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UWB Antenna with Parasitic Patch and Asymmetric Feed

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Abstract: A double sided printed antenna with parasitic patch is proposed for Ultra Wide Band (UWB) applications. Antenna has minimal dimensions of 30 x 24.8 x 1.6 mm^3 with asymmetric feed line, whose impedance is 50 Ω. The presented antenna has gain of 7 dB and an extended bandwidth of 11.51 GHz ranging from 1.69 to 13.2 GHz at VSWR < 2. Economical FR4 epoxy substrate and uniform radiation patterns make this design a practical candidate for integration in UWB systems.

Keywords**:** Microstrip Patch, Ultra Wide band, Parasitic Patch.

1 Introduction

With the development of technology and ever growing need for bigger and better inter-operability, multifunctional systems have become the need of hour. Reduction of cost and volume of the electronic equipment is the current design challenge. In order to satisfy these requirements research efforts are being made to achieve futuristic gadgets in the current era.

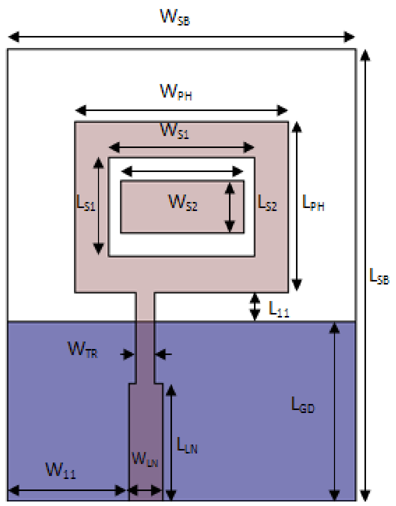
UWB applications helped in achieving multi-standard functionality and higher data rate as compared to any other narrow band application(s). Looking at the bright prospects of UWB applications, Federal Communications Commission (FCC) laid the protocol for these applications in 2002 [1]. According to this publication, the band ranging from 3.1 GHz to 10.6 GHz has been designated as UWB; over which unlicensed low power communications at higher data rates can be performed. With the intention of achieving significantly higher data rates, many attempts have been accomplished by designing small sized and inexpensive antennas capable of UWB functionality.

In the past, UWB was achieved with a high degree of efficiency using coplanar cpw-fed square printed monopole [2], compact cpw fed serrated patch [3], novel pot shaped cpw-fed slot [4], tapered cpw feed and slot stubs [5], cpw-fed aperture antenna using semicircular ring tuning stub [6], rectangular patch with parasitic resonator [7], elliptical patch with bent transmission line [8], u-shaped parasitic elements [9] and modified ground plane with triangular edges [10].

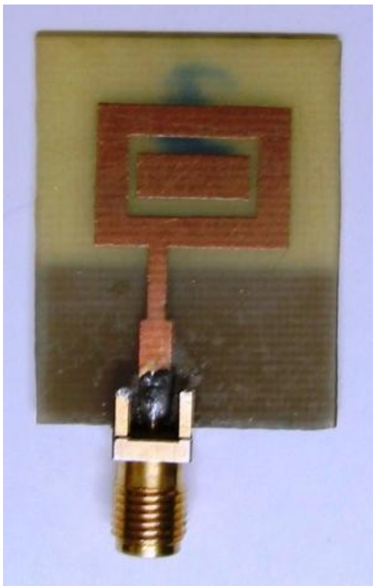
As compared to [2], where impedance bandwidth is from 2.1 to 12 GHz with peak gain of 7 dB, our proposed design is small in size and has larger bandwidth with similar gain response. Antenna design in [4] has a complex geometry consisting of a pot like structure and occupies similar area but yields less bandwidth from 2.9 to 10.2 GHz. In [8], antenna has smaller volume and a larger bandwidth with suitable gain. In our work, adequate bandwidth is achieved with relatively high gain and omni-directional radiation patterns.

2 Antenna Design

The designed and fabricated antenna is shown in Fig. 1.



(a) Antenna Design



(b) Fabricated Antenna

Figure 1 Antenna Geometry

Antenna geometry consists of a symmetric rectangular patch of length (L_{PH}) and width (W_{PH}) printed on FR4 epoxy substrate with relative permittivity of 4.4, relative permeability of 1, dielectric loss tangent of 0.02 and height of 1.6 mm. The overall dimensions of the proposed antenna are 30 (L_{SB}) x 24.8 (W_{SB}) x 1.6 (H_{SB}) mm^3.

Dimensions of patch are calculated using (14-6) and (14-7) of [11]. In order to excite the patch, a transmission line with a characteristic impedance of 50 Ω is used and quarter wavelength transformer is incorporated for better impedance matching [12]. The length of the quarter wavelength transformer is approximated as $\lambda/4\sqrt{\varepsilon r}$ where the width is calculated using (6-7-9) of [12].

Central slot of patch is of 8.9 (L_{S1}) x 10.4 (W_{S1}) mm^2 and floating parasitic patch is of 3.4 (L_{S2}) x 8.8 (W_{S2}) mm^2. This antenna design utilizes the advantages of asymmetric feed position, floating parasitic patch and partial ground plane to achieve UWB.

3 Results And Discussion

Various optimization techniques are applied, starting from the variation in feed position to the introduction of parasitic patch [9, 10]. The following sections present comparative study of different parameters.

A. Changing the width W_{11}:

W_{11} specifies the distance of feed line from left side of the substrate as shown in Fig. 1. The variation in the impedance bandwidth for different values of W_{11} is shown in Fig. 2. It indicates an increment in bandwidth as the feeding is done from the edge of the patch rather than central symmetric position. This offset in the feeding position creates two different lengths of the patch resulting narrow bands. These narrow bands are then widened using partial ground plane.

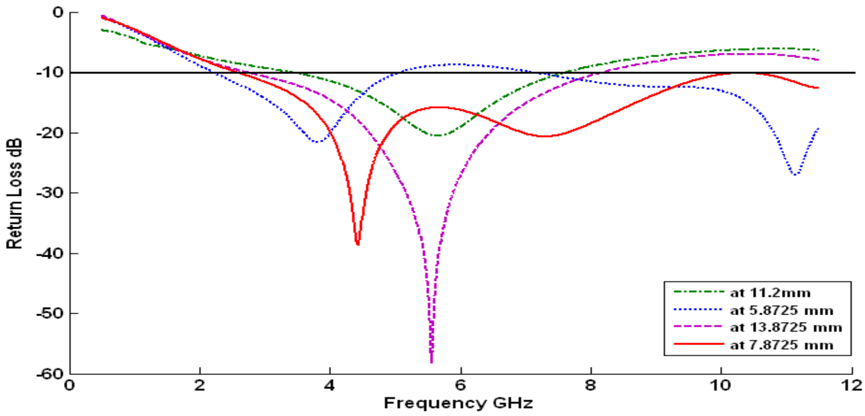


Fig. 2 Variations in the position of feed

B. Introduction of quarter wavelength transformer:

Variation of feed position though increases bandwidth but impedance matching has been achieved using the quarter wavelength transformer. Fig. 3 shows the improvement in the return loss with the introduction of the quarter wavelength transformer.

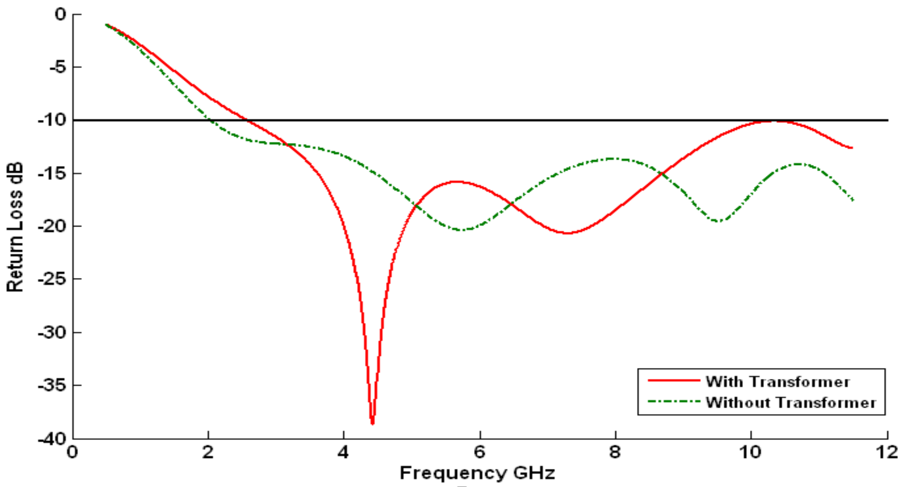


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Fig. 3 Impedance matching using the quarter wavelength transformer

C. Changing the width W_{S2}:

A physical notch was introduced in the wide band approximately at 4 GHz, when W_{S2} was about 3.2 mm. However without this, in terms of impedance bandwidth; response of proposed antenna is average in the upper bands as shown in Fig. 4.

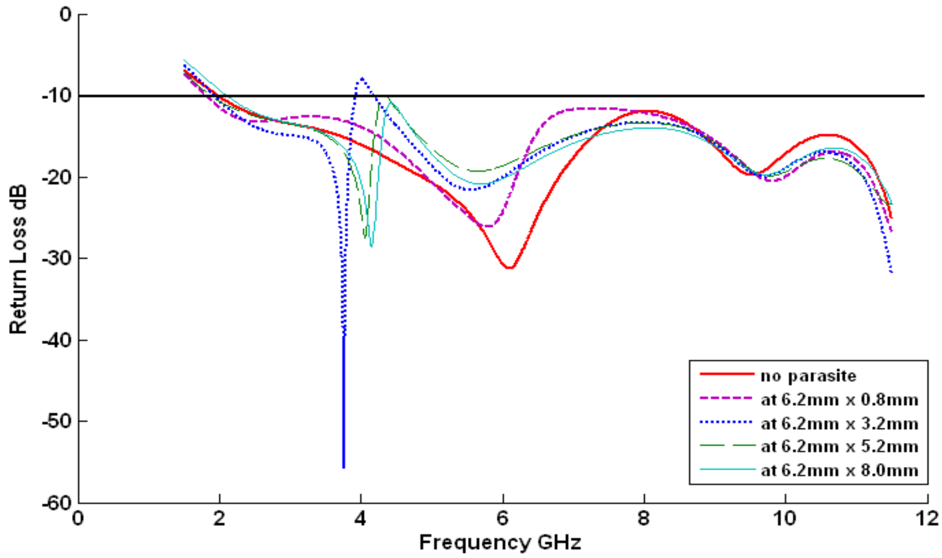


Fig.4 Variations in width of parasitic patch

D. Changing the length L_{S2}:

Variations in the length of parasitic patch at a constant width (W_{S2}) of 8.8 mm yields attractive results. The impedance bandwidth increased in lower bands and also omni-directional radiation patterns were attained with reasonable gain. Antenna design at L_{S2} = 5.4 mm gives good return loss in higher bands but as the length decreases, return loss for the whole band were improved and shown in Fig. 5. L_{S2} = 3.4 mm was optimized length in our case.

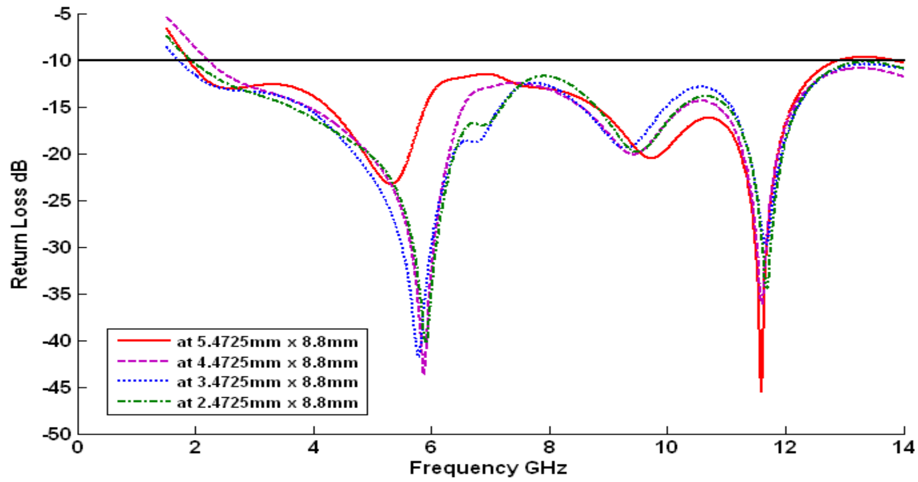


Fig. 5 Variations in length of parasitic patch

E. Optimized antenna parameters:

On the basis of parametric analysis performed in Ansoft HFSS 11.0, the optimized geometrical parameters of presented antenna are given in Table 1.

TABLE I. Antenna Dimensions

Parameter	Dimension (mm)	Parameter	Dimension (mm)
W_{SB}	24.8	L_{SB}	30
W_{PH}	15.2	L_{PH}	11.3
W_{S1}	10.4	L_{S1}	8.9
W_{S2}	8.8	L_{S2}	3.4
W_{TR}	1.36	L_{GD}	11.9
W_{LN}	2.4	L_{LN}	7.8
W_{11}	8.6	L_{11}	1.9

Measured return loss of antenna from network analyzer is depicted in Fig. 6.

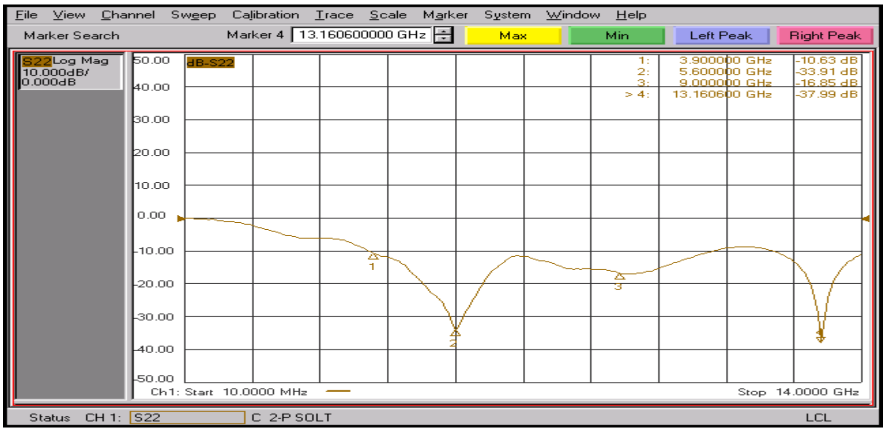


Fig. 6 Measured return loss of the fabricated antenna

Good similarity is found between simulated and measured results as shown in Fig. 7.

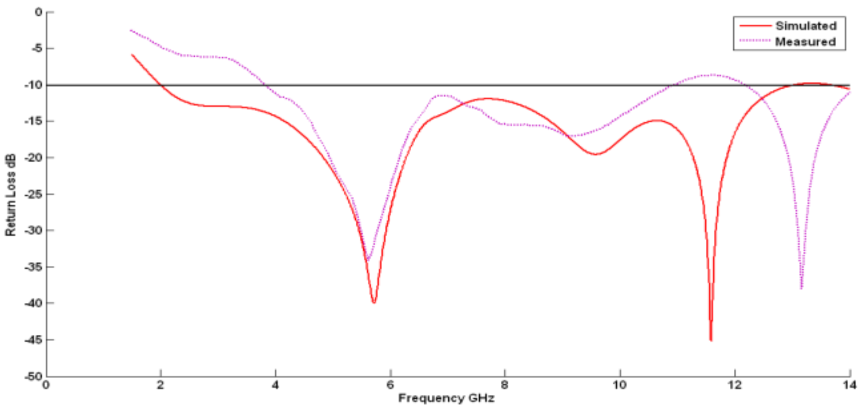
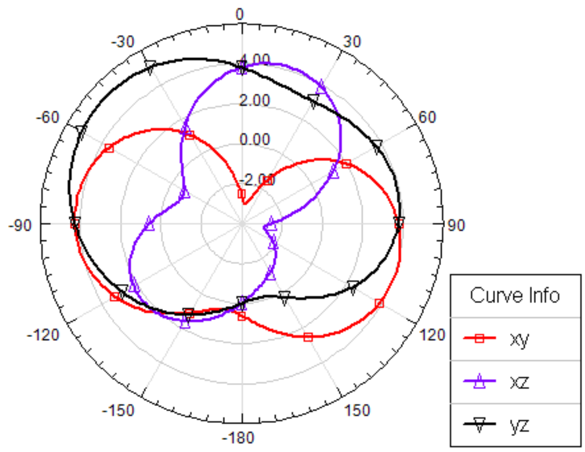
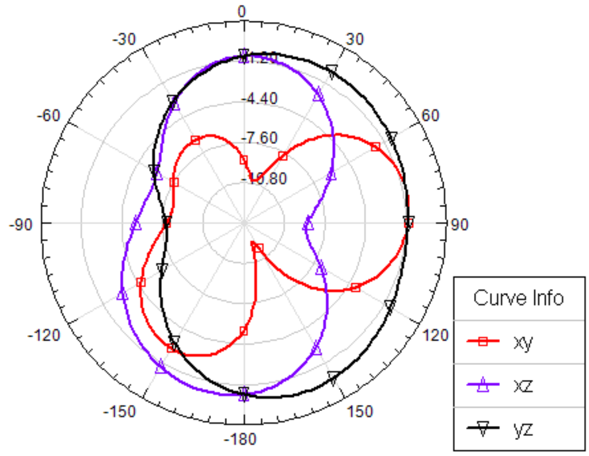


Fig. 6 Simulated and measured return loss of the prposed antenna

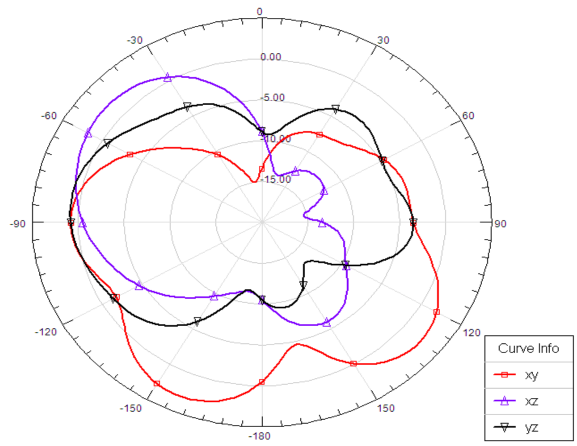
The uniformity of the radiation from this prototype both in azimuth and elevation planes is illustrated in Fig. 8. Stable radiation patterns in E and H planes were achieved.



a) Radiation at 2.4 GHz



b) Radiation at 5.5 GHz



c) Radiation at 10.6 GHz

Fig. 7: Curve Information, where (a) Radiation at 2.4 GHz, (b) Radiation at 5.5 GHz and (c) Radiation at 10.6 GHz

Gain of the proposed antenna is also positive throughout the band and is shown in the rectangular plot shown in Fig. 8.

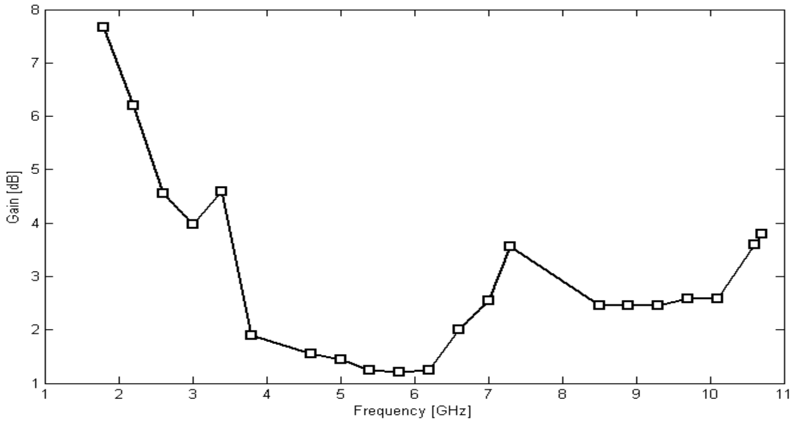


Fig. 8

4 Conclusion

In this paper, a microstrip patch antenna with asymmetric feed line and parasitic patch is presented. The proposed design radiates in an impedance bandwidth of 11.51 GHz incorporating most of the modern standards. Small volume, cost-effective substrate, omni-directional gain pattern and design stability makes this prototype a suitable candidate for installation in numerous light weight portable wireless appliances

References

[1] Federal Communications Commission, *First report and order, Revision of Part 1 5 of commission's rule regarding UWB transmission system FCC* 02-48, Washington, DC, April 22, (2002).

[2] Hou ZHANG, Guiyuan LI, Jian WANG, Xiong YIN, *A Novel coplanar CPW-fed square printed monopole antenna for UWB applications*, ICMMT Proceedings (2010).

[3] Shameena V. A, Sarah Jacob, C.K Aanandan, K Vasudevan, P.Mohanan, *A compact CPW fed serrated UWB antenna*, International Conference on Communications and Signal Processing ICCSP, (2011).

[4] Akkala. Subbarao, Dr. S. Raghavan, *A novel pot shaped CPW-fed slot antenna for ultra wideband applications*, Proceedings of ICETECT, (2011).

[5] Pichet Moeikham, Prayoot Akkaraekthalin, *A compact ultrawideband monopole antenna with tapered CPW feed and slot stubs*", 8th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (2011).

[6] Nipont Tangthong, Virote Pirajnanchai, Numyoot Songthanapitak, Rajamangala, *Wideband CPW-Fed aperture antenna by using a semicircle ring tuning stub*, 8th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (2011).

[7] Hsien-Wen Liu, Student Member, IEEE, Chia-Hao Ku, Te-Shun Wang, Chang-Fa Yang, *Compact monopole antenna with band-notched characteristic for UWB applications*, IEEE Antennas and Wireless Propagation Letters, vol. 9, (2010).

[8] Mohammed Al-Hussein, Youssef Tawk, Ali El-Hajj, and Karim Y. Kabalan, *A low-cost microstrip antenna for 3G/WLAN/WiMAX and UWB applications*, ACTEA Lebanon, July 15-17, (2009).

[9] Sang-Hyuk Wi, Yong-Shik Lee, and Jong-Gwan Yook, *Wideband microstrip patch antenna with U-shaped parasitic elements*, IEEE Transactions on Antennas and Propagation, Vol. **55**, No. 4, April (2007).

[10] R. Azim, M.T. Islam and N. Misran, "Ground modified double-sided printed compact UWB antenna", Electronics Letters, vol. 47 no. 1, 6th January 2011.

[11] Constantine A. Balanis, *Antenna Theory: Analysis and Design*, John Wiley & Sons, Second Edition, New York, (1997).

[12] John D. Kraus, Ronald J. Marhefka, *Antennas for All Applications*", McGraw Hill, Third Edition. New York, (2006).