International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Design and analysis of Inset fed Notch loaded Circular Patch antenna for UWB applications

Mohammad Uzair†, Mukesh Kumar†, A.K.Jaiswal†, Mohd Gulman Siddiqui‡ and Rohini Saxena†

†Dept. of Electronics & Communication Engineering, SHIATS, Allahabad, UP, India
‡Dept. of Electronics and Communication Engineering, University of Allahabad, Allahabad, UP, India

Accepted 01 Sept 2016, Available online 04 Sept 2016, **Vol.6, No.5 (Oct 2016)**

Abstract

A circular patch antenna with inset feed notch loaded MSA (Microstrip Antenna) is described in this paper. The Impedance bandwidth of 12.30 GHz (2.315GHz – 14.624 GHz) is obtained with return loss of -29.913dB at 3.067 GHz, -29.856dB at 8.986 GHz and -35.401dB at 12.745 GHz frequency. The antenna operates at triple band with acceptable values of VSWR (<2) in S band, X band and Ku band respectively. The proposed antenna is simulated using FEM (Finite Element Method) based simulation HFSS (High Frequency Structure Simulation) software.

Keywords: *Microstrip antenna, UWB, Partial ground plane, Notch loaded, Inset feed.*

1. Introduction

The Federal Communications Commission of USA has specified the spectrum from 3.1 GHz to 10.6 GHz for ultra-wideband (UWB) applications (FCC First report and order, 2002). In both conventional communication systems and UWB communication systems, an antenna plays a very crucial role. Nevertheless, there are more challenges in designing an UWB antenna than a narrow band one (Yazdandoostand, *et al*, 2004). MSA is used in wide range of application due to its low profile, conformal and light weight. Simple empirical models have also been proposed to determine the lower-edge frequency for a planar monopole with various planar geometries such as square, circular, trapezoidal and triangular (Ammann, 1999), (Ammann, *et al,* 1999), (Chen, *et al,* 2000).

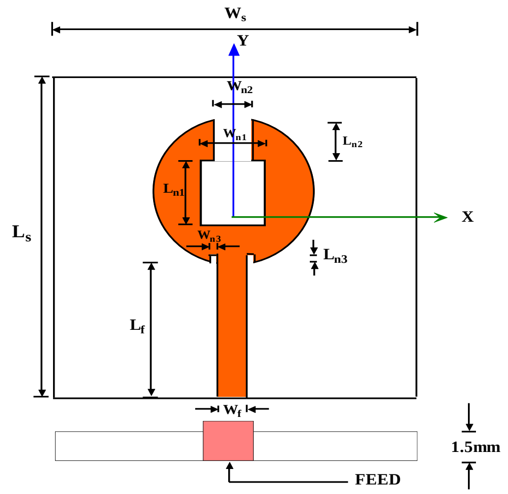
MSA has variety of structures such as rectangular, circular, triangular, square etc. Circular radiating patch has an advantage over other structures as it reduces overall size of MSA. Size reduction and bandwidth enhancement are major design considerations for practical applications of Microstrip antennas (Lotfi-Neyestanak, 2008). Designing a compact MSA that operates over ultra-wide frequency range is still a challenge. Many systems now operate in two or more frequency bands, requiring dual or triple-band operation of fundamentally narrowband antennas (Pozar, *et al,* 1997), (Economou, *et al,* 2000), (Wong, *et al,* 2002). Multi-band antennas with a single radiator are desirable in most applications (Krishna, *et al,* 2008). Therefore size reduction and bandwidth enhancement are major design considerations for practical applications of microstrip antennas (Wong, 2002). For efficient transfer of energy, impedance of the radio, antenna, and transmission line connecting the radio to the antenna must be matched (Ghavami, *et al,* 2004). Also loading of slots and notches affects the resonant frequency which changes with values of inductance and capacitance at which the antenna resonates. Hence using these techniques the antenna can be used where multiband applications are required.

In this paper, a notch loaded circular patch antenna is presented. The basic idea of the design is to provide an inset feed to notch loaded circular MSA so as to achieve maximum bandwidth for the antenna to overcome the main disadvantage of Inset Feed. This method ensures better impedance matching, bandwidth improvement and low VSWR. The circular patch antenna being small in size is a better option for WiMAX technology.

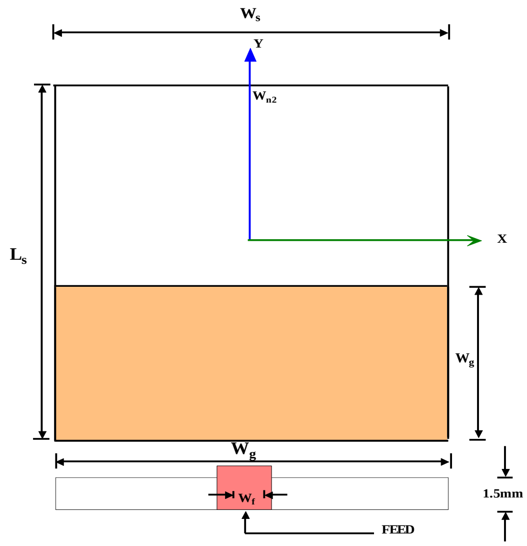
2. Antenna Structure

The Fig. 1 shows the geometry of proposed antenna for UWB applications. The circular patch with notch loaded antenna is fabricated on a substrate FR4 of thickness 1.5mm that has relative permittivity of 4.43 mm. The dimension of the substrate is 42 x 50 x $1.5mm^3$. The proposed antenna is fed through a microstrip line. The parameters of MSA are shown in Table 1.

*Corresponding author: **Mohammad Uzair**



(a)



(b)

Fig.1 The Geometry of Proposed Antenna (a) Front View (b) Back View

Table 1 Antenna Configuration and Parameters

Parameters	Value(mm)
Width of Substrate (W_s)	42
Length of Substrate (L_s)	50
Width of Ground (W_g)	42
Length of Ground (L_g)	19.6
Width of Feed (W_f)	2.8
Length of Feed (L_f)	20.91
Radius of Circular Patch (r)	10
Width of First Notch (W_{n1})	10
Length of First Notch (L_{n1})	12
Width of Second Notch (W_{n2})	3.5
Length of Second Notch (L_{n2})	4.07
Width of Third Notch (W_{n3})	0.74
Length of Third Notch (L_{n3})	0.80

The Simulated results are obtained using HFSS (High Frequency Structure Simulator) based on Finite Elements Method. The antenna consists of (i) a partial ground plane (ii) notch cut in the patch. The other parameters are selected such that the antenna operates in triple band.

Simulation

The simulation phase has been done using Ansoft HFSS software. It has been used widely to determine and plot the reflection parameters, Voltage Standing wave ratio (VSWR), Impedance and the radiation pattern.

Return Loss (S_{11}) is a critical parameter which along with VSWR indicates the degree of exactness of matching between the feeding system, the transmission lines and the proposed antenna.

Mathematically, Return Loss can be calculated as,
Return Loss = $-20\log|\Gamma|$ dB

The proposed antenna has achieved a return loss of -29.9135 dB, -29.8567 dB and -35.4017 dB at 3.0671 GHz, 8.9866 GHz and 12.7450 GHz respectively and is shown in Fig. 2

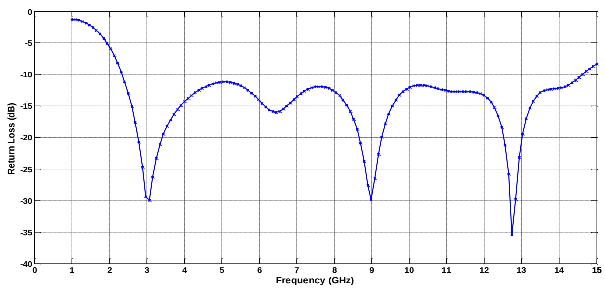


Fig. 2 Simulated Return Loss of the proposed antenna

VSWR denotes power reflected from the antenna, for better matching of antenna with transmission line, the VSWR should be smaller (practically < 2dB) resulting in more power to be delivered to the antenna.
VSWR can be represented as,

$$\text{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

Where,

$$\Gamma = \frac{Vr}{Vi} = \frac{Z_{in}-Z_S}{Z_{in}+Z_S}$$

The observed value of VSWR is obtained to be 0.5550, 0.5587 and 0.2950 at 3.0671 GHz, 8.9866 GHz and 12.7450 GHz respectively. The VSWR versus frequency graph is shown in Fig. 3

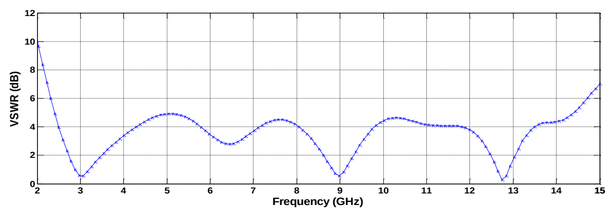


Fig. 3 Simulated VSWR of the proposed antenna

The fractional Bandwidth of the proposed antenna can be mathematically represented using the equation as,

$$BW = \frac{f_2 - f_1}{\sqrt{f_2 f_1}} \text{x } 100\ \%$$

Where, f_2 and f_1 are the higher and lower frequencies for which S_{11} is less than 10dB level.

The fractional bandwidth of the proposed antenna is calculated to be 211% while the Impedance Bandwidth of the antenna is found to be 12.30GHz. The Peak Gain for the antenna is shown in Fig. 4 and the gain variations are less than 7.08 dB.

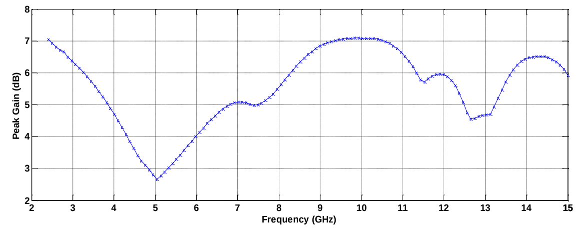


Fig. 4 Simulated Peak Gain of proposed antenna

The current distribution must be zero at ends of patch so that the current cannot flow off the patch. The current distribution is shown in Fig. 5

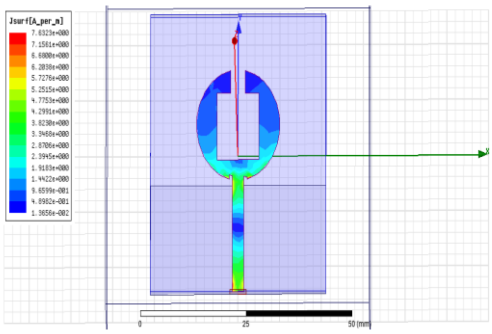
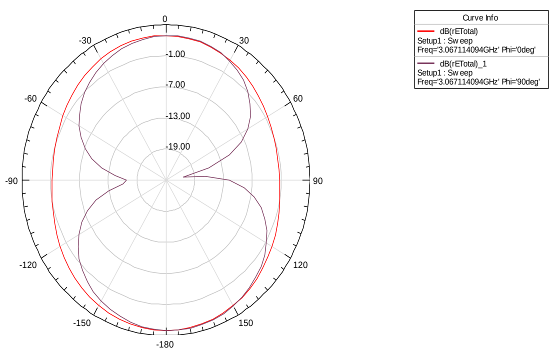
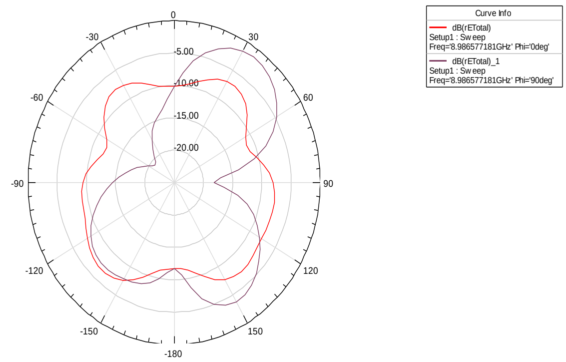


Fig. 5 Simulated Current Distribution of the proposed antenna

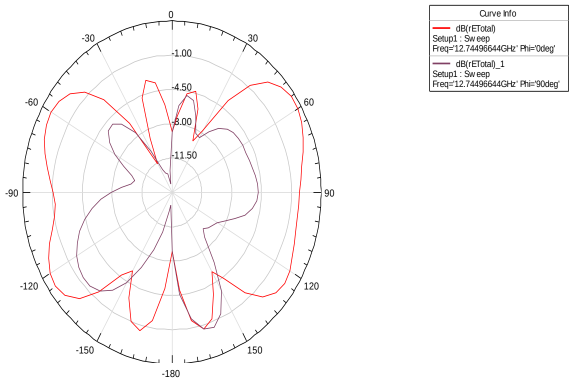
The radiation pattern of the antenna shows good omni directional pattern in xy-plane at 3.067 GHz, 8.986 GHz and 12.745 GHz respectively for ϕ=0° and ϕ=90° and is shown in Fig. 6



(a)



(b)



(c)

Fig. 6 Radiation Pattern of proposed antenna in xy-plane at (a) 3.067 GHz (b) 8.986 GHz (c) 12.745 GHz

Conclusions

The Notch loaded Circular Patch antenna has been shown to provide fractional bandwidth of 211%, return loss less than -10dB over an extremely wide frequency range. The obtained results show good performance in terms of size, radiation patterns, VSWR and gain. The antenna proves to be good for multi-band systems, future wideband data systems, and combination of these with UWB. The antenna meets the UWB bandwidth requirements.

References

Federal Communication Commissions. (2002) First report and order, revision of part 15 of the commission's rule regarding ultra wideband transmission systems.

F. J. J. Jabri, (2012) New compact UWB microstrip-fed printed planar antenna for wireless applications, *Frontiers of Electrical and Electronic Engineering*, Volume 7, Issue 4, pp 374–380.

K. Y. Yazdandoostand, R. Kohno, (2004) Ultra-wideband antenna, *IEEE Communication Magazine*, Vol. 42, No. 66, 29-32.

D. D. Krishna., M. Gopikrishna, C. K. Aanandan, P. Mohanan, and K. Vasudevan, (2008) Compact dual band slot loaded circular microstrip antenna with a superstrate, *Progress In Electromagnetics Research*, PIER 83, 245–255.

K. L. Wong, (2002) Compact and Broadband Microstrip Antennas, *JohnWiley & Sons*.

M Ghavami, Michael L B, Kohno R. (2004) Ultra Wideband Signals and Systems in Communication Engineering. *New York: John Wiley & Sons*.

A. A. L Neyestanak, (2008) Ultra wideband rose leaf microstrip patch Antenna, *Progress In Electromagnetics Research*, PIER 86, 155–168.

D. M. Pozar, S. M. Duffy, (1997) A Dual Band Circularly Polarized Aperture-Coupled Stacked Microstrip Antenna for Global Positioning Satellite, *IEEE Transactions on Antennas and Propagation*, vol. AP-45, no. 11, pp. 1618-1625.

L. Economou, R. J. Langley, (2000) Dual Band Hybrid Vehicular Telephone Antenna, *IEE Proceedings on Microwaves, Antennas, and Propagation*, vol. 149, no. 1, pp. 41-44.

S. Chih-Ming, H. T. Chen, K. L. Wong, (2002) Printed Dual-Band Dipole with U-slotted Arms for 2.4/5.2 GHz WLAN Operations, *Electronics Letters*, vol. 38, no. 22, pp. 1308-1309.

M. J. Ammann, (1999) Square Planar Monopole Antenna, *IEE NCAP*, pp. 37-40.

J. A. Evans, M. J. Ammann, (1999) Planar Trapezoidal and Pentagonal Monopoles with Impedance Bandwidths in Excess of 10:1, *IEEE International Symposium on Antennas and Propagation Digest*, vol. 3, pp. 1558-1561.

Z. N. Chen, (2000) Impedance Characteristics of Planar Bow-Tie-Like Monopole Antennas, *Electronics Letters*, vol. 36, no. 13, pp. 1100-1101.