OPEN ACCESS

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Triple Band-Notch UWB Planar Monopole Antenna

Chandrasekhar Rao Jetti, U. Leelasai, K. Triveni, K. Balasaikrishna, N. Surendra

Abstract*: A triple band notch printed monopole UWB antenna for portable devices is presented in this paper. The antenna is having a size of 26 x 31 x 1.6 mm^3 is fabricated on an FR4-epoxy substrate. The antenna consists of a circular monopole excited by microstrip line and reduced ground on the bottom side. The notch at WiMAX band is created by placing a C-shaped slot on the circular monopole. The second notch at WLAN band is generated by placing a couple of C-shape resonators beside the feed line. Finally, by incorporating the defected microstrip structure on feed line, the third notch at 7.83 GHz X-band satellite service is obtained. The results show that the antenna operates from 2.9 to 11.5 GHz, the peak gain of above 2.3-5.4 dBi, the radiation efficiency of more than 90 % and considerably good radiation properties except at the notched bands. The results demonstrate that the designed antenna is well fit for UWB devices.

Index Terms*: Band-notch, interference mitigation, monopole antenna, ultra-wideband.

I. INTRODUCTION

The current and upcoming wireless communication systems demand high data rate, improved quality of service, low power consumption and less interference with existing communication systems. Since FCC assigned band of 3.1-10.6 GHz for UWB system has paid ample attention because of its inherent advantages like higher data rates, more reliability, extremely less power requirement, low cost and less interference with other systems [1].

However, the existing narrowband wireless communication systems like Wi-MAX (3.3-3.7GHz), WLAN (5.15-5.825 GHz) IEEE 802.11a and X-band satellite communication services (X-band: 7.25-8.395 GHz) also working in the UWB band creating electromagnetic (frequency) interference which results in signal loss. So, the UWB antenna with the band-notching character at the interfering frequency bands is needed. Several printed UWB monopole antenna designs were reported in the past years which includes circular disc monopole [2], and circular/elliptical monopole [3]. Various methods were used in the past few years to attain single and multiple band notch characteristics for UWB systems to suppress interfering from WiMAX, WLAN and X-band systems [4-6]. Method include locating a couple of ground stubs [4]. However, the designed antenna in [4] mitigate the interference from WLAN systems only.Band-notches at WLAN as well as WiMAX bands can be obtained using meandered slot and U-slot [5]. Placing modified capacitance loaded loop (MCLL) resonators near the feed line [6], and by using open loop resonator and defected microstrip structure (DMS) [7]. The designs presented in [5-7] providing triple band notches with good performance, but they are not compact enough and band stop resonators are somewhat complicated. In this communiqué, a simple triple band notch UWB antenna is designed for use in portable devices. The proposed antenna size is 26 mm x 31 mm which a small compared to the designs presented in [4-7]. The designed antenna comprises of a circular monopole antenna with the reduced ground plane. The notches can be obtained by etching C-shaped open loop resonator on the patch, placing a pair of SRRs beside the feed line and embedding DMS resonator on feed line.

II. ANTENNA DESIGN

A. Antenna Geometry

The optimized triple notch UWB monopole antenna is depicted in Fig. 1. The antenna is etched on FR4-epoxy dielectric material. The substrate having 1.6mm height, dielectric constant of 4.4 and 0.02 loss tangent. The antenna size is 26 mm x 31 mm excited by a microstrip line. The designed antenna entails of a rounded disk-shaped monopole which actions as a foremost radiating part having radius *r* and reduced ground. By optimizing the patch radius and ground dimensions, good return loss is achieved. First notch at 3.5 GHz is realized by cutting C-shape slot on monopole. By locating a pair of SRRs near the microstrip feed line, second notch at 5.5 GHz is realized. Third notch at 7.83 GHz X-band is generated by incorporating DMS resonator on the feed line. Ansoft HFSS is used for antenna design, parameters optimization and simulations. The dimensions (in mm) are given as follows: C_1=2.7, C_2=4.6, C_3=12.6, C_4=1.8, C_5=2.75, C_6=1.9, C_7=7.6, D_1=3.4, D_2=1.72, D_3=2.3, D_4=1.08, D_5=1.66, D_6=0.44, D_7=1.02, G_{W1}=8, G_{L1}=11.6, G_{L2}=10.6, L=31, L_F=12.8, L_P=16, *r*=9, W=26, W_F=3.

Revised Manuscript Received on 22 May 2019.
* Correspondence Author
Chandrasekhar Rao Jetti, Assistant Professor in ECE department of K L E F (K L Deemed University
U. Leelasai, B. Tech degree in ECE department of K L E F (K L Deemed University).
K. Triveni, B. Tech degree in ECE department of K L E F (K L Deemed University).
K. Balasaikrishna, B. Tech degree in ECE department of K L E F (K L Deemed University).
N. Surendra, Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P., India.

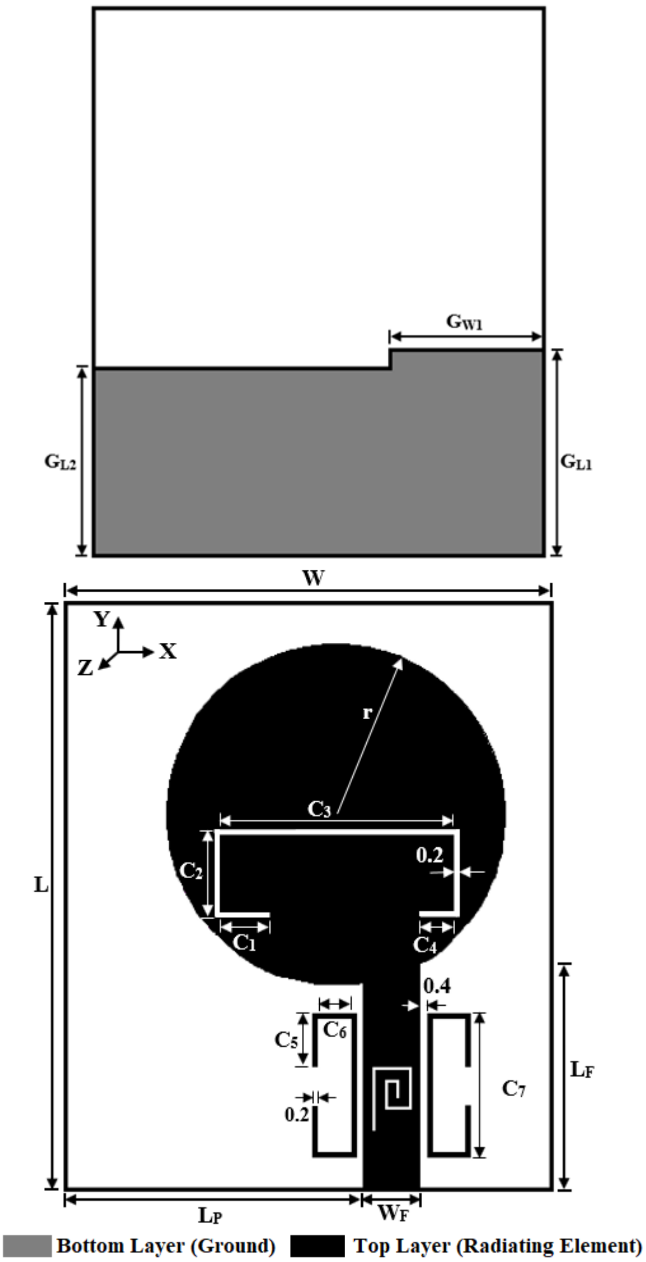


Fig. 1. (a) Proposed antenna geometry and (b) DMS resonator.

B. Antenna Evolution and Working

Antenna-1 is the elementary UWB antenna comprises of microstrip line fed circular shaped radiating monopole and the reduced ground. The return loss parameter of the Antenna-1, 2, 3 and the planned antenna are given in Fig. 2. The Antenna-1 is working from 2.9 to 11.5 GHz as observed from Fig. 2. Antenna-2 represents single notch antenna is formed by etching a C-shape slot on the monopole of Antenna-1 which results in a notch at 3.5 GHz from 3.3 to 3.75 GHz. By adding a pair of SRRs beside the feed line of Antenna-2, dual band-notched antenna namely Antenna-3 can be formed. Antenna-3 is generating dual notches from 3.3-3.83 GHz and 5.05-5.95 GHz. Finally, the planned triple notch antenna is designed by embedding DMS band-stop resonator on the feed line of Antenna-3. The antenna is providing the third notch from 7.15-8.395 GHz in addition to 3.3-3.8 GHz and 5.05-5.95 GHz bands as revealed in Fig. 2.

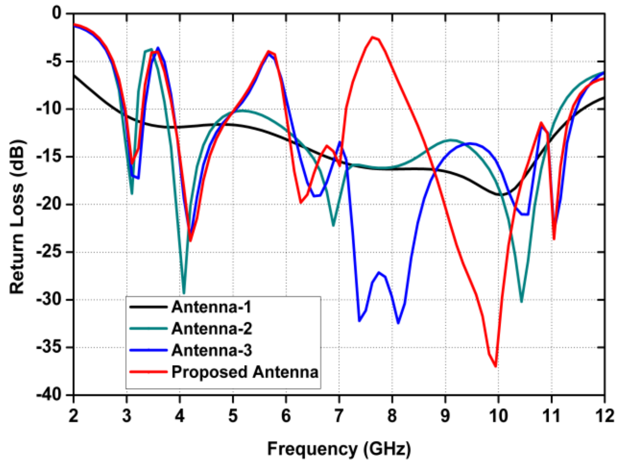


Fig. 2. The return loss parameters.

C. Effects of C-shaped Slot, a Pair of SRRs and a DMS Resonator

The effects of C-shaped slot, a pair of SRRs and DMS band-stop resonator with different lengths on the return loss of UWB antenna along with current circulation at notched bands are presented in this section. In this design, the band-stop features are attained by cutting C-shaped slot on monopole, locating SRRs near the feed and inserting DMS resonator on the microstrip feed line. All the three resonators are of length λ/2 at the notch center frequency, where λ is guided wavelength which is specified by the equation (1)

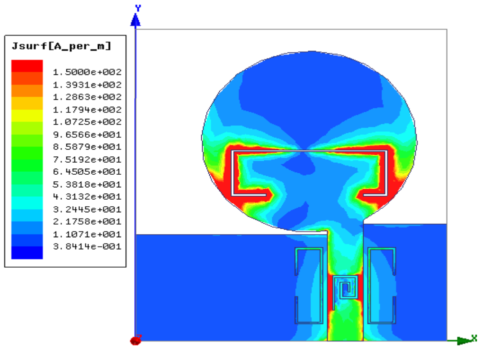
$$\lambda = \frac{c}{f_N\sqrt{(\varepsilon_r+1)/2}}, \qquad (1)$$

and the overall length of the band-notch resonator can be determined using the equation (2) which is given by

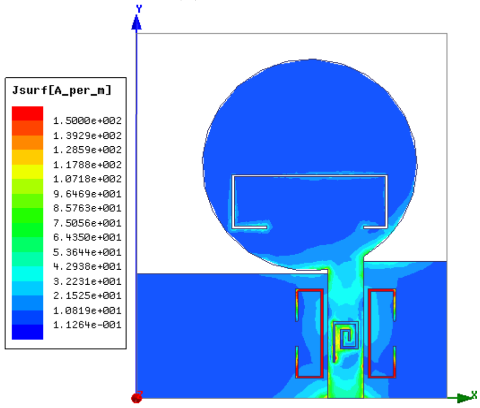
$$L_N = \frac{c}{2f_N\sqrt{(\varepsilon_r+1)/2}}, \qquad (2)$$

where c is light speed, f_N denotes notch center frequency, L_N represents the total length of a resonator and ε_r indicates the dielectric constant. From equation (2), the desired notch position is determined by the suitable selection of resonator length. With ε_r of 4.4, the calculated total lengths are 26.08mm at 3.5 GHz, 16.6mm at 5.5 GHz and 11.65mm at 7.83 GHz whereas the designed total lengths are 26.3mm at 3.5 GHz, 16.9mm at 5.5 GHz and 11.62mm at 7.83 GHz. It is clearly observed from equation (2) that the resonator length has a significant effect on the notch band position and its center frequency. The notch center frequency decreases as the resonator lengths C_1, C_5 and D_1 increases, and vice versa. It is because of the length of the resonator is inversely proportional to its notch frequency. In addition to the return loss parameters, the surface current distribution is also used to illustrate the generation of band notches at 3.5, 5.5 and 7.8 GHz. Fig. 5 (a)-(d) shows the current distribution at 3.5, 5.5 and 7.8 GHz, respectively, and a resonant frequency (9.9 GHz). Since the current is flowing near band-notch resonators, the antenna does not radiate the energy. So, the antenna efficiently suppresses the frequency interference from the existing narrowband systems.

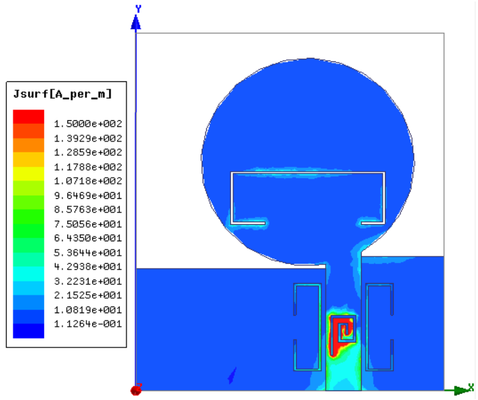
From Fig. 3(d), at 9.9 GHz, the current is flowing along the transmission line and concentrated around the edges of a radiating element; while around the band-stop resonators, the current is very small. Hence, the proposed antenna radiates more energy with a good return loss of less than -10dB.



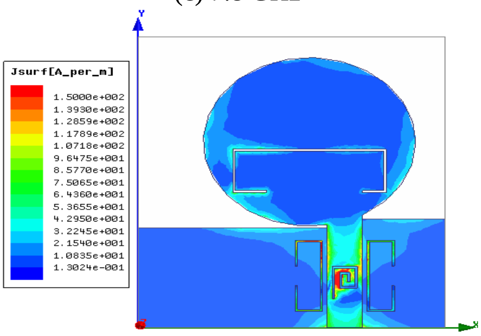
(a) 3.5 GHz



(b) 5.5 GHz



(c) 7.8 GHz



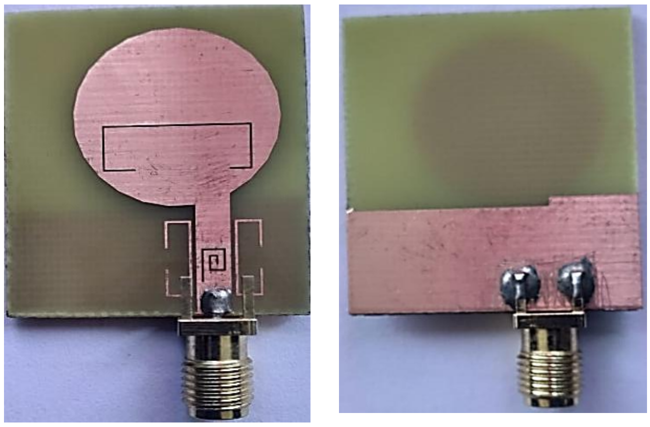
(d) 9.9 GHz

Fig. 3. Surface current distributions.

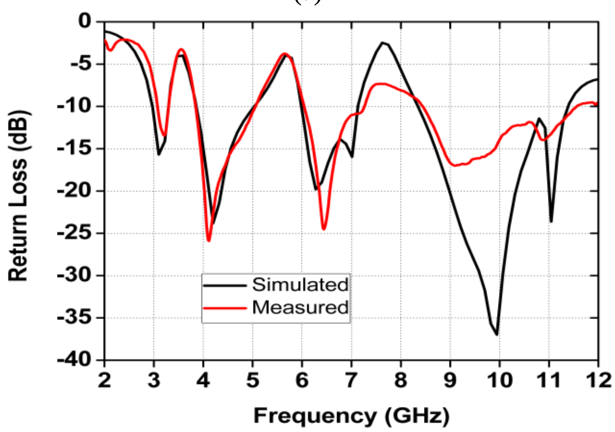
III. RESULTS AND DISCUSSION

Vector network analyzer and an anechoic chamber are used to carry out the measurements of the planned antenna. Fig. 6 (a) & (b) displays the prototype antenna and its simulated & measured return loss parameter, respectively. The antenna is offering good impedance matching characteristics from 2.9 to 11.5 GHz with a return loss of <-10 dB over whole functioning band except at notched bands.

The 2-D radiation patterns of the antenna on the E- and H-planes at 3.2, 4.2, 6.3 and 9.9 GHz, respectively, are given in Fig. 5(a)-(d). The antenna achieves nearly bidirectional pattern on the E-plane and quasi-omni-directional patterns on the H-plane.

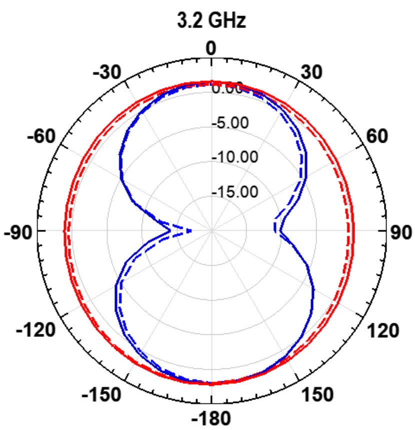


(a)



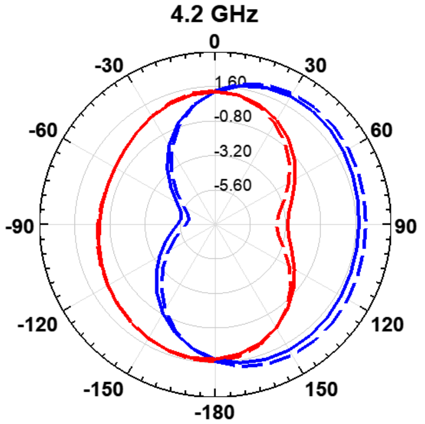
(b)

Fig. 4. (a) Prototype antenna and (b) simulated and measured return loss

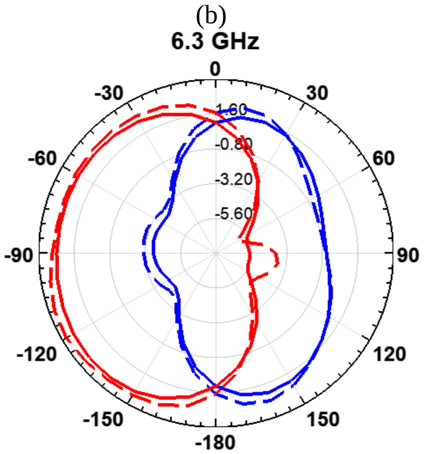


(a)

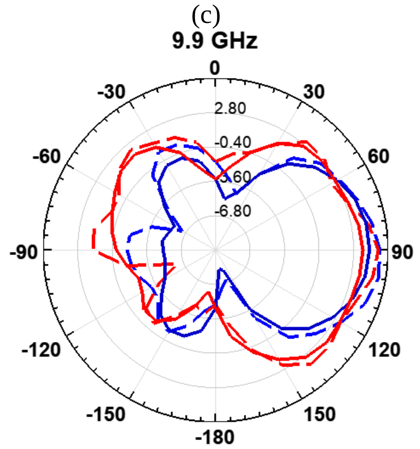
Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication



(b)



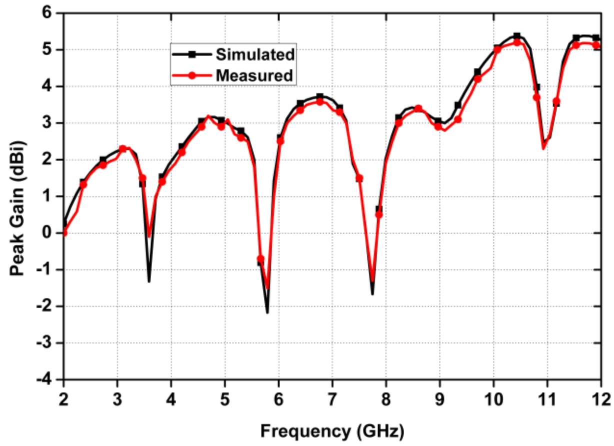
(c)



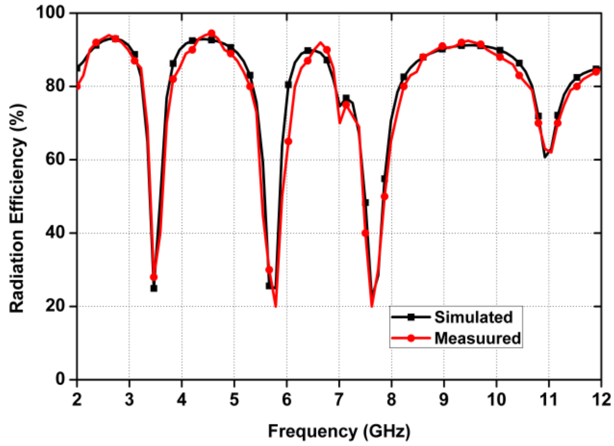
(d)

Fig. 5. The 2-D radiation patterns (Blue color: solid line-simulated E-plane, dashed line-measured E-plane; Red color: solid line-simulated H-plane, dashed line-measured H-plane).

The peak gain and radiation efficacy of the proposed antenna are depicted in Fig. 6 (a) and Fig. 6 (b), correspondingly. The gain of more than 2.3 dBi and efficiency of above 90 % throughout the working band from 2.9 to 11.5 GHz are achieved excluding at band-notches. The reduced peak gains and radiation efficiencies at band notches confirms that the planned antenna greatly lessens the interference from narrowband systems.



(a)



(b)

Fig. 6. (a) Peak gain and (b) radiation efficiency.

REFERENCES

1. FCC, Commission's Rules, Part 15, UWB Transmission Systems First Rep., ET-Docket: 98-153, FCC: 02-48.
2. Liang, J., C. C. Chiau, “Study of a PCDM antenna for UWB systems,” IEEE Trans. on Antennas and Prop., 53(11), 3500-3504, 2005.
3. Abbosh AM, Bialkowski ME. “Design of UWB planar monopole antennas of circular and elliptical shape,” IEEE Trans. on Antennas and Prop., 56(1), 17-23, 2008.
4. F. Y Weing, W.s Cheuing, and T.Yuk, “Compact UWB antennas with single band-notched characteristics using simple ground stubs,” Microwave Optical Technology Letters, 53, 523-529, 2011.
5. Sohail A, B, Kim Dual notch band UWB antenna with improved notch characteristics,” Microw. Opt. Technol. Letters, vol. 60, 925-930, 2018.
6. Wang, J., Yin, Y., Liu, X., “Triple band-notched ultra-wideband antenna using a pair of novel symmetrical resonators,” IET Microwaves, Antennas & Propagation, vol. 8, no. 14, 1154-1160, 2014.
7. Wael Ali, Ahmed A. Ibrahim, Jan Machac, “Compact size UWB monopole antenna with triple band-notches,” Radio Engineering, vol. 26, no. 1, 57-63, April 2017.

AUTHORS PROFILE

Chandrasekhar Rao Jetti was born in A.P, India in 1985. He received his B. Tech, M. Tech degrees in ECE. He is currently working as Assistant Professor in ECE department of K L E F (K L Deemed University). His research interests include UWB MIMO antennas and communications.

U. Leelasai was born in A.P, India in 1985. She is doing her B. Tech degree in ECE department of K L E F (K L Deemed University).

K. Triveni was born in A.P, India in 1985. She is doing her B. Tech degree in ECE department of K L E F (K L Deemed University).

K. Balasaikrishna was born in A.P, India in 1985. She is doing her B. Tech degree in ECE department of K L E F (K L Deemed University).

N. Surendra was born in A.P, India in 1985. She is doing her B. Tech degree in ECE department of K L E F (K L Deemed University).