iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2017 **Issue:** onferende **Month of publication:** September 15, 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue IX, September 2017- Available at www.ijraset.com

Design of UWB Circular Monopole Antenna with Enhance Bandwidth for LTE, WLAN and Radiolocation Application

Ms. Hiral Patel[1], Prof. Manjiri Gogate[2]
[1]Student, [2]Proffesor, Extc, Shree l.R. Tiwari College of Engg

Abstract: A printed monopole circular patch dual band antenna is presented for LTE and ultra-wide band (UWB) application. It contains circular patch for ultra-wide band and an inverted L-strip for LTE application. It has wide band of 2.4 GHz to 2.8 GHz with centre frequency of 2.6 GHz and bandwidth of 0.2 GHz for LTE and it also covers ultra-wide band of 5 GHz- 15 GHz.
Keywords: UWB, LTE, Circular patch, WLAN, RADIOLOCATION.

I. INTRODUCTION

Due to the current enhancement of wireless communication of beyond 4G, which are envisioned to enable wireless connectivity for "all the application at any place and any time", the combination of UWB signals with a second service, such as LTE, operating at a different frequency band is desirable.

Printed monopole antennas have radiation patterns similar to that of a dipole antenna and these monopoles can be easily integrated with other components on printed circuit boards. Many shapes of printed monopole antennas with its calculation are reported in [1,2]. A Circular patch broadband antenna is presented in [3] to works at 2.4 GHz and 7.1GHz for the application of sensing and communicating in a radio system.The Effect of radius of circular patch, width of ground plane, different dielectric constant and variation in feed gap is shown in [4,5]. A novel compact ultra-wide band slot cut elliptical printed monopole antenna with two pair of elliptical slot for higher resonance frequency is represented in [6]. The printed elliptical monopole antenna (PEMA) is presented which operates from 1.9 GHz to 13.3 GHz whereas PEMA with slots is operates from 1.8GHz to 20.9 GHz. [7] shows a Circular Patch Antenna with circular ring slots for wideband applications. It presents the dual band circular patch antenna which cover 4.58 to 5.35 GHz frequency bandwidth at 5 GHz frequency band for access point (AP) WLAN application and also cover 7.65 to 9.3 GHz frequency bandwidth at 9GHz band for Radio location application. A simple microstrip fed printed monopole antenna for the radio frequency identification (RFID) and wireless local area network (WLAN) was illustrated in [8] forming an F-shaped structure to support two resonances at 2.44 and 5.18 GHz, which are reserved for RFID and WLAN applications, respectively.

Modern days of communication systems operate at multiple antenna for different operating frequency on same chip. This creates a space limiting problem and increases the device size which invariably result in increased manufacturing cost. To overcome this problem, we use multiband antenna where the same antenna can be used to operate at multiple frequencies. In a multiband patch antenna, the same antenna operates at different resonant frequency and thus reduces the size of the antenna and device.

In particulardevice, compact size and broad bandwidth antenna providing multiple application is contradictory. Thus, how to reduce the size of an antenna without decreasing its bandwidth is of great interest when designing compact antennas. The multiband printed antenna can control multiple radiating portions separately each having different bands and are formed together on one substrate to emit the electromagnetic wave signals.

In this paper, the compact printed monopole circular patch antenna with inverted L strip controlling dual bands operating for LTE and UWB application is presented. The simulation is performed by using IE3D software and it shows the results consisting return loss, VSWR, efficiency, gain and radiation patterns. The proposed antenna provides a new approach of feed network in which power splitting along with improvement in impedance bandwidth is achieved and this greatly reduces the manufacturing cost which satisfies increasing demands of wireless technology.

A. Antenna Design

Fig 1 shows the geometric structure of the dual band printed monopole antenna fabricated on the FR4 substrate with the relative dielectric constant $\mathcal{E}r$ = 4.43, the thickness of the substrate is 1.59 mm, and the loss tangent is 0.01.The proposed antenna is working

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at 2.4 GHz to 2.8 GHz, 5 GHz to 15 GHz which is LTE and UWB bands respectively. The dimensional area of an antenna is 40x25 mm2.

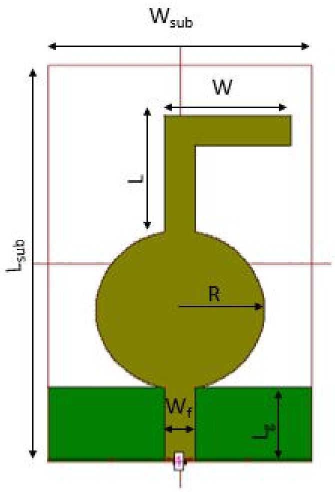

Fig. 1 Geometry of Antenna

Parameters	Dimensions (mm)
L_{sub}	40
W_{sub}	25
R	8
L_g	7.5
W_g	25
L	11.7
W	12

Table 1. Dimensions of Proposed antenna

1) *Lower edge frequency (f_L):*The lower edge frequency f_L can be calculated by following relation [1],

$$f_L = 7.2/\{(L+r+p)\ k\}\quad \text{GHz} \qquad ....(1)$$

$$L = 2A \qquad r = A/4 \qquad ....(2)$$

whereA is the radius of an antenna in cm, p = feed gap in cm, k is correction factor taken as 1.15 for glass epoxy FR-4 substrate. Formula itself indicate that if there is an increase in the value of radius of patch then the value of lower edge frequency will get reduces. And for appropriate size of antenna and some other parameters the value of radius of patch is chosen to be 8mm.

2) *Width of the microstrip line (W_f):* The calculation of the width of microstrip line can be done by using the following equation [1],

$$Z_0 = \frac{87}{\sqrt{\mathcal{E}_r+1.41}} In(\frac{5.9\,h}{0.8\,Wf+t}) \qquad .... (3)$$

Z0 is the characteristic impedance of the microstrip line which is 50Ω, h (thickness of substrate) denotes a typical value taken as 1.6 mm and $\mathcal{E}_r$is the relative permittivity which is 4.4 for FR4 substrate. Therefore, the value of width of microstrip line is 3mm.

3) *Length of ground plane (Lg):* The effect of varying length of ground plane (L_g) on VSWR of two bands can be observed in figure 2. As the length of ground plane increases from 7.5mm to 10mm the bandwidth of second band get reduces, but with lower value of the length of the ground the gain of the antenna get change. So for the required condition the length of the ground plane is chosen to be 7.5mm for good bandwidth and gain.

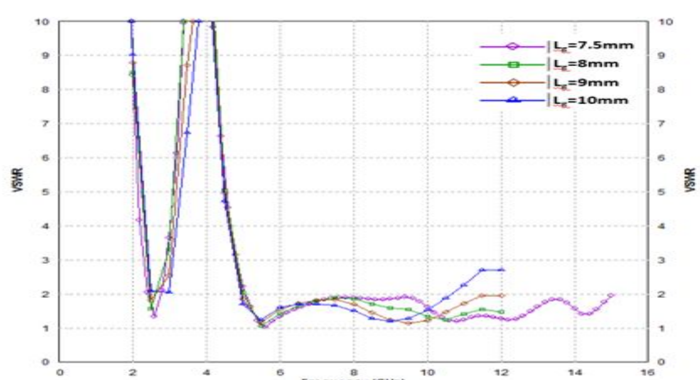

Fig. 2Change in Length of ground plane (Lg)

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4) *Change in width of inverted L-strip (W):*The effect of varying length of ground plane (L_g) on VSWR of two bands can be observed in figure 3.

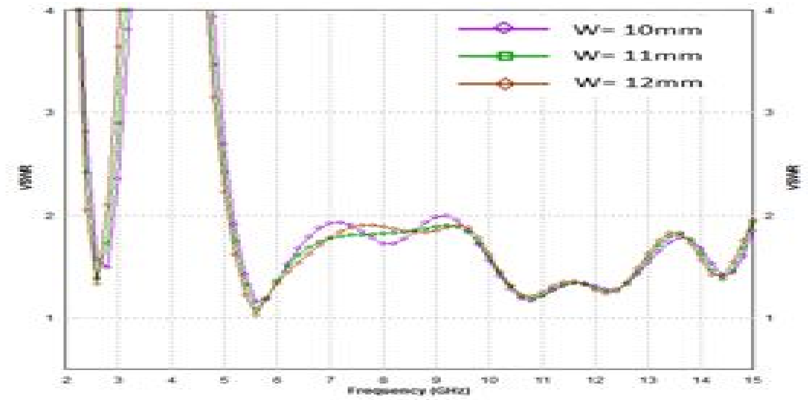


Fig.3. Change in Width of inverted L-strip

The value of width of inverted L-strip is decided as 12mm as to achieve a flatnessbetween 7GHz to 10GHz which is clearly observed by figure 3. And it also helps in to shift first band from 2.715GHz to 2.6GHz which is clearly shown by table 2.

W	Band	Centre frequency (f_{c1})
10mm	2.53GHz - 2.9GHz	2.715GHz
11mm	2.846GHz – 2.846GHz	2.663GHz
12mm	2.4GHz – 2.8GHz	2.6GHz

Table 2.Change in Width of inverted L-strip

5) *Length of inverted L-strip (L):*The effect of varying length of ground plane (L_g) on VSWR of two bands can be observed in figure 4.

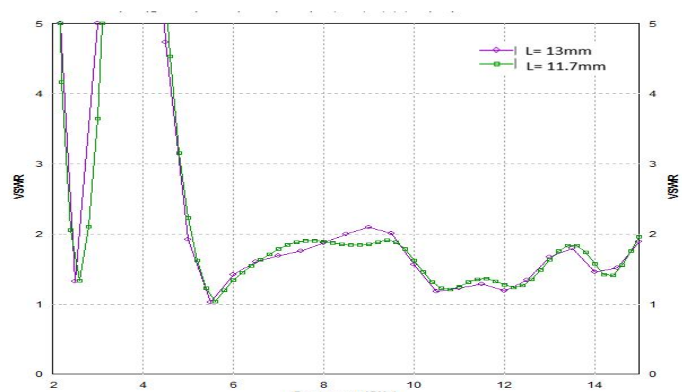


Fig. 4 change in Length of inverted L-strip

The value of length of inverted L-strip is decided as 11.7mm as to get VSWR value of 5GHz to 15GHz band below 2 and if value of L get reduces then it will sift 2.6GHz band toward higher frequency.

II. SIMULATEDRESULT

A. VSWR

Fig. 5 shows the simulated result of VSWR of the antenna. It can be seen that VSWR value is below 2 i.e. (VSWR<2) for two bands, first for 2.4GHz-2.8GHz (LTE band) and second for 5GHz-15GHz (UWB).

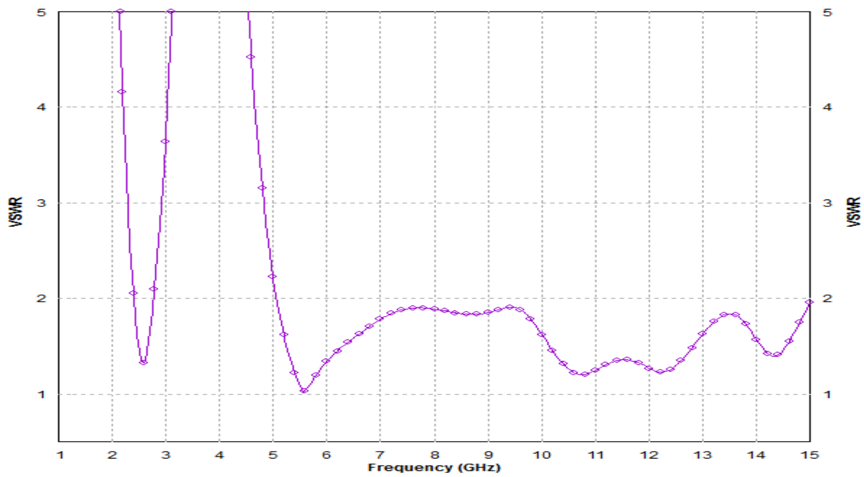
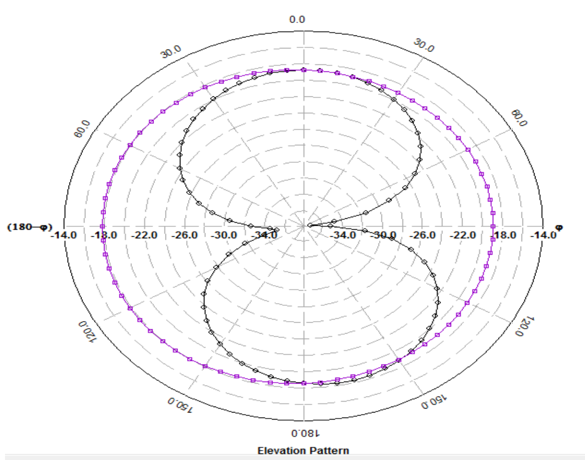


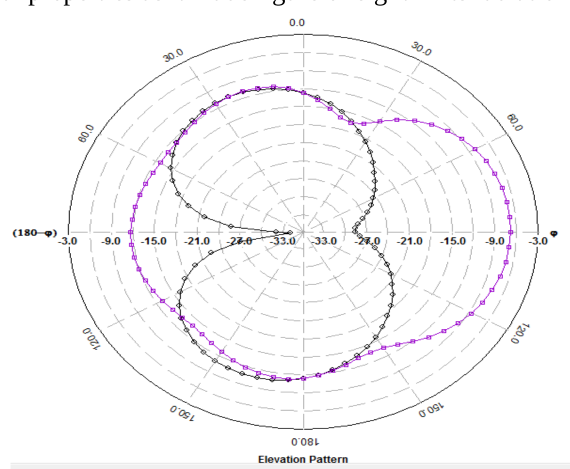
Fig 5. VSWR v/s Frequency [GHz]

B. Radiation Pattern

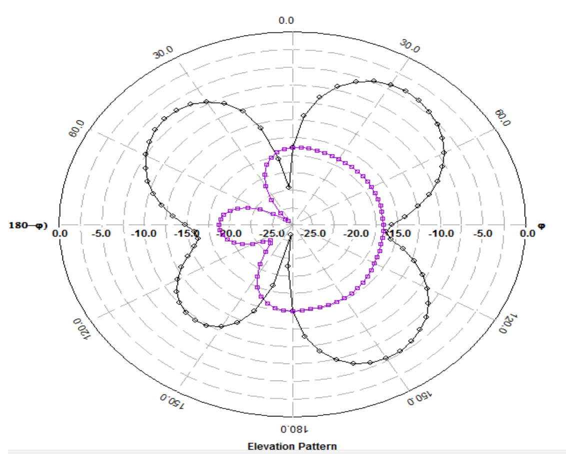
Fig 6 (a), (b), (c) and (d) show the radiation pattern of the antenna at 2.6GHz, 5.5GHZ, 9.6GHz and 12.8GHz respectively. It is clearly shown from the patterns that antenna have the omnidirectional properties as it made figure of eight in its radiation pattern.



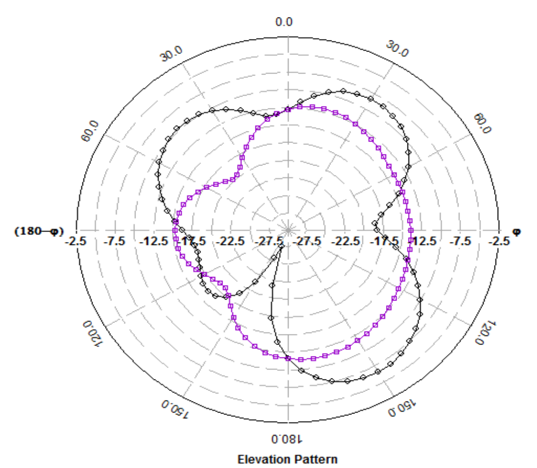
(a)



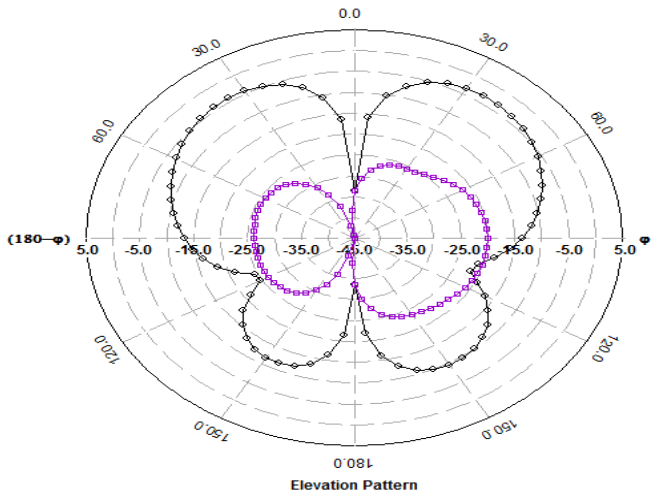
(b)



(c)



(d)



(e)

Fig. 6 Radiation Pattern (a) 2.6GHz (b) 5.5GHz (c) 9.6GHz (d) 10GHz (e) 12.8GHz

C. Simulated Gain

The simulated gain of the proposed antenna is shown by figure 7. The observed gain at different frequencies is shown in table 3.

frequency	Gain (dBi)
2.6GHz	1.3484
5.5GHz	2.0517
9.5GHz	5.5621
10GHz	5.3
12.8GHz	3.92

Table 3. Simulated Gain

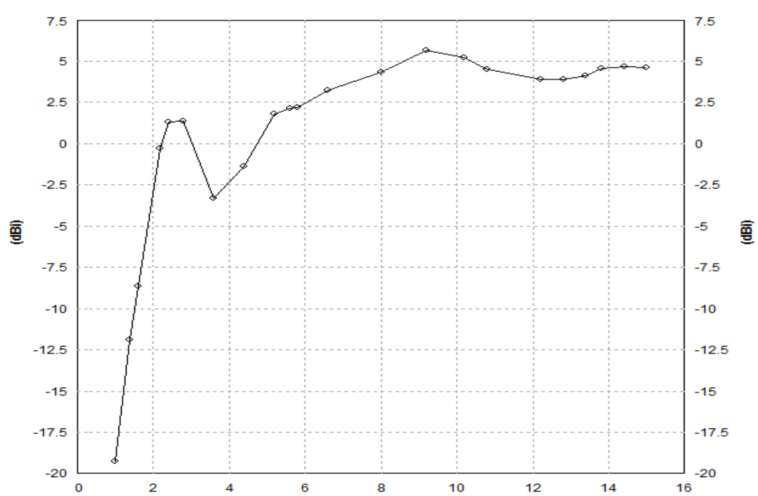


Fig. 7 Simulated Gain

D. Simulated Efficiency

he radiation efficiency of the simulated dual bands antenna is shown in figure 8. The observed gain at different frequencies is shown in table 4.

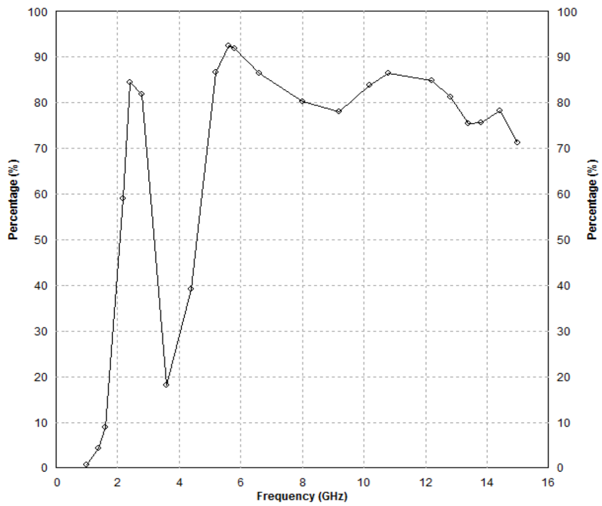


Fig.8 Simulated Efficiency

frequency	Efficiency(%)
2.6GHz	83.02
5.5GHz	90.93
9.5GHz	80.147
10GHz	82.929
12.8GHz	81.183

Table 4. Simulated Efficiency

III. CONCLUSION

The proposed antenna is designed for LTE and UWB application in which it can provide multiple application like WLAN, RADIOLOCATION, satellite communication etc. The antenna also shows the omnidirectional pattern for required bands. And it also achieves good value for gain and efficiency. The low cost, light weight and compact size and characteristics of an antenna make it more suitable for multiband application.

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