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SRR Loaded Dual Band Notched Ultra Wideband Microstrip Antenna

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***Abstract*— In this paper a compact ultra-wideband (UWB) microstrip antenna with dual band-notched characteristics is presented. The proposed antenna isdesigned on an FR-4 epoxy substrate with thickness of 1.6 mm, loss tangent of 0.02 and dielectric constant ε_r =4.4. The proposed antenna has used split ring resonator slot theory to create dual band-notched characteristics in, 3.2 - 3.5 GHz for WiMAX (widely used in Asia Pacific) and 5.1-5.8 GHz for WLAN, respectively. A vector surface current distribution is used to show the effect of SRR slots. The antenna is designed to show broad bandwidth and good omnidirectional radiation patterns in the passband, with a compact size. The proposed antenna is operated over 3 to 11GHz for VSWR < 2. All simulations in this work have been carried out by using the electromagnetic software Ansoft HFSS 13**.

***Keywords* — SRR antenna, UWB antenna, Dual band notched antenna, CSRR antenna, Microstrip antenna.**

I. INTRODUCTION

Federal communication commission (FCC) had declared Ultra Wide Band (UWB) from 3.1-10.6 GHz as unlicensed band for commercial use, and it received great attention of researchers from academics and industries for future applications in this existing unlicensed band [1]. Microstrip antennas are favorable to design UWB antennas due to the attractive merits like, compact size, low cost, ease of fabrication, and good omnidirectional radiation [2]. Existing UWB devices suffers from electromagnetic interferences due to the other narrowband wireless communication systems like, WiMAX applications in 3.3-3.6 GHz band (IEEE 802.16), WLAN systems in 5.1-5.8 GHz band (IEEE 802.11a). So, to eliminate theelectromagnetic interferences with existing systems, it is necessary to design antennas with filtering characteristic.

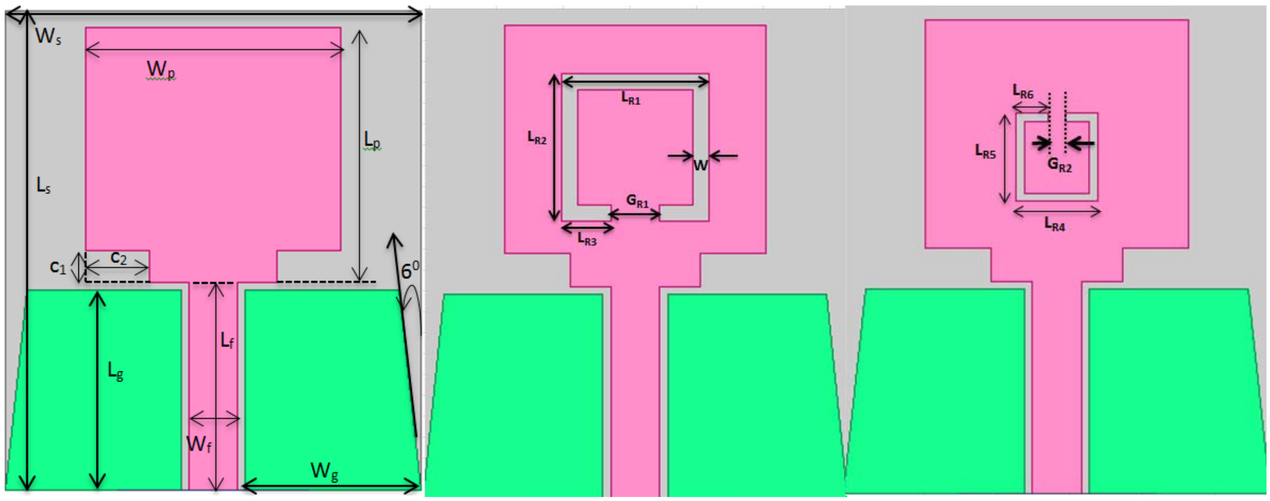
In previous years, varioustechniques have been proposed and presented to implement UWB antennas with band notched characteristics to overcome the earlier discussed problems. Generally, people used conventional methods to design UWB antenna with band notching characteristics.

To solve the EM interference problems, design antenna with band notchedcharacteristics;distinct methods have already been proposed and presented to design UWB antennas with band notched characteristics. Some antennas included different types of slots on the radiating patch or on the ground plane, use of split-ring resonators, tuning stubs, meandering, folded strips, resonated cells on CPW, EBG structure etching on patch/ground plane [3-15].

In this paper, we have proposed a compact UWB antenna with dual notched band for 3.2-3.5 GHz band (WiMAX) and 5.1-5.8 GHz (WLAN) using SRR-1and SRR-2 slot on patch respectively. The complete antenna size is 26x30 mm^2. In this paper, we have proposed a SRR slots on patch that creates band notched characteristics for WiMAX and WLAN. The complete antenna size is 26x30x1.6 mm^3.

II. ANTENNA DESIGN AND ANALYSIS

All the simulation and optimization of the proposed antenna has been done with the Ansoft HFSS 13.Configuration and geometry of proposed antenna is shown in Fig. 1. Fabricated prototype antenna has been presented in Fig.2. FR-4 substrate is used with thickness of 1.6 mm, dielectric constant ε_r = 4.4 and loss tangent of 0.02 to print the proposed antenna.Band notching process have been completed in two steps as described below with two sections A & B. A microstrip feed line of 2.8 mm width has been used to achieve 50 Ω characteristic impedance.



(a) (b) (c)

Fig.1. (a) Primary Antenna(b) SRR-1 Antenna and (c) SRR-2 Antenna

Table I

Optimized dimensions of proposed antenna

Parameter	W_s	L_s	W_g	L_g	L_p	W_p	L_f	W_f	C_1	C_2	L_2	W_1	W_2	G
Unit (mm)	26	30	11	12.5	16	16	13	3	2	4	10	1.1	1.1	5
Parameter	L_{R1}	L_{R2}	L_{R3}	G_{R1}	W	L_{R4}	L_{R5}	L_{R6}	G_{R2}					
Unit (mm)	9	8.3	3	3	1	5	5.4	2	1					

A) *SRR-1 Antenna Design (WiMAX Notched Band)*

A SRRprovides filtering characteristic so, we have useda SRR-1 slot on radiating patch to create notch in WiMAX band. Fig.1 (b) shows the antenna with SRR-1 slot, and its length has been approximately $\lambda_g/2$. Length of proposed square split ring resonator can be calculated from the equation (1) and equation (2).

$$\mathrm{Leq} = (2(\mathrm{LR1} + \mathrm{LR2} + \mathrm{LR3}) - \mathrm{GR1} - 4\mathrm{w}) \qquad (1)$$

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

The value of equivalent length L_{eq} varied according to variation in gap "G_{R1}" which is 3 mm. It is optimized to create notch at WiMAX band. All optimized dimensions of the proposed antenna have been listed in Table I.

B) *SRR-2 Antenna Design (WLAN Notched Band)*

To create notch at WLAN (5.1-5.8 GHz) band we have proposed a SRR-2 antenna and shown in Fig.1 (c).SRR-2 slot, and its length has been approximately $\lambda_g/2$. Length of proposed square split ring resonator can be calculated from the equation (1) and equation (2). But now all the dimensions will be changed according to SRR-2.

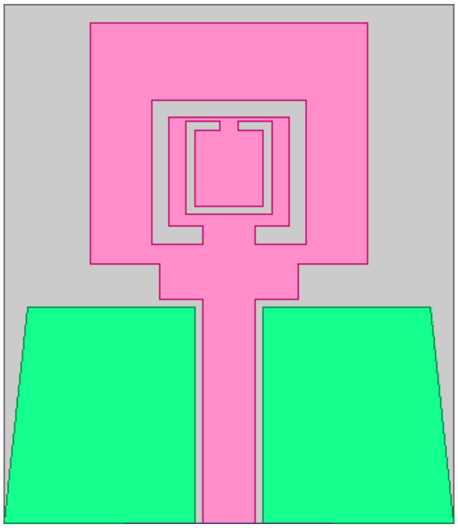


Fig.2. Proposed Antenna

Dualband notch characteristic of proposed antenna have been achieved through the below described operation.
We have first designed a primary antenna (a square patch antenna) which provides the UWB band as VSWR result shown in Fig.3.To create a notched characteristics for WiMAX applications a SRR-1 slot cut on patch and VSWR result is shown in Fig.3. WLAN applications has been achieved by drawing aSRR-2slot on patch and VSWR result is shown in Fig.3.

Proposed antenna is a combination of both the slots to create band notching characteristics and the VSWR of proposed antenna (combined both SRR-1&SRR-2) have been presented in Fig.3 by solid line.

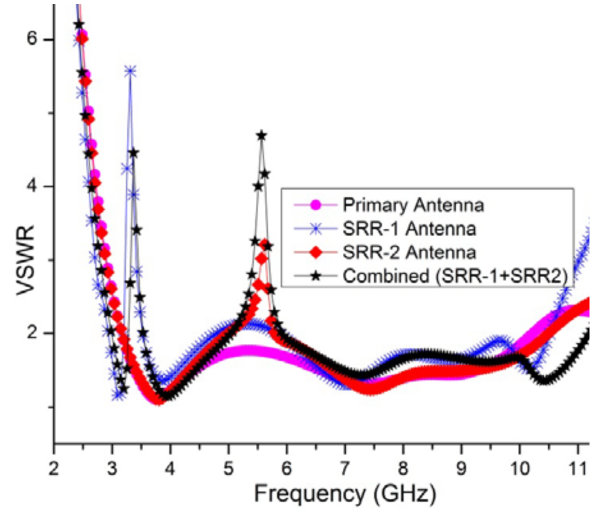


Fig.3. VSWR Vs Frequency Plot of all 4-stages of Proposed Antenna

Equivalent length namely L_{eq} of SRR-1can be optimized according to equation (1) with the variation in gap size G_{R1} or G_{R2}. We have varied gap sizeG_{R1} over a range to optimize the equivalent length and VSWR result has been shown in Fig.4. From Fig.4, we can say that to find a tunable notch frequency through SRR-1 is very difficult and it will also increase complexity and spurious losses.

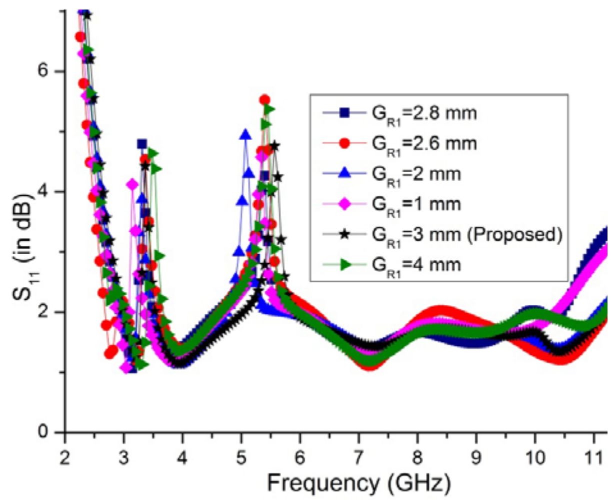


Fig.4. VSWR variation due to SRR-1gapG_{R1} Length.

Similarilly, the equivalent length namely L_{eq} of SRR-2can be optimized according to equation (1) with the variation in gap size G_{R2}. We have varied gap sizeG_{R21}

over a range to optimize the equivalent length and VSWR result has been shown in Fig.5.

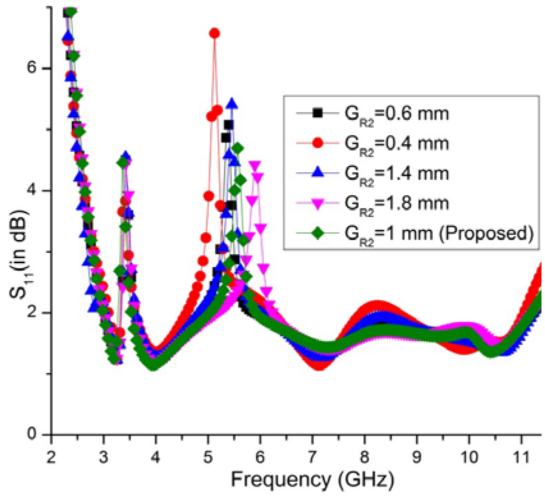
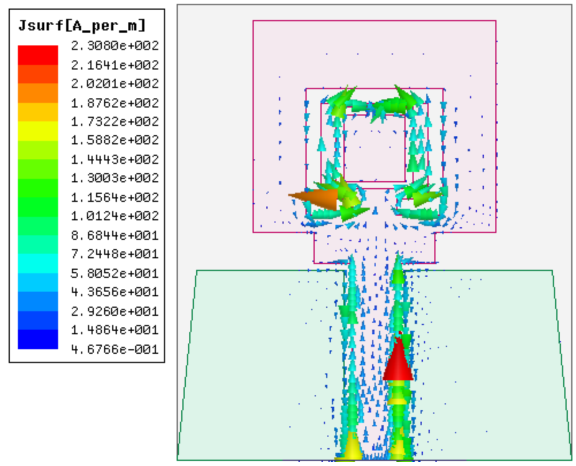
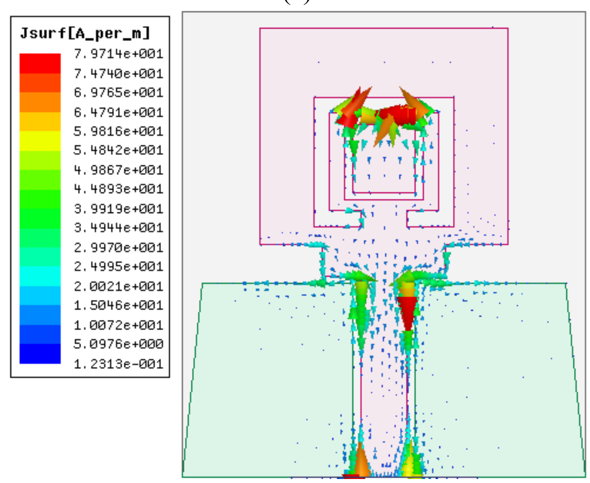


Fig.5. VSWR variation due to SRR-2 gapG_{R2} Length.

SRR-1 & SRR-2 slots have been used to provide the notched bands. The effects of SRR1&SRR-2 can be observed through the vector current distributions on the radiating patch.Vector current effects on the proposed antenna at different frequencies have been presented in the Fig.6. At desired frequencies of 3.3& 5.5 GHz i.e. the notched band, the distribution of the vector current is non-uniform shown in Fig.6 (a & b)have observed stronger vector current distributions concentrated near the edges of SRR-1 and SRR-2 slots at the center frequency of the first notched band 3.3 GHz, and the second notched band 5.5 GHz, respectively. It is a positive response of the slots to obtain the band notched characteristics.



(a)



(b)

Fig.6. Current Distribution (a) 3.3 GHz, (b) 5.5 GHz

III. RESULT AND DISCUSSION

Simulated result of proposed antennafor return loss and VSWR has been shown in Fig.7. & Fig..8. The antenna with SRR quarter wavelength slots successfully exhibits notched band of 3.2 - 3.5 GHz and 5.1-5.8 GHz, maintaining broadband performance from 3.1 to 11 GHz (UWB frequency band) with VSWR less than 2. The simulated radiation patterns at 3.2 and 4.2 GHz have been shown in Fig.9 (a) & (b). The proposed antenna displays good omnidirectional radiation patterns in the H-plane and dipole like radiation patterns in E- plane as shown in Fig.9 (a) & (b). The calculated peak gain and radiation efficiency of the proposed antenna is shown in Fig.10.

Proposed antenna shows the successful band notch creation and broad bandwidth with VSWR < 2.The simulated normalized E-field & H-field co and cross polarization patterns at 3.2 and 4.2 GHz have been shown in Fig.9 (a & b). The antenna displays good omnidirectional radiation patterns in the H-plane and dipole like radiation patterns in E- plane. Measured radiation pattern shows the good agreement with simulated results. The calculated realized peak gain and radiation efficiency of the proposed antenna is shown in Fig.10. Radiation efficiency and realized peak gain both are approximately -1dB for the WLAN bandand for WiMAX band peak realized gain, which means antenna could not receive or radiate power properly so the radiation efficiency is very low for WiMAX band and WLAN i.e. approximately 10% only that shows very low power will be radiated or received by the proposed antenna.

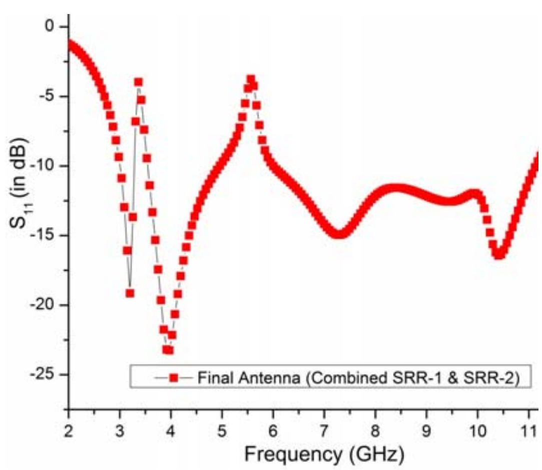


Fig. 7. Return loss S_{11} Vs frequency

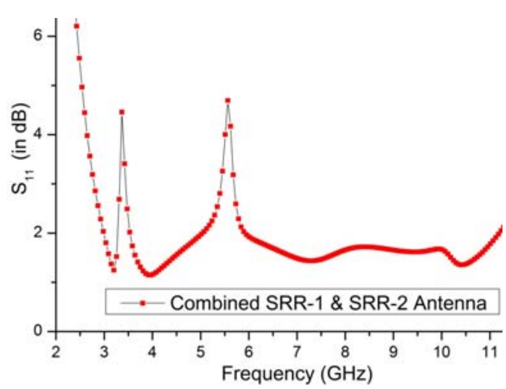
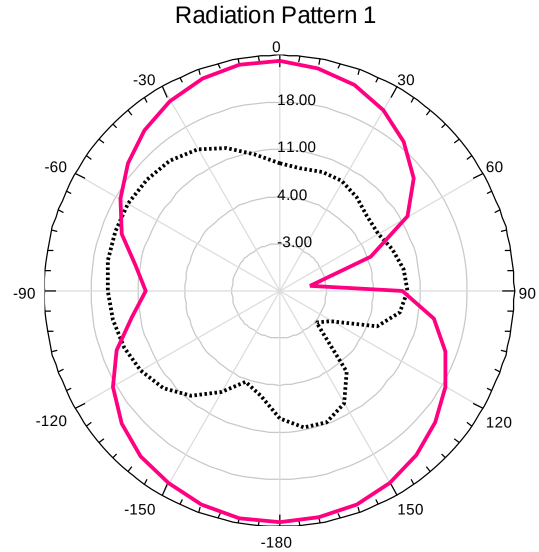
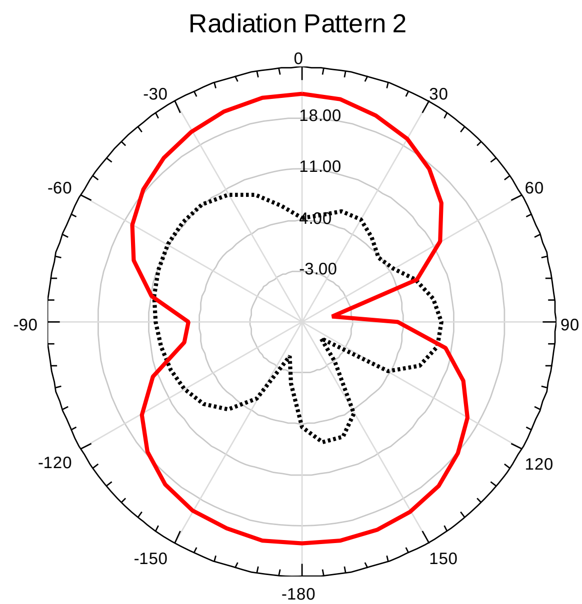


Fig.8. VSWR Vs frequency



(a)At 3.2 GHz (……H-Field, _____E-Field)



(b) At 4.2 GHz (……H-Field, _____E-Field)

Fig.9.Simulated result of E-plane (solid line) and H-plane (dotted line)

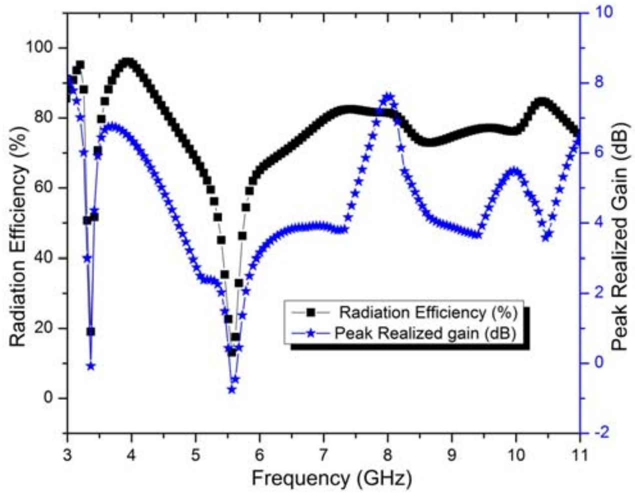


Fig. 10. Simulated Radiation Efficiency and Peak Realized Gain

IV. CONCLUSION

Proposed antenna covers UWB band and band stop filtering characteristics of SRR has been used to minimize the interference problems from WLAN and WiMAX applications. This antenna has simple structure and compact size of 26 x 30 mm ^{2}, Results & analysis of this antenna indicates that SRR approach is better than slot method to produce band notch.

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