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A COMPARATIVE EVALUATION OF TRIPLE FREQUENCY NOTCHED UWB ANTENNA

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ABSTRACT

A comparative study of compact coplanar-waveguide (CPW) fed ultrawideband (UWB) printed monopole antenna (PMA) with triple frequency notching achieved by using single ring split ring resonators (SRR) is presented and validated here on two different substrates such as FR4 Epoxy material and RT Duroid 5870 material. Here also a comparative design study made on two substrates in order to study the effect of permittivity and height of substrates on this antenna. Here the antenna loaded with three single ring SRRs to create triple band notches, in 3.5 GHz for WiMAX, 5.5 GHz for WLAN, and 7.9 GHz for X-band satellite communication systems, respectively. Return loss and voltage standing wave ratio (VSWR) are used to show the effect of these rings. The measured result shows a close correlation to the theoretical results.

KEYWORDS: Ultrawideband (UWB), monopole antenna (PMA), split ring resonator (SRR), WLAN, WiMAX, X band

INTRODUCTION

Ultra-wideband (UWB) communication systems have the promise of very high bandwidth, reduced fading from multipath and low power requirements. Ultra-wideband is a technology for transmitting information spread over a large bandwidth ranging from 3.1GHz to 10.6GHz this should share spectrum with other system users. The main concept behind UWB radio systems is that they transmit pulses of very short duration, as opposed to traditional communication schemes, which send sinusoidal waves. The role that UWB antennas play in all of this is that they have to be able to transmit these pulses as accurately and efficiently as possible. Ultra-wideband characteristics are well-suited to short-distance applications, such as peripherals of PC. Due to low radiation levels accredited by regulatory agencies, UWB systems tend to be short-range indoor applications [1]. There also some existing narrow band systems such as WLAN, WiMAX, HIPERLAN which overlap with the other frequencies in the designated UWB spectrum. Due to the coexistence of the UWB system with frequency bands reserved for narrowband wireless technologies, there is a need for notching methods to provide filtering in order to avoid interference from, or causing interference to, narrowband devices. Till this time there are some antennas are implemented by making several variations in radiator or ground plane. There are many designs are completed. Notch properties are accomplished by using altered ground plane [2]-[4]. Other design configurations are dual-frequency notch and wideband notching by loading SRRs on the CPW-fed monopole antenna [5]-[7], which is designed on a high cost Taconic substrate, compared to other substrates it's market availability is very less , also this paper uses dual pair of double ring SRR with split gaps on opposite sides.

This paper describes an impressive method to design a frequency notched UWB antenna by loading single ring multiple SRRs on the back side of a CPW fed PMA and it is designed on RT Duroid 5870 material, this paper also a made a comparison with the same antenna designed on low cost FR4 Epoxy material[8]. The single ring SRRs are placed symmetrically on the opposite surface of the printed planar monopole antenna along the signal

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line which results in a notch frequency. Resulting notch frequency changes in accordance with the dimensions of single ring 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 behave as magnetic dipoles. The propagating EM signal induces an electro-motive force on the SRR, which in turn induces oscillating current within the single ring SRR [9]. 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 weak radiation at the desired notch frequencies. Multiple notches can be achieved by loading multiple SRR with different geometrical dimensions.

In this analysis simulated results shows the effect of rings on RT Duroid material. Proposed antenna have three frequency notches such as 3.5GHz WiMAX notch, 5.5GHz WLAN notch,7.9GHz X band notch by combining these three in a single printed circular monopole antenna giving triple frequency notch. Here single ring SRR yields a quasi-static resonance that is the notching at a specific frequency [9]. In case of other SRR loaded frequency notched antennas, most of them uses dual pair of double ring SRR for a single frequency band notching. Here used a single ring SRR alone for a specific frequency band notching, thus three single circular rings are used for triple frequency notching also it is designed on RT Duroid 5870 substrate having low permittivity and short substrate width. This work made a comparative design study on RT Duroid 5870 substrate with the same antenna on FR4 Epoxy material [8], in order to understand the effect of dielectric permittivity and substrate height of a substrate on SRR frequencies and notching approaches.

PROPOSED ANTENNA MODEL

Schematic of the prospective antenna with triple frequency notch is shown in Fig.1. The suggested antenna is fabricated on RT Duroid substrate having relative permittivity, $\varepsilon r=2.33$ and thickness $h=1.575mm$ in order to get better notching results than the preceding structure [8]. In comparison with the preceding antenna structure, here the circular SRR ring's split gaps are 180^{o} out of phase from each other ring. The prospective design is shown in Fig.1 (a) and design parameters are described in Table I. The circular UWB monopole having radius R is fed by a co-planar waveguide feed consisting of ground planes having widths W_1 and W_2, length *Ls* and a signal line having length *Ls+t* and width *S.* The slots between the signal line and ground planes have width *Sg*. Antenna mounted with three circular shaped single ring split ring resonators with split gaps are 180^{o} out of phase from each ring, shown in Fig. 1(a), where *r* is the radius of the SRR, conductor width *w* and the split gap *g*. Circular shaped single ring SRRs of three different dimensions are printed on the opposite surface of a feed line separated by the substrate height *h*, as shown in Fig. 1(b). A single ring SRR is shown in Fig.1(c). having dimensions *ri*, which is radius of SRR, conductor thickness *di*, and split gaps *wi*, where *i*=1,2,3 corresponding to the SRR 1,2,and 3 respectively. Table 1 shows the design specifications used for the prototypes. There are some designs changes occur when the proposed antenna is designed on RT Duroid 5870 substrate compared to the antenna in FR4 Epoxy material [8]. Here also the SRR's and antenna dimensions are accurately calculated by using the design equations [8] by considering the operating frequency of PMA and SRR.

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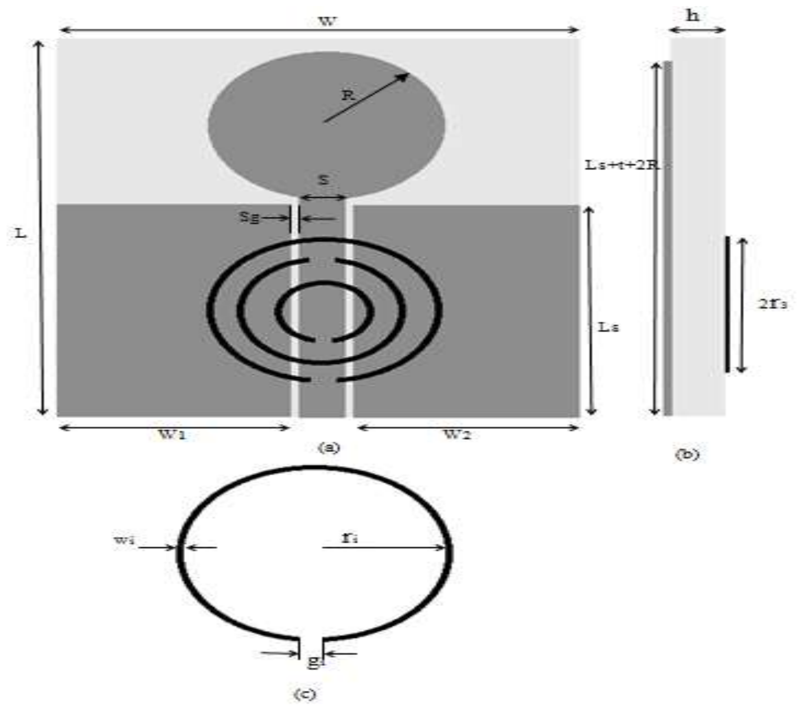

Fig.1. (a) Schematic of a printed circular monopole fed by CPW on RT Duroid : Top view with SRR printed in the back side (b) Side view of the printed circular monopole antenna fed by CPW loaded with SRRs(c) Schematic of circular single ring SRR having dimensions ri, wi and gi, where i=1,2,3 corresponding to SRR 1,2 and 3

Table 1. Design parameters for CPW fed printed planar monopole antenna having triple frequency notch

Design parameters	Dimensions (mm) RT Duroid 5870
R	12.5
L	60
W	50
W1=W2	22
S	5
Sg	0.5
Ls	34
t	0.4
r_1	1.3
w_1	0.3
g_1	2
r_2	6.38
w_2	0.3
g_2	2
r_3	4.29
w_3	0.3
g_3	0.8

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SIMULATED RESULTS AND ANALYSIS ON RT DUROID 5870 SUBSTRATE

A CPW fed circular monopole UWB antenna with SRRs to attain triple frequency notches is simulated on RT Duroid 5870 substrate having thickness h=1.575mm and dielectric constant εr=2.33. Compared to FR4 Epoxy material RT Duroid is a low lossy substrate and its permittivity affects the resonance frequency of SRR. The simulated results give notches at the three frequencies, such as, 3.5GHz, 5.5GHz and 7.9GHz. Fig. 2 shows the simulated return loss characteristics of the antenna in RT Duroid, from figure it can be seen that, the antenna offers better notching at the three frequencies, which is better the performance of antenna in FR4 Epoxy material [8]. The return loss is much higher than -10dB at these three frequencies. Also Fig.3 gives the simulated VSWR results, from which the VSWR at these three frequencies is very much higher than 2, that means the signal at these three frequencies reflected back and its transmission gets rejected. These all are because of the substrate having low permittivity and small substrate height material induces less capacitance. Here also the comparison of the new proposed antenna with triple frequency notched antenna designed on FR4 epoxy material [8] according to the variations of substrate height and permittivity are summarized in Table 2.

a. Simulated return loss and VSWR characteristics

The return loss characteristics of antenna on RT Duroid substrate is shown in Fig.2. By comparing the simulated results of FR4 Epoxy material [8] with RT Duroid substrate, we can perceive that the antenna performance is strongly affected by the substrate permittivity. The performance of the proposed antenna is improved when using the substrate having low dielectric permittivity and low lossy behavior.

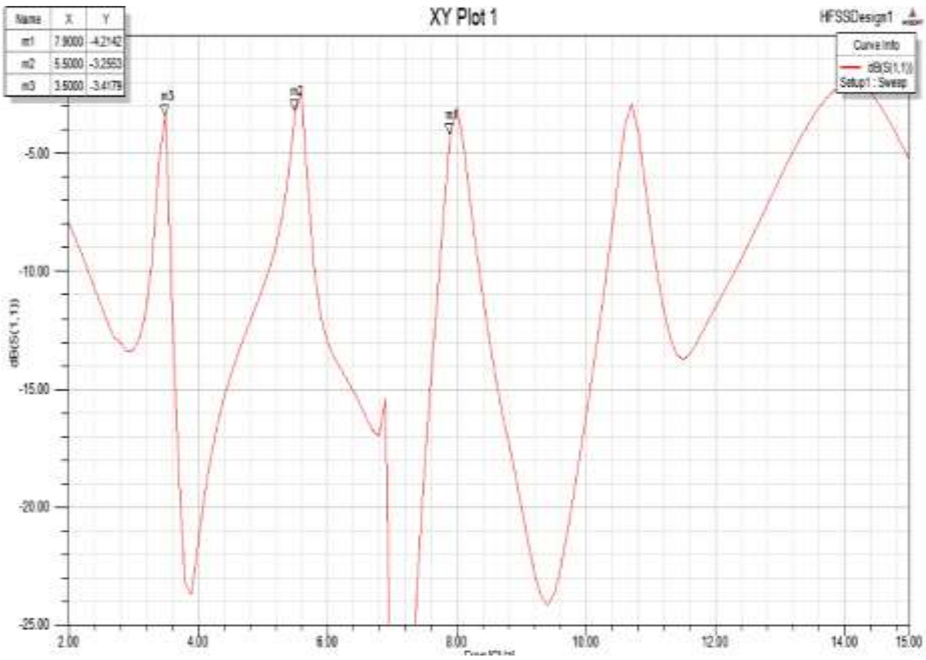

Fig.2. Simulated return loss of triple frequency notched planar UWB monopole antenna on RT Duroid

b. Simulated VSWR characteristics

The VSWR characteristics of antenna on RT Duroid substrate is shown in Fig.3. By comparing the results of FR4 Epoxy material [8] with RT Duroid substrate, we can perceive that the antenna performance is strongly affected by the substrate permittivity. The performance of the proposed antenna is improved and here it provide better impedance matching when using the substrate having low dielectric permittivity and small substrate width.

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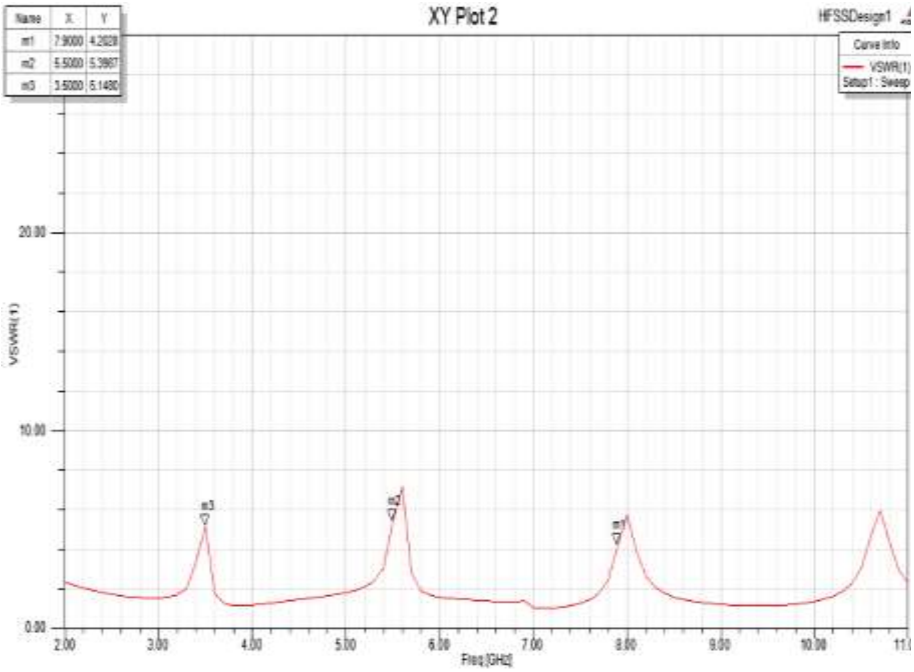

Fig.3. Simulated return loss of triple frequency notched planar UWB monopole antenna on RT Duroid 5870

Table 3. Comparison table

Substrate	Permittivity	Substrate height(in mm)	Return Loss(in dB)			VSWR		
			3.5GHz	5.5GHz	7.9GHz	3.5GHz	5.5GHz	7.9GHz
FR4 Epoxy Material	4.4	1.6mm	-5.6 dB	-4.9 dB	-6.09 dB	2.89	3.81	2.68
RT Duroid 5870	2.33	1.575mm	-3.49 dB	-3.25 dB	-4.25 dB	5.4	7.3	5.8

After examining the return loss and VSWR plot the suggested antenna on RT Duroid material having $\varepsilon r= 2.33$ and $h=1.575mm$, deliver these better results due to substrate's low capacitance and the results are tabulated in Table 3, which is far better than the antenna fabricated on FR4 Epoxy material [8].

CONCLUSION

A CPW fed circular monopole UWB antenna loaded with circular single ring SRR with triple frequency notch characteristic on RT Duroid material has been proposed and presented in this work. The paper also studied the effect of dielectric permittivity and substrate height on the resonance frequency of SRR and the antenna performance. The performance of the antenna is better in materials having low values of dielectric permittivity. That is dielectric with lowest dielectric constant ($\varepsilon r = 2.33$) provide better impedance matching, hence has

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nominal effects and do not disturb much the performance characteristics of the antenna. The obtained results also indicate that return loss and VSWR increases, however notched bandwidth decreases with the low permittivity material. These effects are due to less capacitance of the substrate having low permittivity and small substrate height. By analyzing these results, the obtained results are summarized and we can easily say that the suggested antenna offers better notching than the predecessors. The configuration works with accurate positioning of the SRRs on the opposite side of the feed line. The electromagnetic coupling between the SRRs and the CPW feed line at its resonance frequency yields the desired frequency notch. The antenna dimensions and the SRR dimensions are independent of each other, SRR dimensions only depends on notching frequency. The notch frequency can be varied to the desired value by varying the SRRs dimensions.

REFERENCES

[1] Hedayat Rousta, Mohammad Naser-Moghadasi, and Bal S. Virdee, "Compact UWB Planar Monopole Antenna ",IEEE Antennas and wireless propagation letters, VOL. 8, 2009
[2] Q.-X. Chu and Y.-Y. Yang, "A compact ultrawideband antenna with 3.4/5.5 GHz dual band-notched characteristics," *IEEE Trans. Antennas Propag.*, vol. 56, no. 12, pp. 3637–3644, Dec. 2008.
[3] C.Y. Hong, C.W. Ling, I. Y. Tarn, and S. J. Chung, "Design of a planar ultrawideband antenna with a new band-notch structure," *IEEE Trans. Antennas Propag.*, vol. 55, no. 12, pp. 3391–3397, Dec. 2007.
[4] J. Y. Sidiqui, C. Saha, and Y. M. M. Antar, "Compact SRR loaded UWB circular monopole antenna with frequency notch characteristics," *IEEE Trans. Antennas Propag.*, vol. 62, no. 8, pp. 4015–4020, Aug. 2014.
[5] J. Y. Sidiqui, C. Saha, and Y. M. M. Antar, "Compact Dual SRR loaded UWB monopole antenna with dual frequency and wideband frequency notch characteristics," IEEE antennas and wireless propagation letters, vol. 14, 2015.
[6] R. Marqués and F. Martín, "Split ring resonators and related topologies," in *Theory and Phenomena of Metamaterials*, F. Capolino, Ed. Boca Raton, FL, USA: CRC Press, 2009, ch. 16.
[7] J. D. Baena, R. Marques, J. Bonache, F. Martín, F. Falcone, T. Lopetegi, M. Beruete, M. A. G. Laso,J. Garcia, M. Sorolla, and F. Medina, "Modified and complementary split ring resonators for metasurface and metamaterial design," in Proc. 10th Bianisotropics Conf., Ghent, Belgium, 2004, pp. 168–171.
[8] Anju A Chandran and Shiney Thankchan, "Triple frequency notch in UWB antenna with single ring SRR loading", Elsevier, Procedia Computer Science, Volume 93, 2016,pp 94-106
[9] Jamel BT, Mondher L and Fethi ,C "A New Proposed Analytical Model of Circular Split Ring Resonator". 2011Journal of Materials Science and Engineering B1, pp. 696-701.

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