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DESIGN OF A CIRCULAR MONOPOLE ANTENNA HAVING TRIPLE BAND NOTCHED UWB APPLICATIONS

Milan Kumar, Deepali Singh

Department of Electronics & Communication Engineering, Ajay Kumar Garg, Ghaziabad

***Abstract* - The EM conduct of the coplanar waveguide fed, filled split ring resonator to the ultra-wideband antenna with triple band notched symptoms have offered. In this paper, the antenna has been fed from 50ohm microstrip feed file and has a rare shape. The size of proposed antenna 30x35x1.6 mm^3 is very compact and easy to integrate with handheld devices. The antenna having major bandwidth from 2.49GHz to 10.65GHz with VSWR < 2 over the entire range except at these three band notches, for WiMax at 2.98 to 4.09 GHz, WLAN at 5.17 to6.1 GHz and X- band satellite communication system at 6.99 to 8.15 GHz. The radiation pattern of H-plane is omnidirectional and radiation pattern of E-plane exhibits like a dipole. The antenna gain is stable across the absolute operating frequency besides at these three notches. Therefore, a VSWR< 2 with a large bandwidth was cognizable. This work investigates several problems simulated using HFSS (High frequency structure simulated) tool.**

Keywords: - Ultra-wideband (UWB), Circular Monopole, Triple band-notched antenna, Split Ring resonator (SRR).

I. INTRODUCTION

In 2002, the FCC (Federal Communications Commission) release of 10 dB unlicensed bandwidth of 7.5 GHz, ranging from 3.1 to 10.6 GHz by effective isotropic radiated power (EIRP) spectral density as -41.3 dBm/MHz for commercial use in radio communication. The UWB communication has witnessed all over the world to make use of this bandwidth for enhanced data rate and a variety of other purposes. The UWB communication has the inherent advantage of small size, low power consumption, simple structure and ease of concord together with high transmission rates and relatively good omnidirectional property. While 7.5 GHz bandwidth is the core motivation for developing high data rate Devices, which may potentially meddle with UWB communication such as WiMax system at 3.69 GHz, WLAN communication system operating at 5.63 GHz and X-band satellite communication system at 7.57 GHz. While having 6.99 to 7.49 GHz for downlink and 7.65 to 8.15 GHz for uplink communication. The antenna being an essential component of UWB communication, it is thus incumbent to design the same having band notched function to avoid interference with the excluding wireless network technologies. The main challenge in designing an UWB antenna for indoor communication system is the avoidance of interference with egress narrowband services, which may cause potential interference.

Characteristic of the multi-frequency signal rejection, complementary co-directional SRR is promising for UWB antenna insure multiple notched bands. With its help in this communication, single, dual, triple notched bands can be easily cognizable at such a dense antenna respectively. Especially, the proposed triple band notched antenna is designed for three suitable applications in a small enough size. In the recent literature, the UWB monopole planar antenna is widely used due to its simple structure and low cost. Several designs of monopole planar UWB antenna have proposed. Some of these antennas, it involves complex calculation and complicated fabrication process. Therefore, we use a simple method to design the CPW feed circular monopole antenna using UWB applications with notch characteristics.

II. PROPOSED ANTENNA DESIGN

This paper describes a design of a triple band UWB circular monopole antenna by loaded an SRR on the opposite surface of a CPW fed circular monopole

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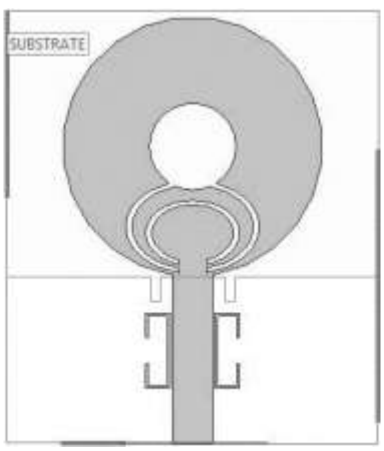
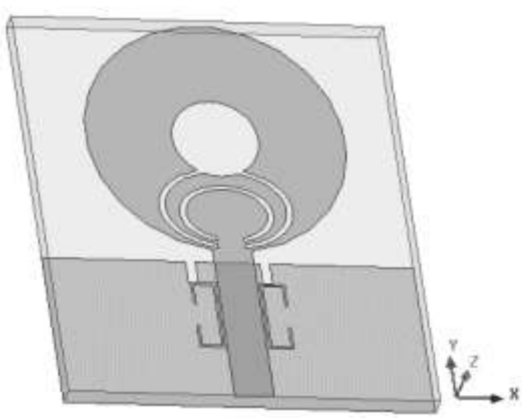
antenna. The SRR pair is inductively coupled to the radiator and loaded on the backside of the CPW feed line, which results in a notch frequency determined by the SRR geometrical dimensions. SRR is one of the metamaterials artificial structures that is implemented in antenna design for their unique negative permittivity/permeability properties. SRR will be designed using the material to achieve notches characteristics centered at 6.85GHz so as to reduce the interference from WiMax, WLAN and X-band satellite communication system. The suppression of the useless radiation from the WLAN notch frequency is due to the effect of a strong magnetic coupling between the SRR. The magnetic coupling between the SRRs are used here to filter out the undesired frequencies and avoid possible interference within the UWB (3.1 to 10.6 GHz) region.



(a)



(b)

(c)

Fig.1: Design of proposed antenna (a) & (b) Top view, (c) Side view

Theproposedantenna has optimizedby usingHFSS(HighFrequency Structure Simulator). The elliptical SRRs are cut from the circular patch and rectangular SRR is placed on the side by side of the microstrip patch with a 0.02 mm small difference should be properly arranged in such a manner so that antenna is able to operate on three different frequencies i.e. 4.63 GHz, 6.59 GHz and 8.44 GHz. The oppositecornersofthe patch aretruncatedin order tomake the antennacircularly polarized. Antenna design isshownin Fig.1. InFig.1, (a) & (b)showsa top viewofthe antennaand(c)showssideviewofthe antenna and the side view showingsubstrate, patch, groundand feedingof designingan antenna.

Parametric view of designing patch is shown in Fig.2. The dimension of each part of circular monopole antenna i.e. CSRR, SRR, ground and the patch are shown. Length and width of the antenna and each part are shown by using parameters r, r1, r2, e1, e2, e3, e4, d, f, L, L1, W R S S1 and S2. The FR-4 material substrate is used.The lengthandwidth ofmicrostripfeedarealsoindependentand could bechangeaccordingtothedesiredresults.

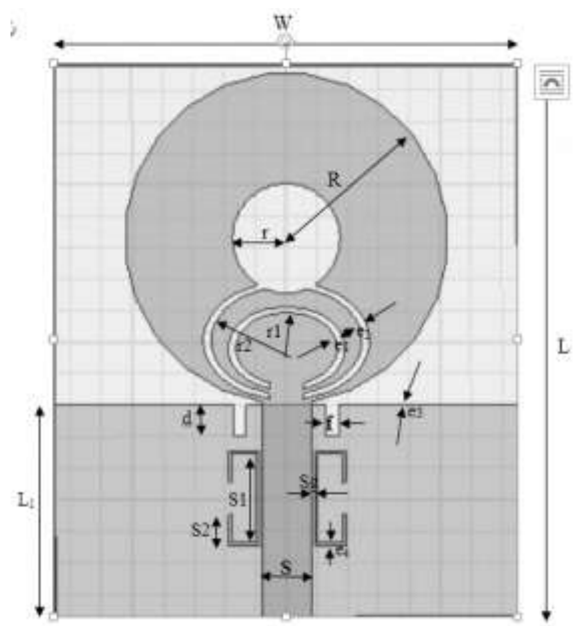
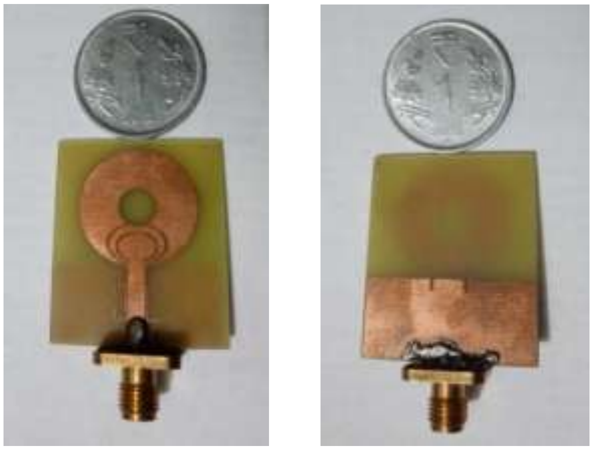


Fig.2: Patch of designing an antenna

Inthisdesign,thelengthoffeedis10mm, the width of the feed is 12 mm and that feed connect with the ground and a patch of the antenna.



(a)(b)

Fig.3: Fabricated prototype design (a) Front, (b) Back side

The circular monopole antenna having 25mm feed with coplanar waveguide loaded SRR would design using HFSS. These parameters are mentioned in Table I.

TABLE - I

Parameter	Value (mm)
L	30
W	30
L1	13.5
S	3.2
S1	6
S2	2
Sg	0.2
R	10.46
R	3.34
r1	3.3
r2	4.9
e1	0.35
e2	0.35
e3	0.122
e4	0.2
D	2
F	0.8

The propagating EM signal along the CPW having its magnetic field oriented along the axis. The SRR induces an electromotive force which turns induces a current oscillating between the two rings of the SRR. This oscillating current between two rings yield a resonance, which determined by the SRR's geometry and prohibits signal propagation at that frequency. This resonance frequency can be determined from the equivalent current approach demonstrated in which involves calculation of distributed capacitance between the rings of the SRR and total inductance of the SRR. The SRR resonance frequency can calculate from the following section. SRR resonance frequency calculated by formulae,

$$f_0 = 1/2\pi\sqrt{1}/\sqrt{LC} \quad \ldots.(1)$$

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

$$\varepsilon_{reff} = (\varepsilon_r + 1)/2 + (\varepsilon_r - 1)/2\left(1 + 12\left(\frac{H}{w}\right)\right)^{-\frac{1}{2}} \quad (2)$$

Where, ε_{eff} is the effective dielectric constant andε_r is 4.4 as the substrate is FR4, h is 1.6 mm having height of the substrate. By using, all valuesε_{eff} can be calculate.

III. SIMULATED RESULTS AND DISCUSSIION

A triple band CPW fed circular monopole UWB antenna to obtain multiple frequency notches is simulated on FR4 substrate having thickness h=1.6 mm and dielectric constant E_r=4. 4. This fabricate were designed and simulated on HFSS and compared with measured results.

The simulated quantity of the reflection coefficient (S_{11}) of the circular monopole UWB antenna having design parameters is in Table I. Figure 4 shows the frequency response of the circular monopole antenna and dip of the notch characteristics below from -10dB for the entire bandwidth (3.1 GHz to 10.6GHz). The simulated S_{11} characteristics of rectangular shaped CSRR and elliptical cut SRR loaded circular monopole antenna. The current oscillating between the SRR's exhibits filter characteristics, which determined by SRR's geometry and desired notch frequency. The rectangular shaped CSRR is placed on the backside of the circular monopole antenna and arranged side-by-side of the microstrip feed line and due to this one notch generated. In addition, the other two SRR (split ring resonator) is cut from the circular monopole patch and these SRR are generate own notches.

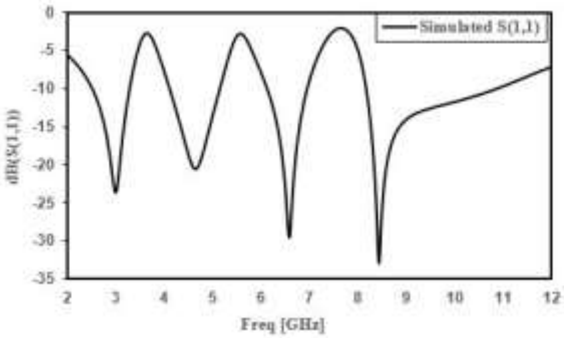


Fig.4: Simulated return loss (S_{11}) of the SRR loaded CPW fed UWB circular monopole antenna with triple notch frequency

The rectangular SRR generates one notch of WLAN, which frequency notch is obtained at 5.51GHz with-29.58dB (5.15GHz to6.13GHz) return loss.The second notch of WiMax generate due to inner small elliptical SRR, which frequency notch is obtained at 3.63GHz with -20.58 dB (3.29 to 4.11GHz)return loss. In addition, the third and last notch of X-band satellite communication is generatedbecause of outer elliptical SRR, which has 7.65 GHz frequency notch and-32.96dB (6.96 to 8.17 GHz) return loss. Moreover, the X-band satellite communication is reserve for defense services. For better rejection coefficient, the voltage standing wave ratio should be less than 2. Here, the VSWR of the triple notch circular monopole antenna is shown in Figure 5.

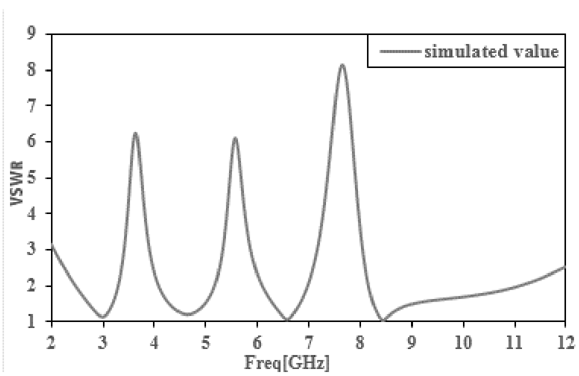


Fig.5: Simulated VSWR of the antenna

The VSWR plot of the SRR loaded circular monopole antenna is shown in above figure. The figure observed that VSWR values are less than 2 for entire bandwidth except 3.63 GHz, 5.57 GHz and 7.64 GHz notch frequencies. In addition, the measured VSWR values are shown in below figure.

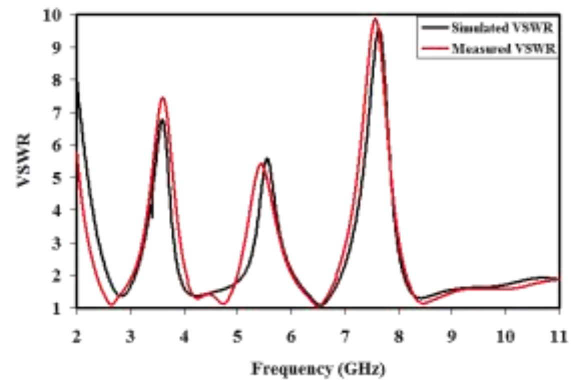


Fig.6: Simulated and measured VSWR of proposed triple notched band UWB antenna

The measured VSWR values of the proposed circular notch band antenna are shown in figure 6. It observed that VSWR value is less than 2 for full bandwidth, expect 3.63GHz, 5.55GHz and 7.61GHz notch frequencies. The measured VSWR values of the proposed antenna are 3.63 GHz at 1.04 5.55 GHz at 1.02 and 7.61 GHz at 1.00.

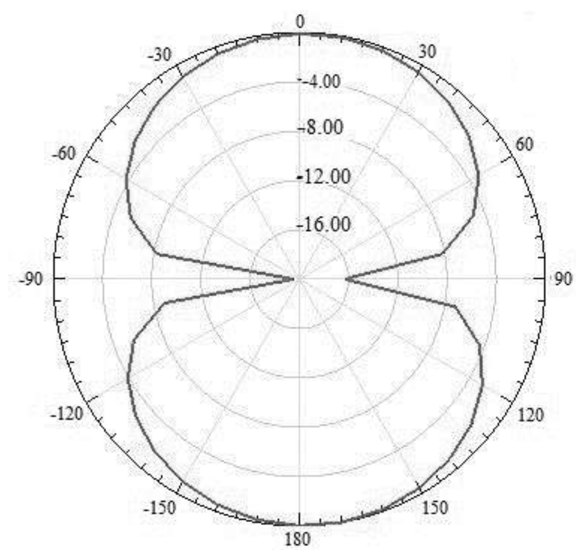


Fig.7: Radiation pattern of directional E-plane antenna

The radiation pattern shows the variation of the power radiated by an antenna is a function of the direction away from the antenna. This power variation function of the arrival angle has observed in the antenna's far field.

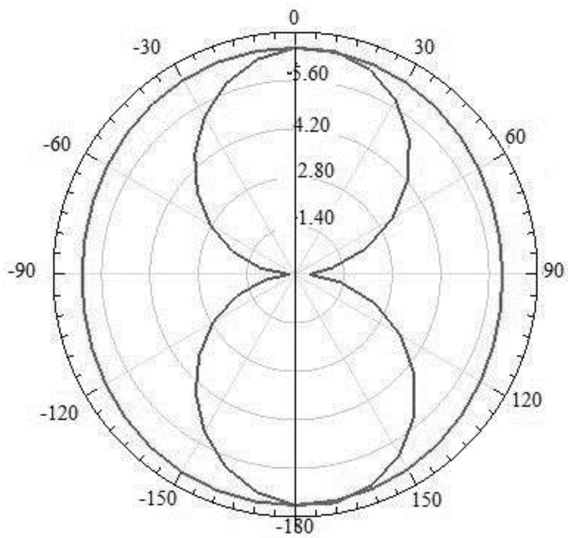


Fig.8: Radiation pattern of the E and H plane directional pattern

The center frequency of desired antenna is 6.85GHz, the whole antenna will support on the center frequency at 6.85GHz, and the bandwidth is 3.1 GHz to 10.6 GHz (Ultra-wideband frequency).TheRadiationpatternoftheproposedantenn afor6.85GHzisshowninFig.7. The design antenna shows a directional radiation pattern, in other words, an antenna radiates in a particular direction and operate its own center frequency at 6.85GHz. TheRadiationpatternoftheproposedantennafor omnidirectional pattern and directional pattern is shown in Fig.8. Radiation pattern for omnidirectional at (Phi= 0°) Ø=0° and directional pattern at (Phi= 90°) Ø=90°. Omnidirectional pattern has plotted on an XZ - Plane and the directional pattern has plotted on a YZ - plane. In Fig.7, the radiation pattern of directional antenna is also known Dipole pattern (E-Plane) and the omnidirectional pattern is on H-Plane. In Fig.8, the radiation patterns are on the EH - plane.

The simulated gain of the antenna is shown in Fig.9. The pattern of gain indicates the antenna has a stable gain over the entire UWB except at notched bands where the sharp decrease in gain is observed. Here the gain increase from 2.34dBi, up to 3.4401dBi and decrease to -7.6098dB near the notched bands. The decrease gain form -4.8442dB to -7.6098dB that mean,

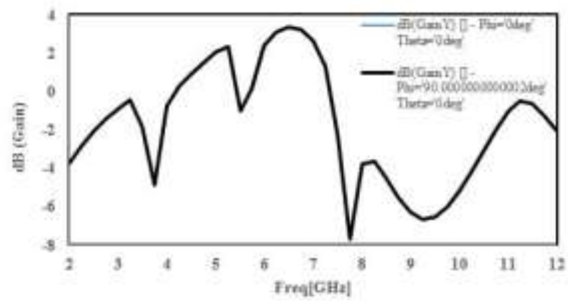


Fig.9: simulated peak gain of the proposed antenna

The antenna could not work properly at these frequencies. Moreover, the dBi mean decades with the isotropic mean at that frequency the antenna radiates omnidirectional pattern in other word, antenna radiate in all the direction equally.

IV. CONCLUSION

This paper presents the design of an SRR loaded triple notched band UWB circular monopole antenna of size of 30x35 mm^2 with 1.6mm thickness on FR4 substrate. The antenna has designed for HFSS 13.0 tool. The proposed antenna is able to cover the entire UWB spectrum except at three-notched band at 3.63 GHz, 5.51 GHz and 7.65 GHz has been obtained by an elliptical SRR cut from circular patch and one rectangular SRR in radiating patch and the microstrip feed line respectively. The rectangular SRR is the use of the WLAN band while elliptical SRR is the use of WiMax band and X-band satellite communication. A CPW fed circular monopole loaded SRR with a frequency notch characteristic has proposed. The work with precise positioning of the SRR place on the backside of the CPW. The electromagnetic coupling between the CPW and SRR resonance frequency yields the desired notch. Since, the antenna design and SRR dimensions are independent of each other; the notch frequency can be customized to the desired value by changing the SRR dimensions.

REFERENCES

[1] J.Y. Siddiqui, C Saha, Y.M.M. Antar, 2014, "Compact SRR Loaded UWB Circular Monopole Antenna with Frequency Notch Characteristics", *IEEE transactions on*

antennas and propagation, Vol. 62, No. 8, pp. 4015-4020

[2]P. Wang, G. J. Wen, Y. J. Huang, and Y. H. Sun, "Compact CPW-fed planar monopole antenna with distinct triple bands for WiFi/WiMAX applications," Electron. Let., vol. 48, pp. 357–359, 2012.

[3] D. T. Nguyen, D. H. Lee, and H. C. Park, "Very compact printed triple band-notched UWB antenna with quarter-wavelength slots," IEEE Antennas Wireless Propag. Let., vol. 11, pp. 411–414, 2012.

[4] M. -C. Tang, S. Xiao, T. Deng, D. Wang, J. Guan, B. Wang, and G.-D.Ge, "Compact UWB antenna with multiple band-notches for WiMAXand WLAN," IEEE Trans. Antennas Propag., vol. 59, no. 4, pp.1372–1376, Apr. 2011.

[5] L.-N. Zhang, S. S. Zhong, C. Z. Du, and J. H. Chen, "Compact UWBplanar monopole antenna with band-notch function," Microw. Opt.Technol. Lett, vol. 51, no. 8, pp. 1908–1911, 2009.

[6] L. Peng and C. L. Ruan, "UWB band-notched monopole antenna designusing electromagnetic-bandgap structures," IEEE Trans. Microw.Theory Tech., vol. 59, no. 4, pp. 1074–1081, Apr. 2011.

[7] W. C. Liu, "Dual wideband coplanar waveguide-fed notched antennaswith asymmetrical grounds for multi-band wireless application," IETMicrow. Antennas Propag., vol. 1, no. 5, pp. 980–985, 2007.

[8] J. Liang, L. Guo, C. C. Chiau, X. Chen, and C. G. Parini, "Study ofCPW-fed circular disc monopole antenna for ultra-wideband applications,"IEEE Proc. Microw. Antennas Propagat., vol. 152, no. 6, pp.520–526, Dec. 2005.

[9] H.W. Liu,C.H.Ku, and C. F.Yang, "Novel CPW-fed planar monopoleantenna for WiMAX/WLAN applications," IEEE Antennas WirelessPropag. Lett., vol. 9, pp. 240–243, 2010.

[10] Jawad K. Ali, "A new dual band E shaped slot antena design forwireless applications," Progress in Electromagnetic ResearchSymposium Proceedings, Suzhou, China, Sep. 12-16, 2011, pp.1258-1261.

[11] G. P. Gao, Z. L. Mei, and B. N. Li, "Novel circular slot UWBantenna with dual band-notched characteristic," Progress inElectromagnetic Research C, vol. 15, pp. 49-63, 2010.

[12] K.-H. Kim and S.-O. Park, "Design of the band-rejected UWBantenna with the ring-shaped parasitic patch," Microwave andOptical Technology Letters, vol. 48, no. 7, pp. 1310–1313,2006.

[13] C. Y. Hong, C. W. Ling, I. Y. Tarn, and S. J. Chung, "Design of aplanar ultra-wide band antenna with a new band-notch structure,"IEEE Trans.Antennas Propag., vol. 55, no. 12, pp. 3391-3397,Dec. 2007.

[14] High Frequency Simulation Software, Ansoft Corp., vol. 13.

Milan Kumar Dhiman received the B.tech degree in Electronics Communication Engineering from Sunderdeep Engineering College, Ghaziabad fromUttar Pradesh Technical University (UPTU) Lucknow, in 2014. He pursing M.tech in Electronics Communication Engineering from Ajay Kumar Garg Engineering College, Ghaziabad from Dr. Abdul Kalam Technical University (AKTU) Lucknow, from 2014. His area of interest is Antenna and Propogation in UWB region.

Deepali Singh received the B.tech degree in Electronics andInstrumentation Engineering from Uttar Pradesh Technical University (UPTU) Lucknow. Currently she is working as Assistant Professor in Electronics and Instrumentation Engineering Department of Ajay Kumar Garg Engineering College, Ghaziabad, Uttar Pradesh, India. Her area of interest is Microstip Antenna, Signal Processing and Image Processing.