symmetrical Circular Split Ring Resonator (SCSRR) in ground plane to create band notching characteristic at higher frequency X band (7.25-8.4 GHz).So, now our new proposed triple band notched antenna has rejection characteristics at 4 GHz (for C-band 3.7 GHz to 4.2 GHz), at 5.5 GHz (for WLAN-band 5.15GHz to 5.825 GHz) and at 7.5 GHz (for X-band 7.25 GHz to 8.4 GHz).

Keywords

Microstrip Patch Antenna, WLAN, UWB

I. Introduction

An antenna designer has to face the challenges such as achieving radiation stability, reducing the antenna size and minimizing interference with other wireless systems. A big challenge in the design of a UWB antenna is to avoid the interference from narrow band systems like WLAN operating in the environment so that UWB technology can be operated in parallel with other existing systems. To solve this problem the UWB antennas should have band notching properties for the minimization of the interference from other active environment.

In wireless communication we mainly exploit the Electromagnetic Spectrum. Earlier systems were narrowband long range systems but in order to extend the use of available spectrum we are now using UWB (ultra-wide band) short range systems which require low power and these are built using inexpensive digital components. And Microstrip antenna is used for implementing UWB systems as it shows good broadband characteristics.

In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. This technological trend has focused much effort on the design of a Microstrip patch antenna using notched slots.

In this paper, the pattern of triple band notched Microstrip patch antenna for UWB applications have been analyzed and studied. Before designing the one more new band notch in previously proposed dual band antenna, we will have a look on our previously designed dual band notch antenna through the following figures in which primitive UWB antenna, UWB Antenna with Elliptical Complementary Split Ring Resonator (ECSRR) in Patch (for band-notch at 4.0 GHz) and UWB Antenna with Circular Split Ring Resonator (CSRR) on back side of patch (for band-notch at 5.5 GHz) is shown.

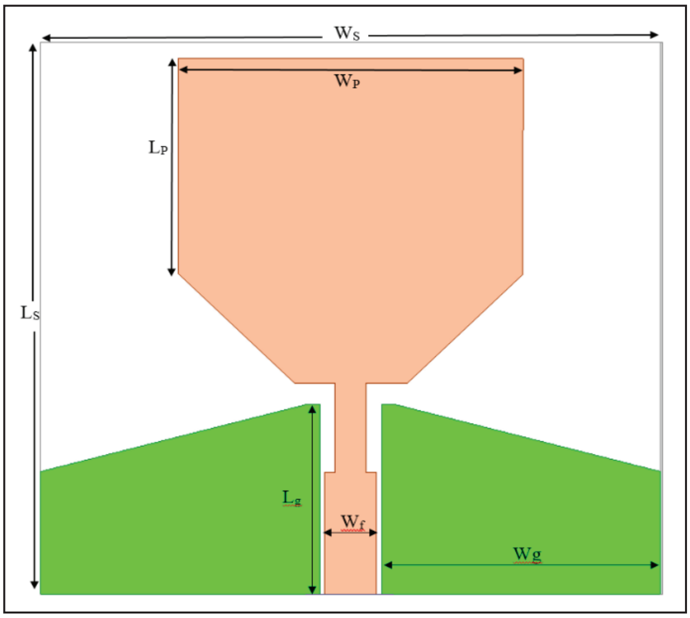

Fig. 1: Primitive UWB Antenna

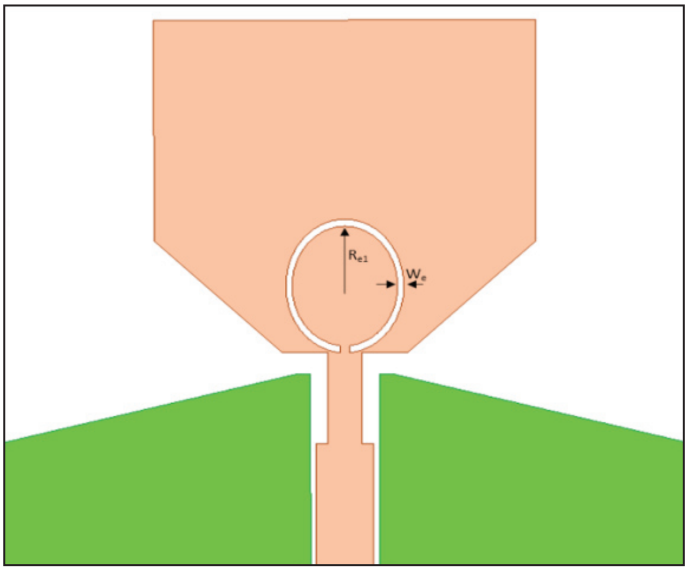

Fig. 2: UWB Antenna With ECSRR

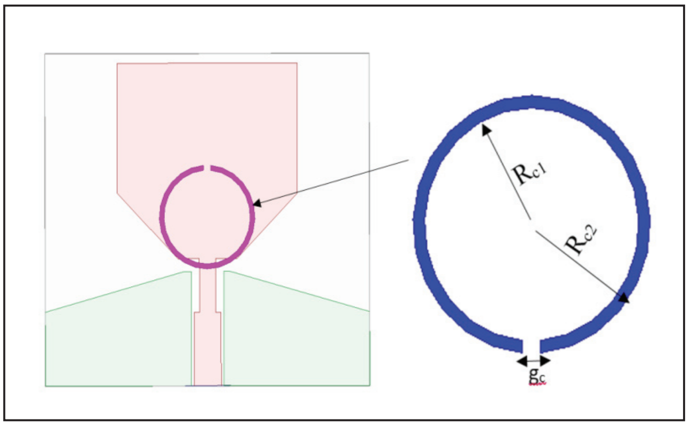

Fig.3: UWB antenna with CSRR on back Back side of patch

II. Antenna Design

A. UWB Antenna with Symmetrical Circular Split Ring Resonator (SCSRR) in ground (band-notch at 7.5GHz)

Now, at this point we are introducing a new band notch in ground as SCSRR which can be seen in the fig. 4. Proposed antenna have used Symmetrical Circular Split Ring Resonator (SCSRR) in ground plane to create band notching characteristic at higher frequency X band (7.25-8.4 GHz).

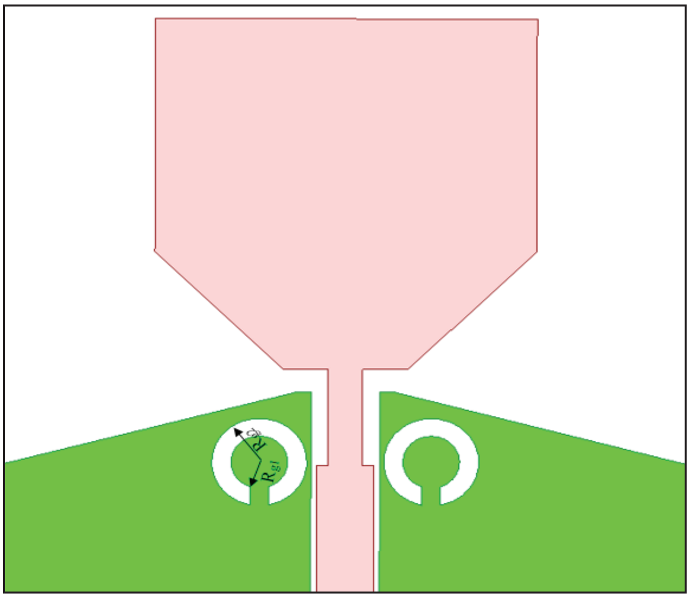

Fig. 4: UWB Antenna with SCSRR

Presented antenna is capable to overcome the interference problem due to the X band applications in UWB spectrum. Band notching characteristics of proposed X band notched UWB antenna can be seen fig. 5.

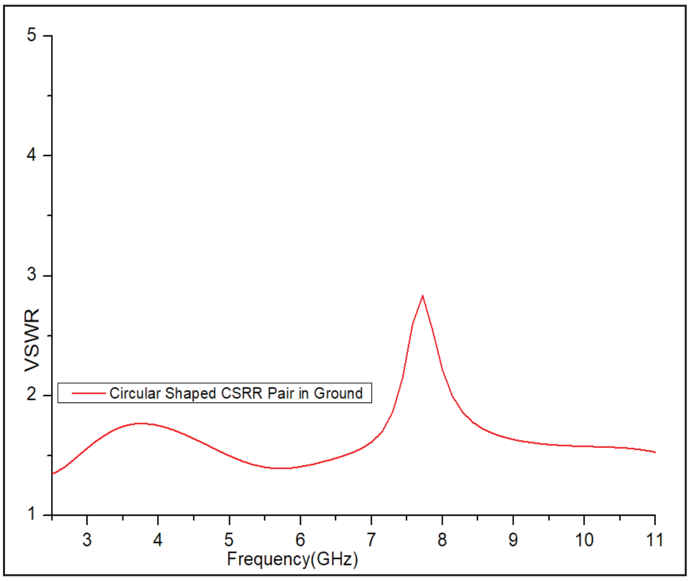

Fig. 5: VSWR Vs Frequency Curve

From the fig. 5 we can observe that VSWR of X band notched UWB antenna with respect to frequency also validate that proposed antenna can radiate/receive electromagnetic signals except X band. The proposed antenna possesses band notch or band rejection from 7.25GHz to 8.4 GHz with VSWR approximately more than 2 in this frequency range and in the rest UWB spectrum VSWR is less than 2.

Table 1: Dimentional Details of UWB Antenna with SCSRR

Parameter	Unit (mm)
R_g	1.01
R_{g1}	1.49
R_{g2}	2.5
G_2	1

The results for return loss and smith chart for antenna with SCSRR in patch is shown in the fig. 6 and in fig. 7.

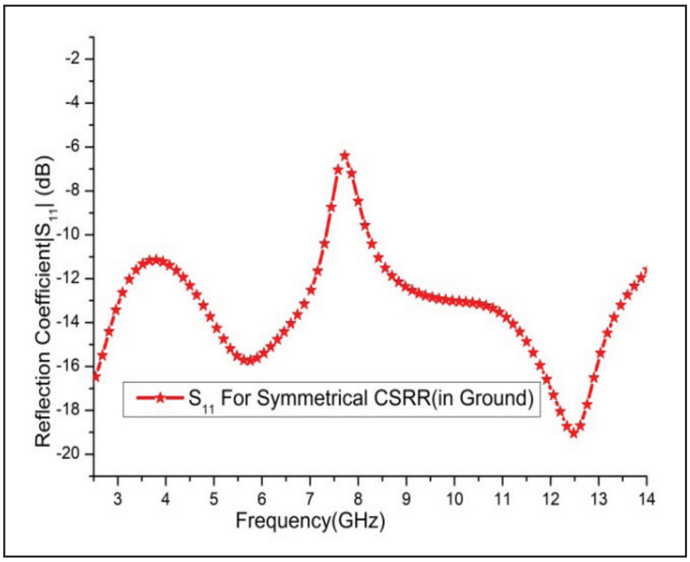

Fig. 6: Return Loss of Antenna with SCSRR in Ground

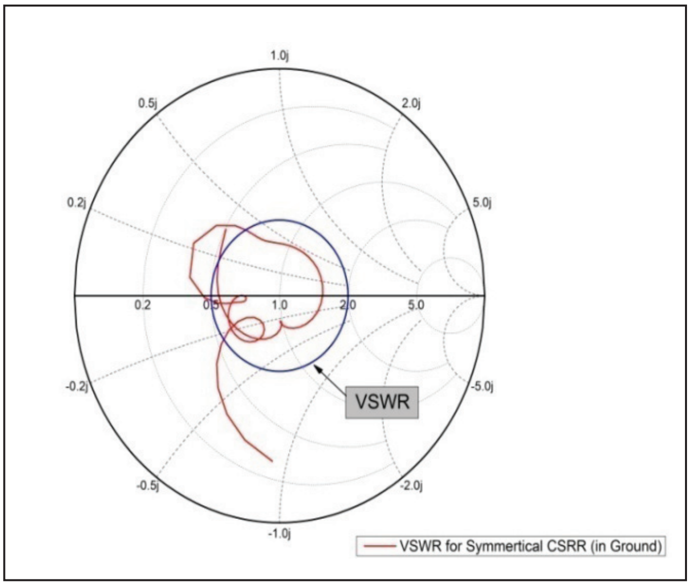

Fig. 7: Smith Chart of Antenna with SCSRR in Ground

B. Fabrication of Triple Band Notched UWB Antenna Design

The design and structure of suggested antenna has been simulated and augmented using Ansoft HFSS 13 and is presented in fig. 8. Fabricated model of microstrip patch antenna is displayed in fig. 9 and 10. For the fabrication of this proposed antenna FR-4 substrate of thickness =1.6 mm, dielectric constant ε_r = 4.4, and loss tangent = 0.02 is used. Proposed antenna has CPW feeder of width 1.8 mm and Length 15.7 mm.

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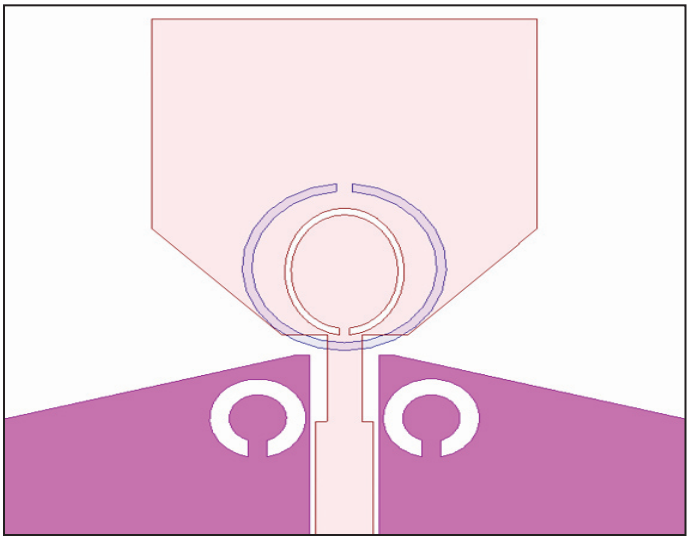

Fig. 8. Design of Proposed Antenna

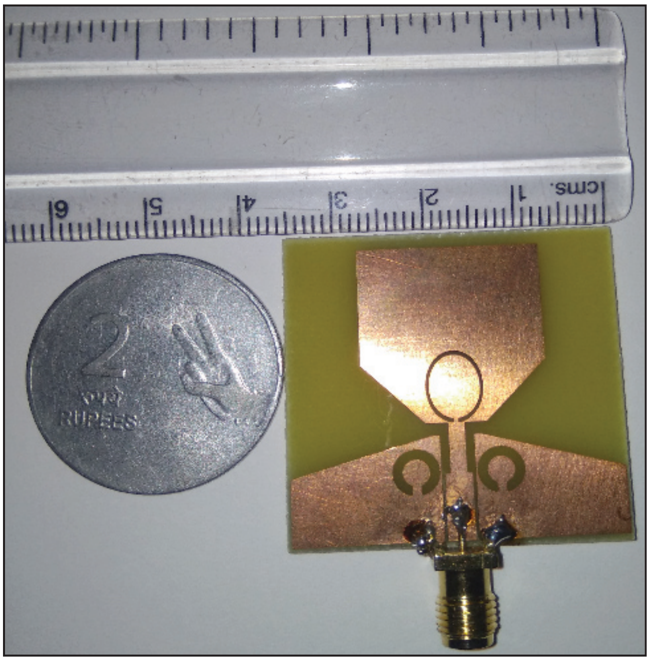

Fig. 9: Top View (Prototype) of Fabricated Antenna

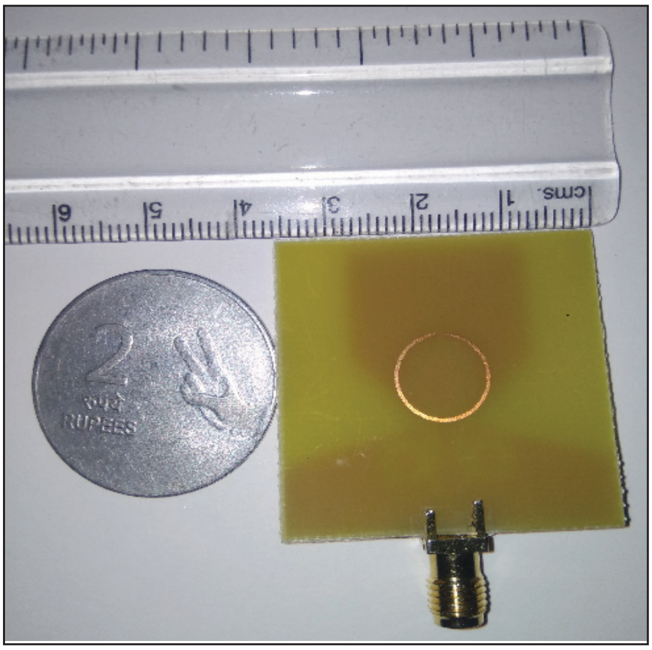

Fig. 10: Bottom View (Prototype) of Fabricated Antenna

Table 2: Optimized Measurements of Proposed Antenna

Parameters	W_G	L_G	W_S	L_S	W_p	L_p	R_{c1}
Units (mm)	16.2	7.55	36	34	20	20	1.49
Parameters	R_{g1}	G_1	G_2	G_c	W_f	L_f	
Units (mm)	4.8	0.5	1	0.8	3	13	

Fig. 11 shows the VSWR for various states of the antenna and solid line is used to present the VSWR of proposed antenna.

The antenna with Elliptical Complementary Split Ring Resonator (ECSRR) on radiating patch and Circular Split Ring (SRR) at back side of patch and Symmetrical Circular Split Ring Resonator (SCSRR) in ground successfully exhibits notched band of 3.8-4.2 GHz, 5.2 -5.8 GHz and 7.25-8.4 GHz maintaining broadband performance from 3.1 to 10.6 GHz (UWB frequency band) with VSWR less than 2.

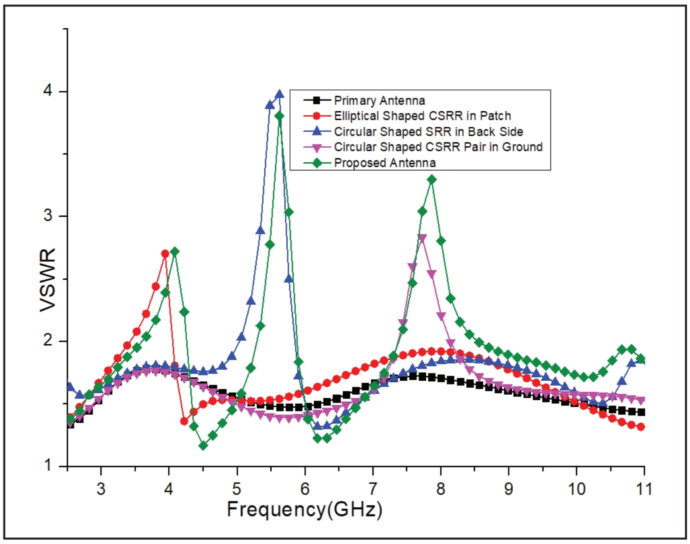

Fig. 11: VSWR Due to Various Slots

C. Parametric study of proposed Triple band Notched UWB antenna

To create band notch at X-band (7.25-7.75 GHz) Symmetrical Complementary Split Ring Resonator (SCSRR) has been used. Primarily we have calculated the resonator length with following equation

$$Leq = (2\pi Rg - G2) \quad (1)$$

$$f_c = \frac{c}{2 * L_{eq} * \sqrt{\frac{\varepsilon r+1}{2}}} \quad (2)$$

Where f_C = Resonance frequency

L_{eq} = Equivalent length of SCSRR slot
ε_r = Relative permittivity of substrate

An augmented comparable length namely L_{eq} of slot shape strip can be considered according to equation (1) with the distinction in gap size G_2. We can change the gap size G_2 over a range to optimize the equivalent length. We have established different VSWR result with varied gap size

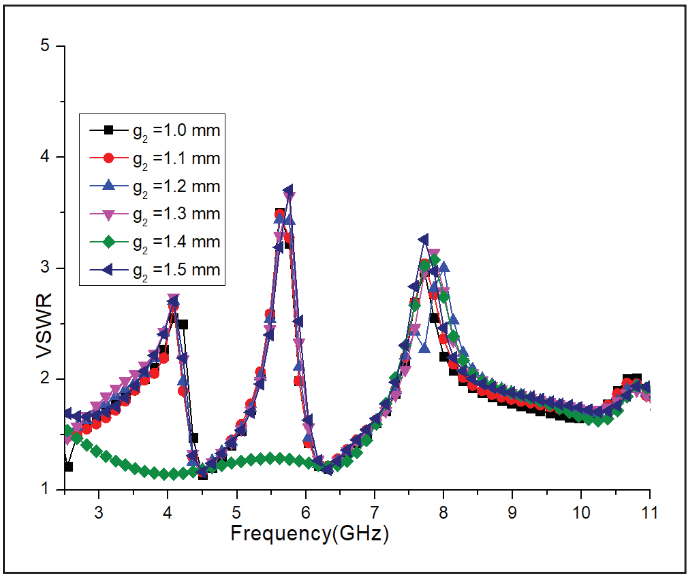

Fig. 12: VSWR Variation Due to SCSRR Gap G_2 (in Ground)

D. Measured Results of Triple Band-Notched UWB Antenna

Comparison of VSWR of simulated and measured result has been done with Vector Network Analyzer (VNA). It can be seen from the following fig. 13 that simulated results have satisfactory agreement with measured results. From measured VSWR result of suggested Triple band-notched UWB antenna it can be realized that the suggested antenna covers the complete UWB spectrum except C band, WLAN Band and X-band with VSWR less than 2.

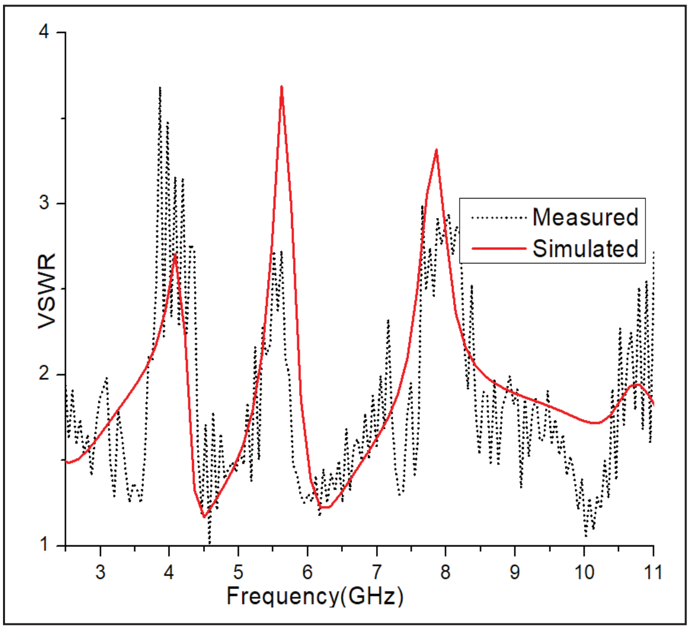

Fig. 13: Simulated and Measured VSWR Vs Frequency Graph of Triple Band Notched UWB Antenna

III. Conclusion

Today researcher's interest in the area of UWB technology has been increased due to many advantages such as high data rate, highly secure and immune towards multipath communication. In this paper, a CPW feed antenna with defected ground plane for UWB application is presented. UWB characteristic has been observed by making slot in the patch. Result, also shows band notching property from 3.7 to 4.2 GHz, 5.15 to 5.825 GHz and 7.25 GHz to 8.4 GHz therefore, the proposed antenna overcomes the signal interference problem with existing C-band, WLAN and X-band. The simulation and measured results of the designed antenna are in good agreement with each other, and therefore can be suitably used for UWB application in C-band, WLAN and X-band environments.

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