

# Design a Notch Loaded U-shaped Textile Antenna for Wireless Communication System

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**ABSTRACT:** In this paper the notch loaded U-shaped design of microstrip patch antenna using textile as substrate has been proposed & studied. In the proposed design, Jeans is used as a substrate and copper tape is used to make ground & patch. This paper shows research on wearable microstrip patch antennas designed and developed for various wireless applications at 2.45 GHz frequency. The proposed antenna has been designed for 2.45 GHz frequency and simulated using IE3D simulation tool. The substrate is jeans and has thickness of 1 mm, dielectric constant of 1.7, and loss tangent of 0.025. The obtained bandwidth is 42.2 % (2.19 GHz – 3.356 GHz) with return loss of -21.15dB, gain of 4.72 dBi, directivity of 4.92 dBi, antenna efficiency of 95.6 % and radiation efficiency of 96.3 % at resonant frequency 2.442 GHz. The antenna is fed by 50Ω Micro strip line feed.

**KEYWORDS:** Microstrip patch antenna, Textile substrate, Copper Tape, IE3D simulation tool, and Microstrip line feed.

## INTRODUCTION

In this advance technology period the wireless communication is mostly used for communication and data transfer purpose. Several antennas are widely used for wireless communication [1-3]. In the recent year the wireless communication is essential for everybody in routine life like as mobile, Wi-Fi and Wi-Max. This advancement in wireless system is due to integration of microwave circuit component with same circuit board such as resistor, inductor, capacitor and micro strip patch antenna. For better performance of wireless communication wide band antenna will require to design. Due to need of user for portable health care, tracking, navigation and sports monitoring etc. wearable antenna [5-8] have received major attention during the last decade. Wearable antenna is flexible, compact and light. Textile antenna use textile material as a substrate has a very low dielectric constant which reduces the surface wave losses and improves the impedance bandwidth. For textile antenna microstrip patch antenna is preferred because microstrip patch antenna associate metallic ground plane between radiating patch and body which reduce the effect of radiation on body. The specific absorption rate (SAR) [9] shows the rate of energy absorption by the human body tissue when exposed to fields radiated by the antenna. This is used to be measured for any wearable antenna design.

The proposed antenna is made of jeans fabric & patch and ground are made of copper self adhesive tape. For enhancing bandwidth of proposed antenna doing notch on U-shaped [10-12] microstrip patch antenna and microstrip feed [13-14] is used. Simulation results such as reflection coefficient, gain, directivity, radiation pattern and efficiency are presented.

## II. MATHEMATICAL FORMULAS TO CALCULATE THE DESIGN DIMENSIONS OF MICROSTRIP PATCH ANTENNA

The mathematical formula [4] is used to calculate the dimensions of ground plane and microstrip patch in the form of length and width.

The formula of calculating the width of Patch antenna is given as:

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$$W = \left( \frac{c}{2f_r} \right) \left( \frac{\epsilon_r + 1}{2} \right)^{-1/2}$$

Where:  $c = 3 \times 10^8 \text{ ms}^{-1}$ ,  $\epsilon_r = 1.7$ ,  $f_r = 2.45 \text{ GHz}$

Formula of effective dielectric constant is given as:

$$\epsilon_{eff} = \left( \frac{\epsilon_r + 1}{2} \right) + \left( \frac{\epsilon_r - 1}{2} \right) \left( 1 + \frac{12h}{W} \right)^{-1/2}$$

Where:  $h = 1 \text{ mm}$

Formula of extension in length is given as:

$$\Delta L = 0.412h \left( \frac{\epsilon_{eff} + 0.3}{\epsilon_{eff} - 0.259} \right) \left( \frac{\left( \frac{W}{h} \right) + 0.264}{\left( \frac{W}{h} \right) + 0.8} \right)$$

The formula of calculating the length of Patch antenna is given as:

$$L = \left( \frac{c}{2f_r \sqrt{\epsilon_{eff}}} \right) - 2\Delta L$$

### III. ANTENNA DESIGN SPECIFICATION

For calculation of dimension several parameter such as resonant frequency ( $f_r$ ), dielectric constant ( $\epsilon_r$ ), substrate thickness ( $h$ ) and loss tangent ( $\tan \delta$ ) and  $50\Omega$  Microstrip line is used as feed into patch are required. The antenna specifications that are required are given in table 1.

TABLE 1: ANTENNA DESIGN SPECIFICATIONS

S. NO	Antenna Parameter	Data
1.	Resonant frequency ( $f_r$ )	2.45 GHz
2.	Substrate thickness ( $h$ )	1 mm
3.	Dielectric constant ( $\epsilon_r$ )	1.7
4.	Loss Tangent ( $\tan \delta$ )	.025

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## IV.ANTENNA DESIGN PROCEDURE

Using the above equations and design specification, the dimensions of the antenna is calculated. In the design of proposed antenna firstly form a rectangular patch with calculated dimensions of patch and made a U-shaped design on patch by loading notch. Then create a notch of length L1 and width W1 symmetrically on both side arm of U-shape design near the microstrip feed of 50 Ω. U-shaped design has been modified by increasing notch width and reducing notch length stepwise. By doing this procedure the bandwidth has been enhanced and resonant peak shifted towards lower frequency side. The notches are symmetrically designed and Different dimensional parameters of proposed antenna are given in table2.

A 50Ω microstrip line feed is used at mid of length of the patch antenna. The position of feed is (Lg/2) on the positive X axis from the origin.

TABLE 2: CALCULATED ANTENNA DIMENSIONS

S No.	Antenna Dimension	Data (mm)
1.	Ground Length (L <sub>g</sub> )	52.2
2.	Ground Width (W <sub>g</sub> )	58.7
3.	Patch Length (L <sub>p</sub> )	46.2
4.	Patch Width (W <sub>p</sub> )	52.7
5.	L1	4
6.	W1	14
7.	L2	7.5
8.	W2	20
9.	L3	3
10.	W3	3
11.	Ls	3
12.	Ws	3

The design of calculated notch loaded U-shaped microstrip patch antenna is shown in figure 1

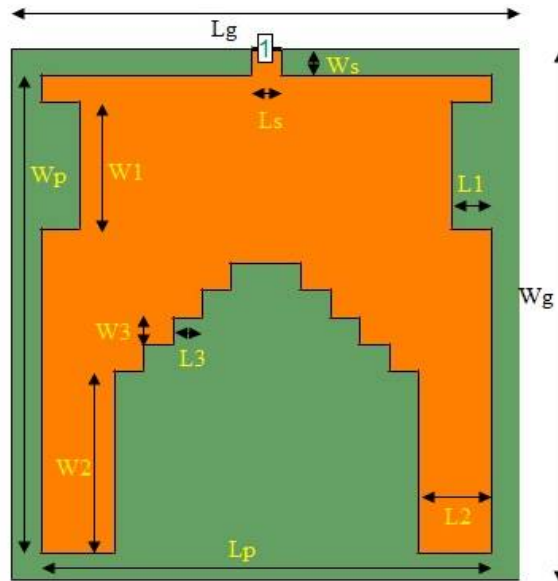


Figure 1: Geometry of proposed antenna and all dimensions in mm

### V.SIMULATION RESULT AND DISSCUSSION

The simulation performance of proposed microstrip patch antenna is analyzed by using IE3D simulation software tool at select resonant frequency of 2.45 GHz. The graph of return loss Vs frequency is plotted for the range of frequency 1GHz to 4GHz, because within this range the curve crosses the -10dB which is shown in figure 2.

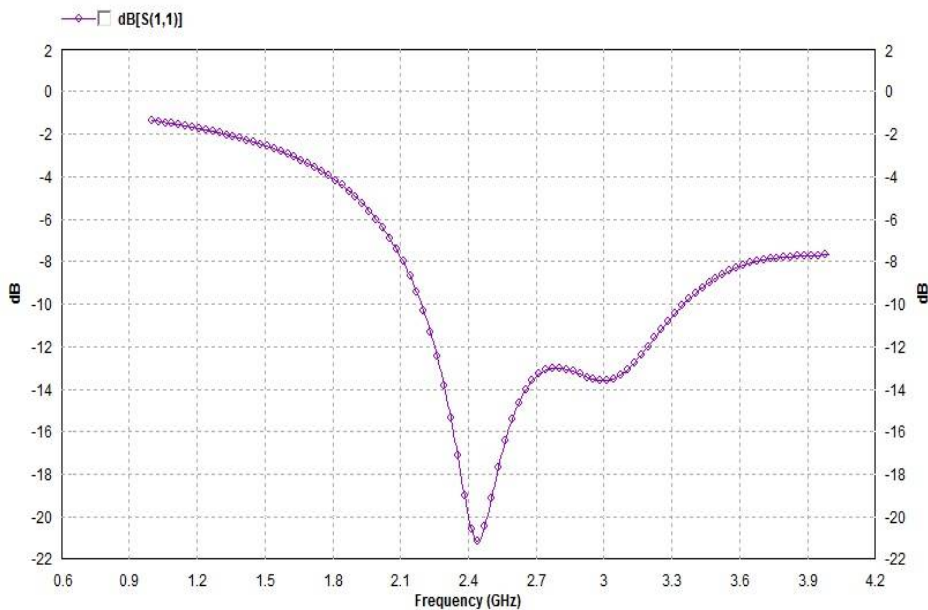


Figure 2: return loss vs. frequency graph of proposed antenna

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From figure 2, it is observed that the bandwidth of proposed antenna 1169 MHz (42.2 % fractional bandwidth) between 2.190 GHz to 3.356 GHz band and Return loss of -21.15 dB at resonance frequency 2.442GHz has been obtained. It is also observed that operating resonance frequency 2.442 GHz shows close agreement with designed resonance frequency 2.45GHz.

The graph of Gain Vs Frequency of proposed antenna is shown in figure 3.

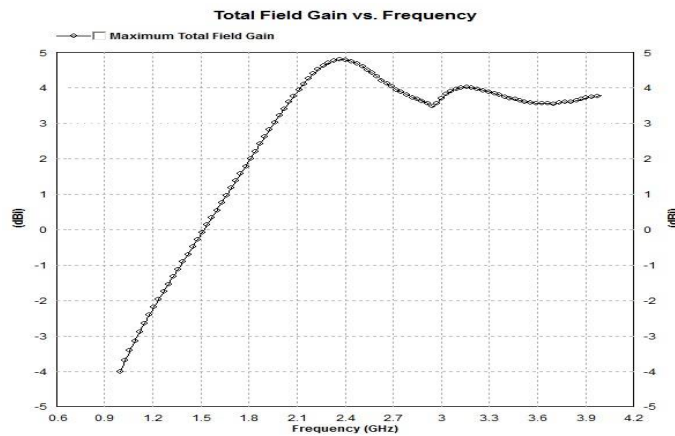


Figure 3: Gain Vs. Frequency graph

The maximum gain of proposed antenna is 4.785 dBi. It is also observed that the gain of proposed antenna at resonant frequency 2.442 GHz is 4.723 dBi.

The graph of Directivity Vs Frequency of proposed antenna is shown in figure 4.

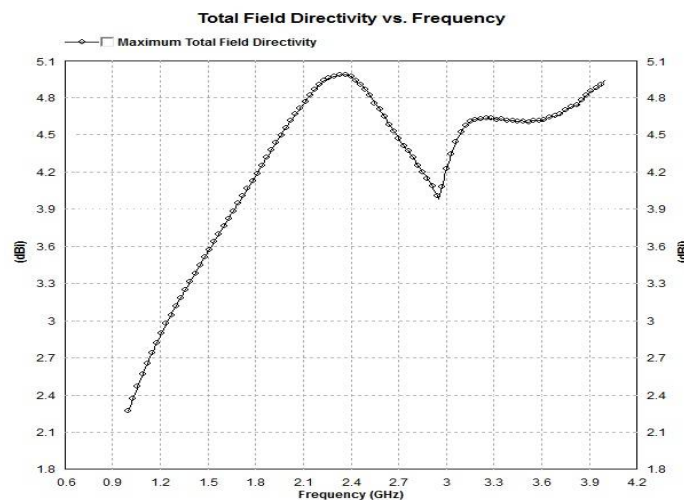


Figure 4: Directivity Vs. Frequency graph

The maximum directivity of proposed antenna is 4.987 dBi. It is also observed that the directivity of proposed antenna at resonant frequency 2.442 GHz is 4.919 dBi.

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The graph of Efficiency of proposed antenna is shown in figure 5.

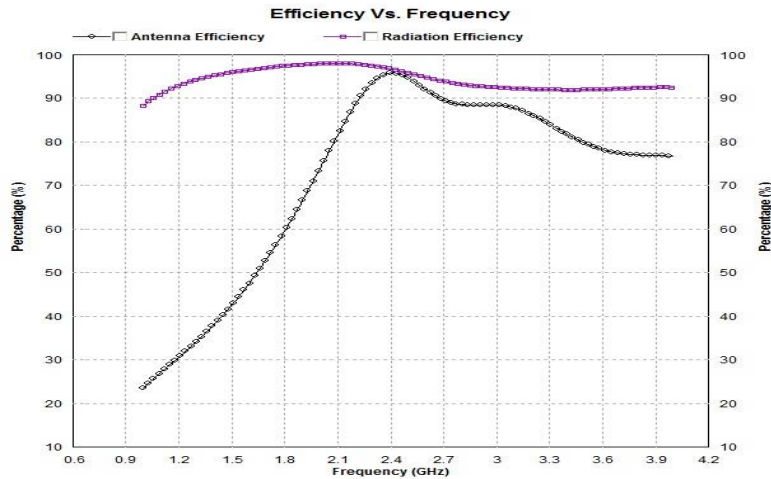


Figure 5: Efficiency Vs. Frequency graph

From figure 5 it is observed that the maximum antenna efficiency and radiation efficiency of proposed antenna is 95.74 % and 97.93 % respectively. It is also observed that the antenna efficiency and radiation efficiency of proposed antenna at resonant frequency 2.442 GHz is 95.57 % and 96.31 % respectively.

The graph of radiation pattern of proposed antenna is shown in figure 6.

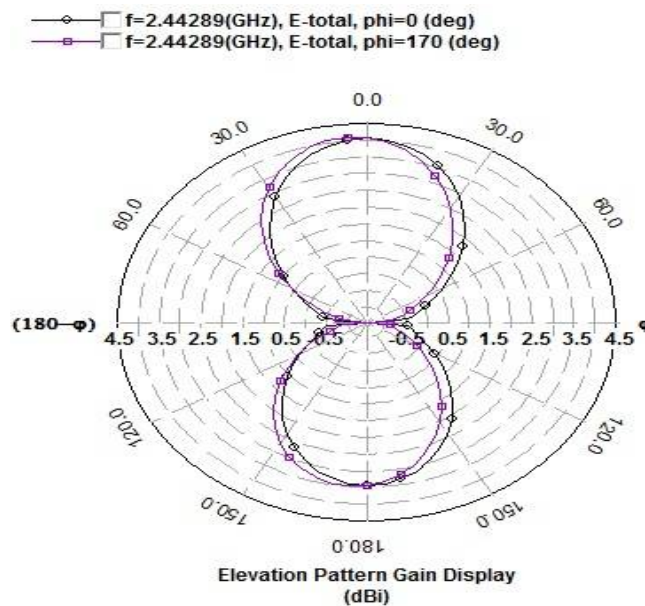


Figure 6: Radiation pattern

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The radiation pattern represents radiation of all power in two directions therefore it shows that the proposed antenna has bidirectional radiation pattern.

## VI.CONCLUSION

From the analysis of proposed antenna it is concluded that the bandwidth, resonant frequency and return loss depends on dimensions of the notch. It is observed that the bandwidth enhanced up to 42.2 %. It is also concluded that the operating frequency and design frequency of proposed antenna shows close agreement. The proposed antenna can be utilized in wireless communication system.

## REFERENCES

1. Marno van Rooyen, Johann W. Odendaal and Johan Joubert "High-Gain Directional Antenna for WLAN and Wi-MAX Applications" IEEE Antennas and wireless propagation letters, Vol. - 16, pp. 286-289, 2017.
2. Yu-Jen Chou, Guo-Sheng Lin, Jun-Fu Chen, Lih-Shan Chen and Mau-Phon Houng "Design of GSM/LTE multiband application for mobile phone antennas" Electronis Letter Vol. 51 No. 17, pp. 1304-1306, 20th August 2015.
3. N. Herscovivi, N.H. Nashua and E. Dziadek, "Omni directional antennas for wireless communication", Antennas and Propagation Society International Symposium, pp. 556 – 559, 1999.
4. Constantine A. Balanis, "Antenna Theory-Analysis and Design", 3rd Edition, A John Wiley & Sons, INC., Publication.
5. Roy B. V. B. Simorangkir, Yang Yang, Ladislau Matekovits and Karu P. Esselle "Dual-Band Dual-Mode Textile Antenna on PDMS Substrate for Body-Centric Communications" IEEE Antennas and Wireless Propagation Letters, Vol. 16, pp. 677-680, 2017.
6. J. Tak, S. Woo, J. Kwon, and J. Choi, "Dual-band dual-mode patch antenna for on-/off-body WBAN communications," IEEE Antennas Wireless Propagation Letter, vol. 15, pp. 348-351, 2016.
7. S. Agneessens, S. Lemey, T. Vervust, and H. Rogier, "Wearable, small, and robust: The circular quarter-mode textile antenna," IEEE Antennas Wireless Propagation Letter, vol. 14, pp. 1482-1485, 2015.
8. Q. H. Abbasi, M. U. Rehman, X. D. Yang, A. Alomainy, K. Qaraqe, and E. Serpedin, "Ultra wide band band-notched flexible antenna for wearable applications," IEEE Antenna Wireless Propagation Letter, vol. 12, pp. 1606-1609, Jan. 2014.
9. S. W. Lee, S. M. Park, N. Kim, S. W. Park, and S. Y. Rhee, "Design and SAR Measurement of the Trapezoidal Shape Antenna," Progress In Electromagnetics Research C, Vol. 26, 127-136, 2008.
10. Abdelheq Boukarkar, Xian Qi Lin, Yuan Jiang, and Yi Qiang Yu "Miniaturized Single-Feed Multiband Patch Antennas" IEEE Transactions on Antennas And Propagation, Vol.- 65, No. 2, pp. 850-854, February 2017.
11. Shuo Liu, Wen Wu, and Da-Gang Fang "Single-Feed Dual-Layer Dual-Band E-Shaped and U-Slot Patch Antenna for Wireless Communication Application" IEEE Antennas And Wireless Propagation Letters, Vol. 15, pp.468-471, 2016.
12. Kratika Tiwari, Kaushal Prasad, Rishabh Kumar Baudh, Saurabh Singh "Design and Optimized Analysis of Defected U Shaped Microstrip Line Fed Patch Antenna with Trapezium Slot for Wideband Applications" International Journal of Scientific Engineering and Research (IJSER) Volume 5 Issue 1, January 2017.
13. Ashish Singh, Mohammad Aneesh, Kamakshi, Anurag Mishra and J. A. Ansari, "Analysis of F-shape micro strip line fed dual band antenna for WLAN applications," Wireless network, Vol. 20, Issue 1, pp 133-140, January 2014.
14. Y. Sung, "A printed wide-slot antenna with a modified L-shaped micro strip line feed for wideband applications", IEEE Trans Antennas Propagation, pp.3918-3923, 2011.