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A Novel Micro-Strip Patch Antenna for UWB Application with Band Notched Performance for Polarization Diversity

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Abstract: UWB has become the most promising solution for future short-range high-data wireless communication applications. *Ultra Wideband (UWB)* antennas are operating in the range of (3.1-10.6) GHz allocated by *Federal Communication Commission (FCC)*. The performance of micro strip is not good for higher frequency application. So, it is not suitable candidate for wideband antenna. *CPW (Coplanar Waveguide)* feed UWB antenna is more suitable because of its simple configuration, repeatability, low cost & is capable of generating different types of polarization quite efficiently. In this project, a new CPW fed Ultra Wide Band antenna with band notched performance for polarization diversity application will be proposed. Some frequencies in this particular band are used for other applications, like 5.2 and 5.8 GHz used for WLAN application &3.5 GHz for Wi-MAX application. UWB devices may cause interference to these systems. So, band-notched characteristic is required at particular frequencies. One method to achieve band-notch at desired frequency is cutting slot on Antenna. It can be further modified for supporting applications requiring polarization diversity using *MIMO (Multiple input multiple output) communication*.

Index Terms: Coplanar-fed, polarization diversity, ultra wideband antenna, band notching filter.

1. INTRODUCTION

UWB is a free band. It is mainly used for the indoor application, *ultra wide band (UWB)* has become one of the most favourable technologies for wireless communications owing to its promising features such as low susceptibility to multipath fading, reduced probability of detection and intercept, and potentially high data rates.

The frequency band of 3.1-10.6 GHz is allocated to UWB application by *Federal Communications Commission (FCC)* this brings opportunity and challenges for antenna designer to design optimized antenna with reduced size, low manufacturing cost, good impedance match over whole frequency band, suitable feeding mechanism and reduce interference with other existing systems. Some frequencies in this particular band used for other application like 5.2 and 5.8 GHz used for WLAN application, 3.5 GHz for Wi-MAX application. UWB devices may cause interference to these systems. So, band-notched characteristic is required at particular frequencies. One method to achieve band-notch at desired frequency is cutting slot on patch. Different shapes of slots are used (V-shape, arc-shape and Ushape) [2] Due to promising results and low cost this method is widely used. Micro strip ring-resonator on the patch is another effective method for band-notch Attaching parasitic element of different shapes at the ground, same response can be achieved. CPW feed UWB antenna is more suitable because of its simple configuration and low cost in additional, feed line is determined by ratio of the line width and the width of the gap between ground plane and feed line [1] and [2]

Antenna is printed on substrate whose relative permittivity is 3.2 and height is 1.524 mm. The rectangular patch with matching stub is very widely used structure in micro strip technology [9]. We make it compatible with CPW technology. Here antenna and feeding structure are on the same plane and due to this single layer structure manufacturing become very easy and low cost. Width of feeding line and gap between transmission line and ground is decided such that characteristic impedance of 50Ω is obtained. Here width

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of feeding line Wf = 2.8 mm and gap between feed line and ground g is 0.5 mm. Gap between upper edge of ground and lower edge of patch is decides the overall performance of an antenna. Here, this gap is fixed at 1.5 mm. Slot at both end of ground used to improve higher frequency performance. If the return loss is < –10 db then the antenna is matched with the transmission line.

2. ANTENNA DESIGN

The Figure 1 shows the design of the proposed antenna. The antenna material is ROGERS RT/DUROID 5870 substrate ($\varepsilon r = 2.33$, $h = 1.57$ mm and tan $\varepsilon = 0.0005$ with a spacing of 3 mm (0.68 λ_n). Each patch comprises a semicircle with a rectangular section on the top. The two branches are fed through 50- coplanar lines. The back side of the substrate is devoid of metallization. The total area of the antenna structure is 27 × 52 mm the detailed dimensions are given in Table 1.

Table 1
Parameter value of fabricated antenna

Parameter	*a*	*b*	*c*	*d*	*r*	*w*	*I*	*k*
Value-mm	52	27	4.5	11.4	11	3.2	0.15	0.1

a = width of the antenna; *b* = height of the antenna; *r* = radius;
w = width of feed line; *l* = gap between feed line and ground;
d = height of the ground; *k* = gap between radiating element and ground

A photograph of the Design antenna is shown in Figure 1. In order to demonstrate the antenna operation, the simulated current distribution on the antenna at 7.5 GHz is depicted; it shows the surface current vector when ports 2 and 1 are terminated with 50 Ω load shown in the Figure 2.

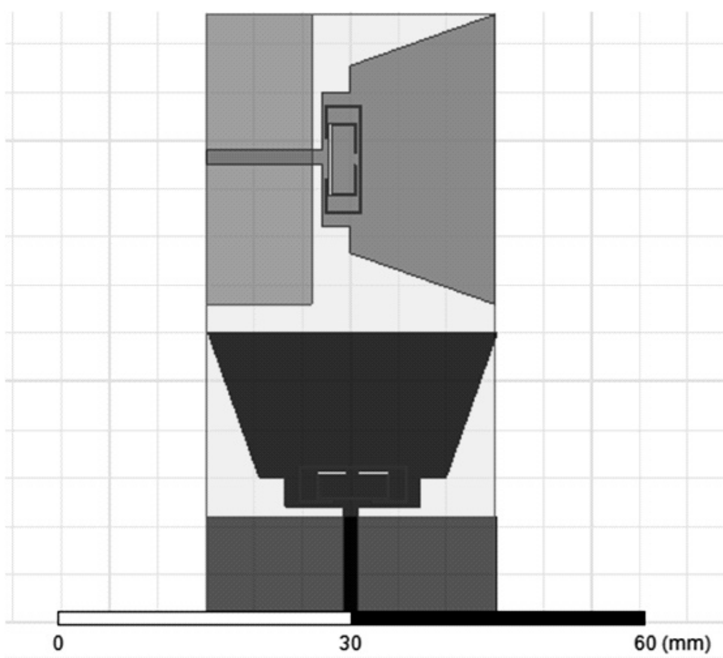

Figure 1: Proposed antenna design

The Figure 3(a) and (b) shows the corresponding reflection co-efficient $|S_{11}|$ and $|S_{22}|$. It is observed that when the antenna port 1 and 2 are matched, the current vector is aligned with the *y*-axis, which leads to an *e*-field linear *y*–polarization. When the current vector is aligned with the *x*-axis, it leads to a linear *x*–polarization. It is also seen that the coupled fields to the adjacent branch are aligned with the excited port field [4].

Figure 2: Current density flow port 1 and port 2 are matched

As observed, decreasing "*r*" from 11mm to 9 mm and 7 mm leads to 9.3% and 14.8% up shift in the –10 dB lower frequency edge of $|S_{11}|$ and $|S_{22}|$ respectively,which reduces the antenna bandwidth. Moreover, decreasing from 4.5 mm to 2.5 mm and 0.5 mm results in a $|S_{11}|$ lower-frequency edge up shift of 12.8% and 15%, and a $|S_{22}|$ up shift of 17% and 22.7%, significantly reducing the antenna bandwidth [6]. It is also seen that $|S_{21}|$ is below –20 dB for these parameters variations. That was show in the Figure 3 (c)

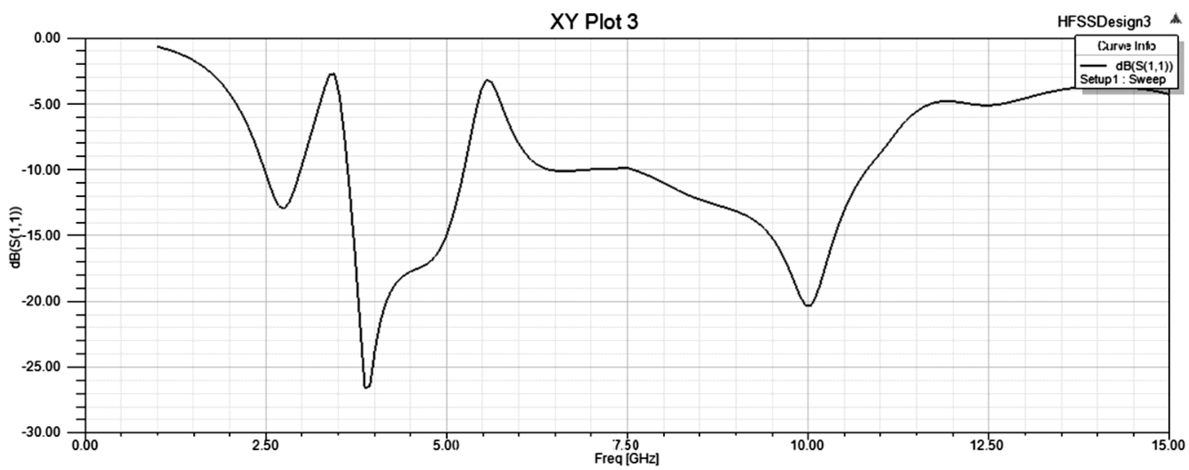

Figure 3: (a) Stimulated antenna reflection co-efficient $|S_{11}|$

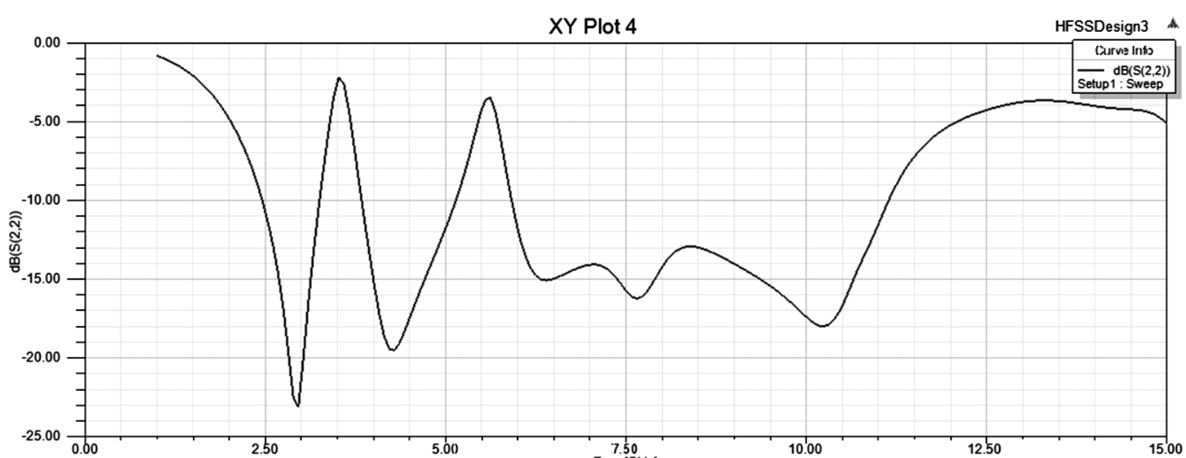

Figure 3: (b) Stimulated antenna reflection co-efficient $|S_{22}|$

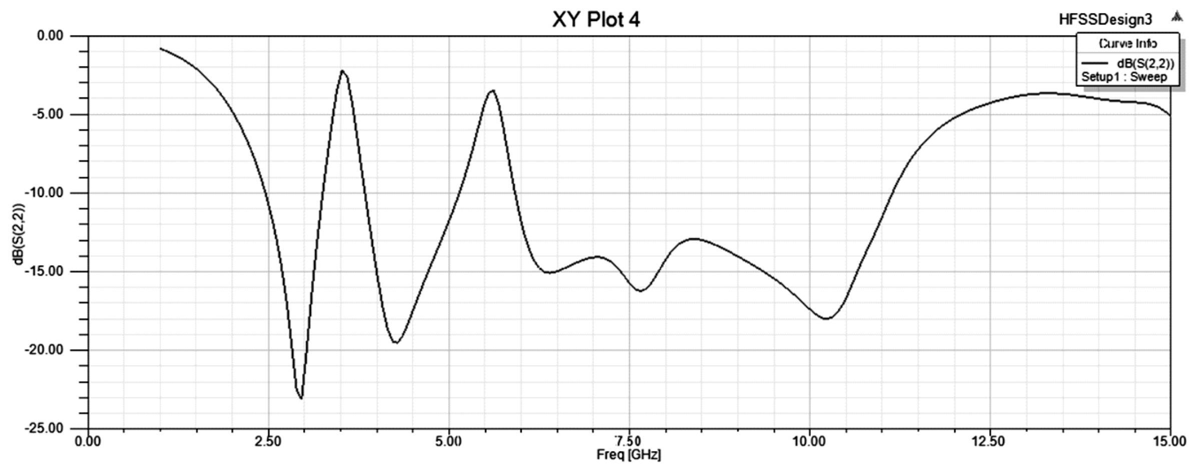

Figure 3: (c) Mutual coupling of isolation $|S_{21}|$

3. EXPERIMENTAL RESULTS AND DISCUSSION

The measured results including s-parameters, radiation pattern, return loss, gain, peak-directivity, accepted-power, incident power and front to back ratio validate the proposed design both for frequency and time domain [1] and [6]

Measured and simulated antenna parameters are depicted in Figure 4. As it can be seen, reflection coefficient impedance bandwidths, based on $|S_{11}|$ and $|S_{22}| < -10$ dB almost in the entire band except at 7–7.4 GHz where $|S_{11}|$ reaches a maximum of 9.5 dB at 7.2 GHz, of port 1 and port 2 are 3.25–12 GHz (115%) and 3.55–11.7 GHz (107) %, respectively. Moreover, $|S_{21}|$ is lower than −22 dB over the entire range of frequencies. The discrepancy between simulated and measured s-parameters responses is attributed to factors.

But in-between this (3.1-10.6) GHz WI-FI, WLAN, BLUETOOTH are also used from (5.2-5.8) GHz and (3.4-3.8)GHz for wimax. It will Experience the interference from WI-FI, WLAN,WIMAX and BLUETOOTH. So we need to remove (5.2-5.8) GHz and (3.4-3.8) GHz frequency from our Ultra wide band antenna .That means we had to implement a band notched filter .That will filter (5.2-5.8) and (3.4-3.8) GHz from the ultra wide band Range

Total size of the antenna is: 27 × 52 × 1.57 (mm)

L	W	H

The output of the return loss (a), radiation pattern (b), gain (c) is shown in the below Figure 4.

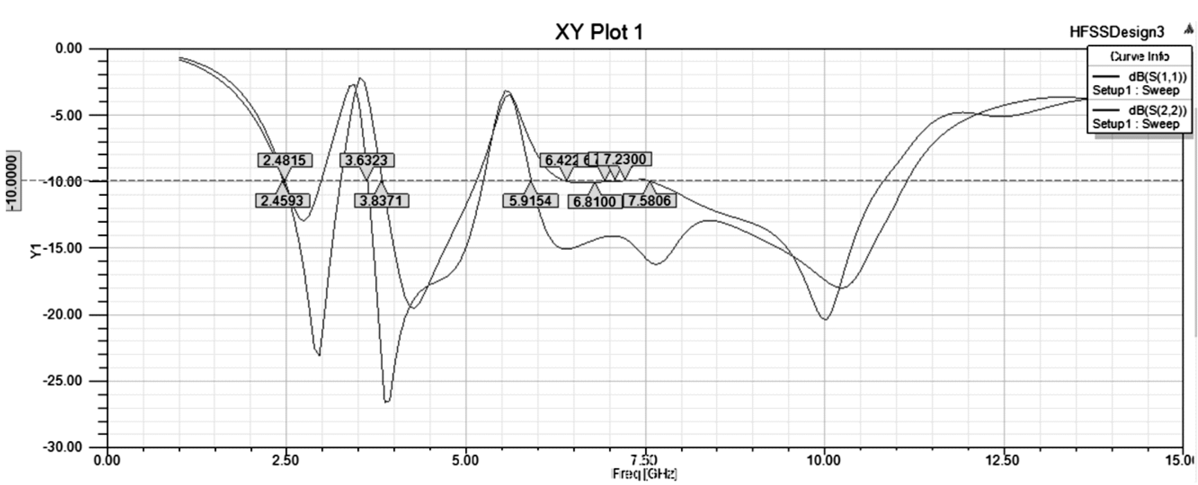

Figure 4: (a) Return loss

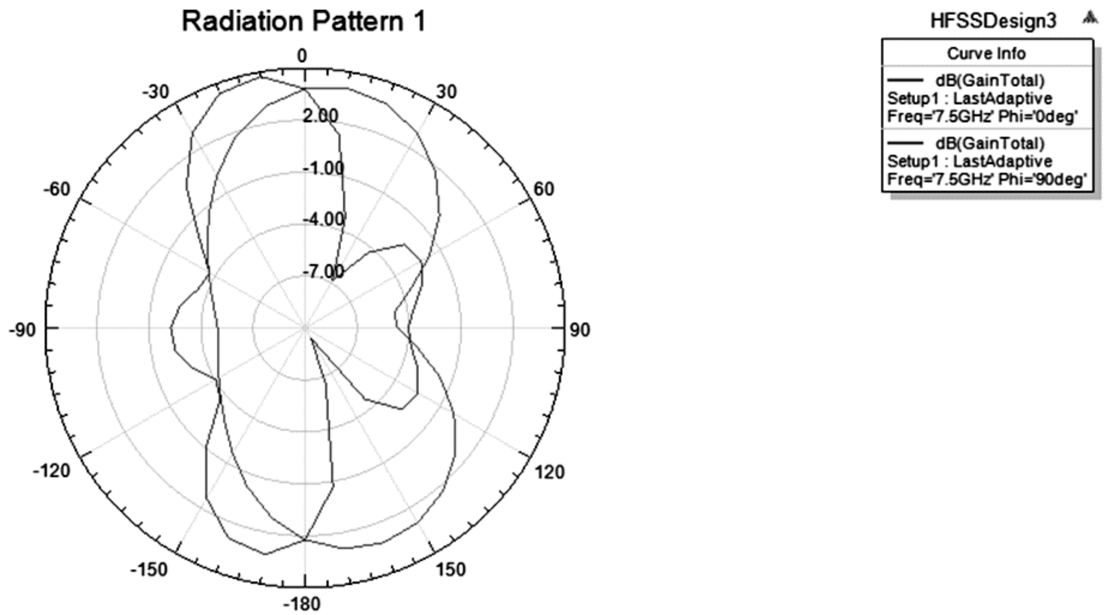

Figure 4: (b) Radiation pattern

Figure 4: (c) Gain

Antenna Parameter specifications (a) and maximum data rate (b) are mentioned in the below Figure 5.

Quality	*Frequency*	*Value*
Max U	7.5 Ghz	0.21628 W/sr
Peak Directivity		3.4802
Peak Gain		3.0333
Peak Realized Gain		2.7192
Radiated Power		0.78133 W
Accepted Power		0.89645 W
Incident Power		1 W
Radiation efficiency		0.87158
Front to back ratio		3.7656

Figure 5: Antenna Parameter Specifications

eE field	*Freq*	*Value*	*At(phi, theta)*
Total	7.5 Ghz	12.773 V	150 (degree)
			10 (degree)
X		8.3926 V	120 (degree)
			90 (degree)
Y		12.452 V	150 (degree)
			10 (degree)
Z		6.1013 V	100 (degree)
			130 (degree)

Figure 5: (d) Maximum data rate

To evaluate the diversity performance, the envelope correlation coefficient, ρ_e has been computed using the following equation

To evaluate the diversity performance [2]

$$\rho_e = \frac{|S_{11}^* S_{12}^* + S_{21}^* S_{22}^*|^2}{(1-(|S_{11}|^2+|S_{21}|^2))(1-(|S_{22}|^2+|S_{12}|^2))}$$

The envelope correlation coefficient for our proposed UWB diversity antenna is below 20dB across the entire ultra-wide band width .Note that the correlation at low frequencies, which is usually much higher, is still very low in our proposed diversity antenna.[2] These results indicate the effectiveness of the designed dual orthogonal polarization, which leads to a good diversity performance.

4. CONCLUSION

The patch antenna was designed for UWB frequency by using the notch filter both at TX and RX to extract the freq (3.1-10.6)

GHz. It will Experience the interference from WI-FI, WLAN, WIMAX and BLUETOOTH. So we need to remove (5.2-5.8) GHz and (3.4-3.8) GHz frequency from our Ultra wide band antenna .That means we had to implement a band notched filter .That will filter (5.2-5.8) and (3.4-3.8) GHz from the ultra wide band Range. These results show that the proposed antenna is suitable for future portable UWB diversity applications.

References

1. Seyed Ramin Emadian and Javad Ahmadi-Shokouh Very Small Dual Band-Notched Rectangular Slot Antenna With Enhanced Impedance Bandwidth IEEE Transactions on antennas and propagation, Vol. 63, No. 10, October 2015.
2. A Novel Compact CPW-Fed Polarization Diversity Ultra wideband Antenna Mohsen Koohestani, Student Member, IEEE, Antonio A. Moreira, and Anja K. Skrivervik IEEE antennas and wireless propagation letters, Vol. 13, 2014.
3. Mohsen Koohestani, student Member, IEEE, Antonio A. Moreira, and Anja K. Skrivervik a Novel Compact Cpw - fed Polarization Diversity Ultra wide band Antenna. IEEE Antennas and Wireless Propagation Letters, Vol. 13, 2014.
4. Chine Jen Wang and Kai lung Hsiao. CPW Fed Monopole Antenna for Multiple System Integration. IEEE Transactions on Antenna and Propagation, Vol. 62, No. 2, Feb 2014.
5. J. Liu, K. Esselle, S. Hay, Z. Sun, and S. Zhong, A compact super wide band antenna pair with polarization diversity, IEEE Antennas Wireless Propagation. Letters, vol. 12, pp. 14721475, 2013.
6. M. Koohestani, N. Piers, A. K. skrivervik, and A. A. Moreira time domain performance of patch-loaded band-reject UWB antenna, electron. Letters, Vol. 49, No. 6, pp. 385386, 2013.
7. G. Quintero J.f. Zãijrcher and A.K. Skrivervik, system Fidelity factor: a new method for comparing UWB antennas, IEEE trans. antennas propagation, Vol. 59, No. 7, pp. 25022512, Jul. 2011.

8. A UWB band pass filter with multi notched bands using micro strip/coplanar waveguide Binyan Yao, Yong gang Zhou, Qunsheng Cao college of information and technology, Nanjing university of aeronautics and astronautics, Nanjing, 210016, china.
9. Gain enhancement of a Cpw - fed horse shoe shaped slot antenna with defected ground structures for WImax/wlan applications Vivek Tiwari Kirti vyas neha Goyal lecturer, Dep't. of ECE Arya college of engg and i.t kuakas, Jaipur, India.
10. A printed diversity cantor set fractal antenna for ultra wideband communication applications yingsong li, wenxing li, chengyuan Liu, to Jiang College of information and communications engineering, Harbin, p.r.china Li yingsong, Li wenxing, Li chengyuan, Jiangtao @ hrbeu.edu.cn.
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