DESIGN OF ULTRA WIDE BAND MONOPOLE ANTENNA WITH DUAL BAND NOTCH CHARACTERSTICS.

Author[1]: TAMMINEEDI RAGHAVENDRA SAI RAKSHIT,
Author[2]: VALIVETI VIJAY KUMAR,
Author [3]: RACHAKONDA HARI KIRAN.

[1] *Student, ECE, VASIREDDY VENKATADRI INSTITUTE OF TECHNOLOGY, A.P., INDIA*
[2] *Student, ECE, VASIREDDY VENKATADRI INSTITUTE OF TECHNOLOGY, A.P., INDIA*
[3] *Student, ECE, VASIREDDY VENKATADRI INSTITUTE OF TECHNOLOGY, A.P., INDIA*

ABSTRACT

In This project, we design an ultra-wideband (UWB) flexible antenna with a dual band-notched property. This antenna is fed by a coplanar waveguide (CPW) phased transmission line to achieve an impedance bandwidth of 1.95–35 GHz for VSWR ≤ 3. A double C-shaped slot within the monopole radiation patch and two L-shaped slots etched on the ground are introduced to reject the bands of 3.5 GHz (3.2–3.8 GHz) and 5.5 GHz (4.8–5.7 GHz), respectively, which are assigned to WiMax and WLAN applications. A Rogers4350 substrate is used to realize a low profile (0.29λL×0.22λL×0.00065λL, where λL is the free-space wavelength of the smallest operating frequency). The measured results show that the antenna has a UWB omnidirectional radiation specific that is suitable for UWB wireless communications.

Keyword: - *Key word1: ultra-wideband antenna, Key word2: VSWR, Key word3: S-parameters, Key word4: CST- Software, key word5: Rogers4350B substrate.*

1. INTRODUCTION

In UWB wireless communication system, Ultra-wideband (UWB) antenna is an important element. It has attracted lots of study interest from numerous researchers due to its advantages of small size, very wide bandwidth, low cost, and good radiation characteristics [1]. A lot of exploration workshops on UWB antenna design have been published in the once decade [2–6]. For illustration, in 2008, an antipodean Vivaldi antenna that operated from 3.1 to 10.6 GHz (7.5 GHz bandwidth) was proposed in [2]; in 2013, an electromagnetic band gap structure was introduced into the design of a UWB antenna, which increased the bandwidth of the antenna from 9.27 GHz to 9.33 GHz [3]; in 2019, a flexible UWB antenna with 15.05 GHz bandwidth was designed in [4]. Obviously, the bandwidth as large as possible is anticipated in UWB antenna design. Still, it will cause interference in some useful frequency bands, similar as a WLAN (2.4–2.5 GHz) band, WiMax (3.5–3.7 GHz) band, and the IEEE 802.11a (WLAN) systems operating in the frequency band of 5.15–5.825 GHz [7–15].

By adding a filter [8–10] to the feed network of the antenna, we can avoid this interference and it is one of the effective ways. In 2012, a second-order maximally flat band stop filter at 5.5 GHz was introduced into a UWB antenna (operating at 3.1–10.6 GHz) to achieve a notch-band suppression from 5.15 to 5.95 GHz [8]. In 2017, a balanced band gap UWB filtering antenna was proposed in [9], which could cover 2.95–10.75 GHz except for the notch band of 5.01–6.19 GHz. In the same time, a reconfigurable filtering antenna that could switch between WLAN and UWB bands was presented in [10]. Occasionly, the design of the filter will increase the complexity and size of the antenna.

We were intended to design an antenna with good notch performance. In [1, 11–13], two or three band-notched antennas have been proposed, but these antennas were fabricated on a non-flexible substrate, similar to Rogers RO4003 [1], FR4 [11], and RT/ Duroid 6010LM [12] substrates. Due to their lack of conformability and flexibility, they cannot be fraudulent on the terminals. During the decade, numerous UWB flexible antennas have been presented [4–6]. Still, the utmost of them cannot achieve the intended notched-band property.

Recently, a conformal one notched-band flexible antenna was designed and fabricated on a polydimethylsiloxane (PDMS) substrate [14]. However, its electric size was relatively large and cannot cover the whole UWB. In 2014, by loading remainders and grooving a slot on the radiation patch, we designed a polyimide flexible UWB antenna that operated from 2.76 to 10.6 GHz with dual-notched bands of 3.5 GHz and 5.5 GHz [15]. Although its two stopbands can be designed independently, the length of the remainders would affect the total bandwidth of the UWB antenna. Besides, a stepped impedance resonator was introduced to achieve a good impedance matching, which was hard to design. In addition, the influence of the antenna bending on performance and the relationship between the impedance matching and its gain are not considered in that paper.

In this paper, we are designing a circle-shaped UWB monopole antenna with a dual band-notched characteristic at the WiMAX and WLAN bands is presented and fabricated on a Rogers4350 substrate, which has the advantages of excellent mechanical strength, thermal stability, low transmission loss, and insertion loss at high frequency. Details of the antenna design are presented, and its bandwidth, radiation patterns, and peak gains are measured and studied in this paper.

2. ANTENNA DESIGN AND PARAMETRIC STUDIES

Figure 1 illustrates the design progress of the antenna to realize the dual-band rejection of 3.5GHz and 5.5GHz. It can be divided into three steps. First, a circle patch fed by a coplanar waveguide (CPW) trapeziform feed line is presented (see Figure 1(a)). Then, two symmetrical C slots are fitted into the radiation patch and connected with a rectangular slot to reject the band of the 3.5GHz (see Figure 1(b)). Finally, as shown in Figure 1(c), two grooves are dug out of the ground to block the transmission of the WLAN signals. These antennas are printed on ultra-thin Rogers4350 substrates with a thickness of 0.1 mm and relative permittivity of 3.5.

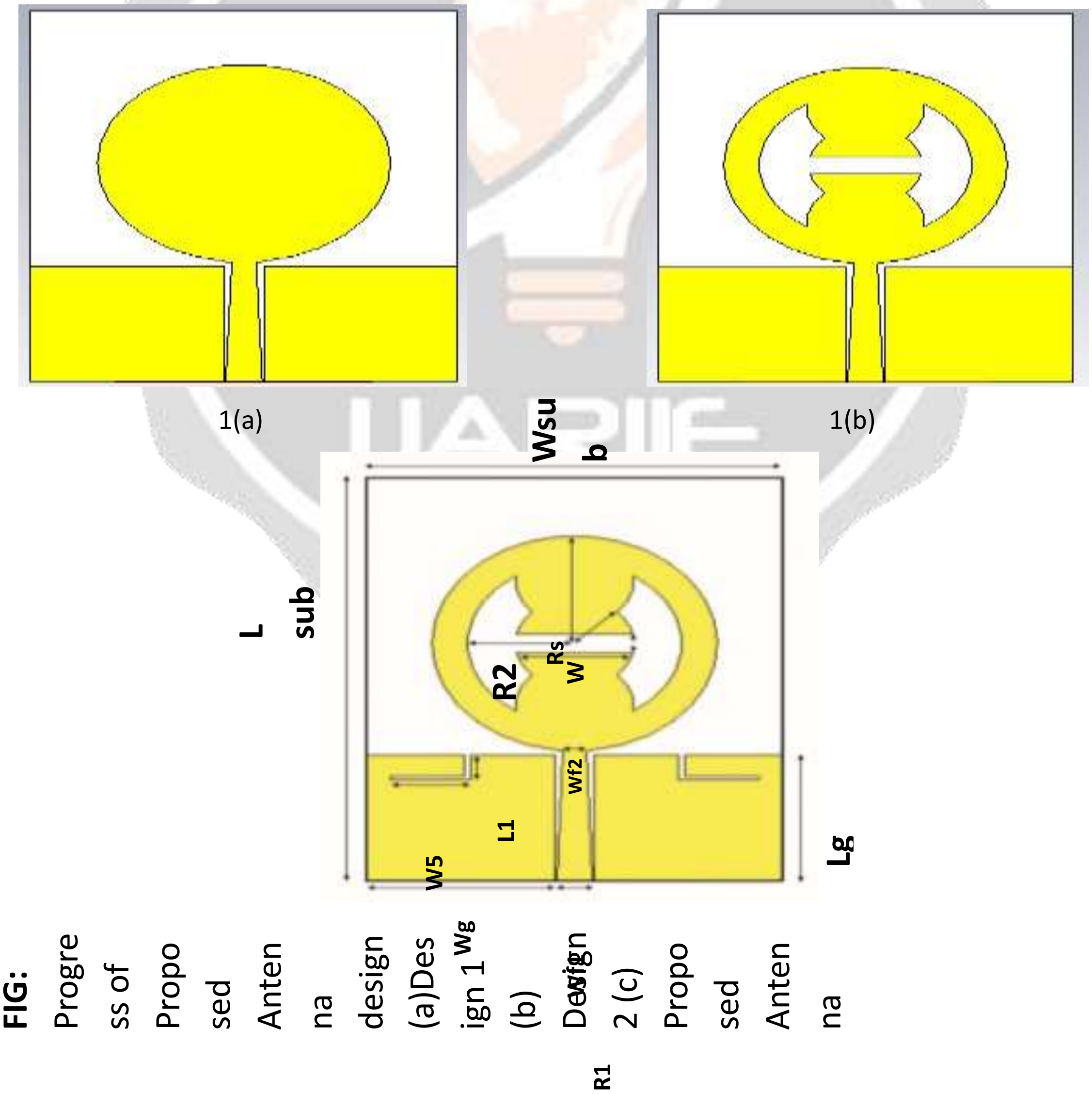

FIG: Progress of Proposed Antenna design (a)Design 1 (b) Design 2 (c) Proposed Antenna

We compare VSWR simulated results of three designs, which are shown in figures. It is clearly observed from the figure that 'Antenna 1' has a broadband characteristic; 'Antenna 2' produces a stopband at the lower frequency; and 'Antenna 3' has two stopbands in the higher band. The effects of the parameters on 'Antenna 3' are studied. The variation of the VSWRs with the main parameters is shown in Figure 3. As shown in Figure 3(a), when θ increases from 80◦ to 120◦, the first stopband shifts to a lower frequency with a higher VSWR, and the high-frequency part remains basically unchanged. It means that the WiMAX signals can be further suppressed. Figure 3(b) illustrates the effects of W4 on the second stopband. It is found that with the increase of W4, the stopband of the WLAN part gradually shifts to a high frequency. When W4 = 6.8 mm, the high frequency stopband just falls at 5.5 GHz. Through adjustment, the optimized parameters are determined and listed in Table 1.

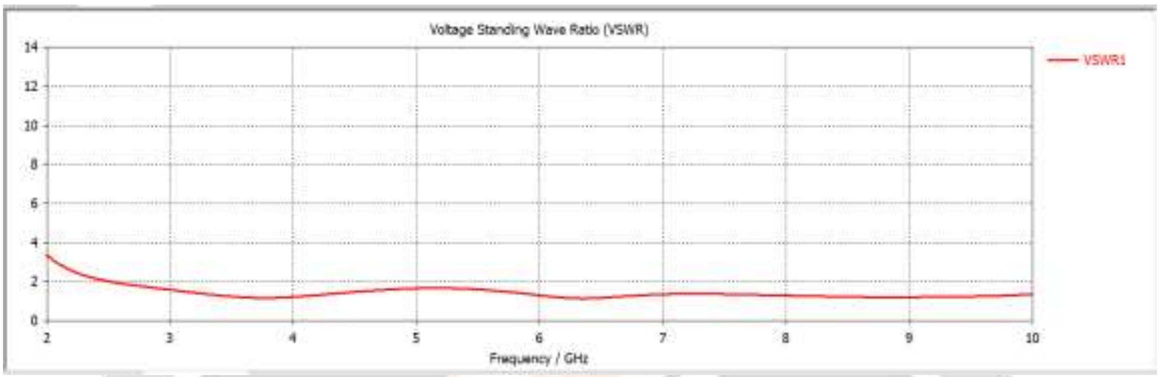

FIG: VSWR OF DESIGN-1

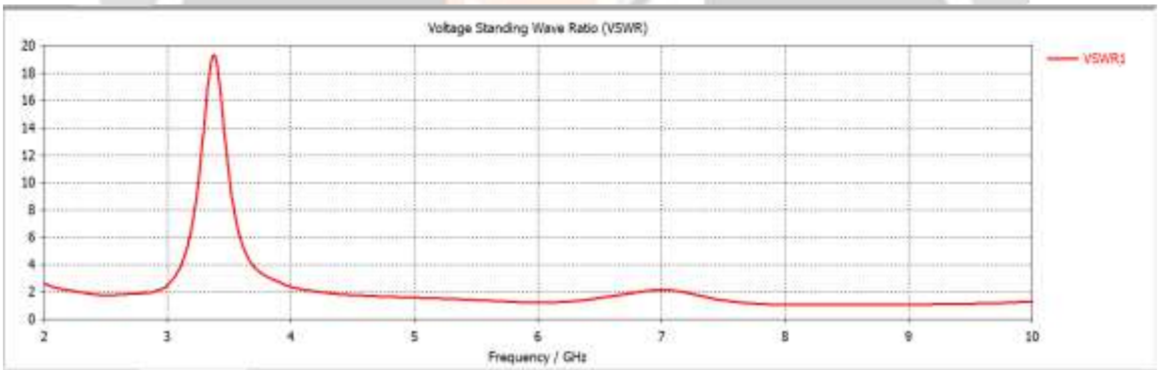

FIG: VSWR OF DESIGN-2

The antenna is bent at different angles. We use R (as shown in Figure 4(a)) to measure the degree of bending. The simulated bending characteristics are shown in Figure 4. It can be seen that bending only brings a slight frequency offset and a reduction in VSWR in the notch band, but the antenna still maintains a good notch property and a good impedance match at the other frequencies.

Table-1: Optimized parameters of proposed antenna.

Parameter	Wsub	Lsub	R1	R2	RL	ϑ	L1	W1
Dimension(mm)	35	45	12	4.8	9	120	2	9.6
Parameter	Wf2	Wf1	L6	Wg	Lg	L4	L5	W5
Dimension(mm)	2.5	3	14.5	15.85	14	3	0.2	7.8

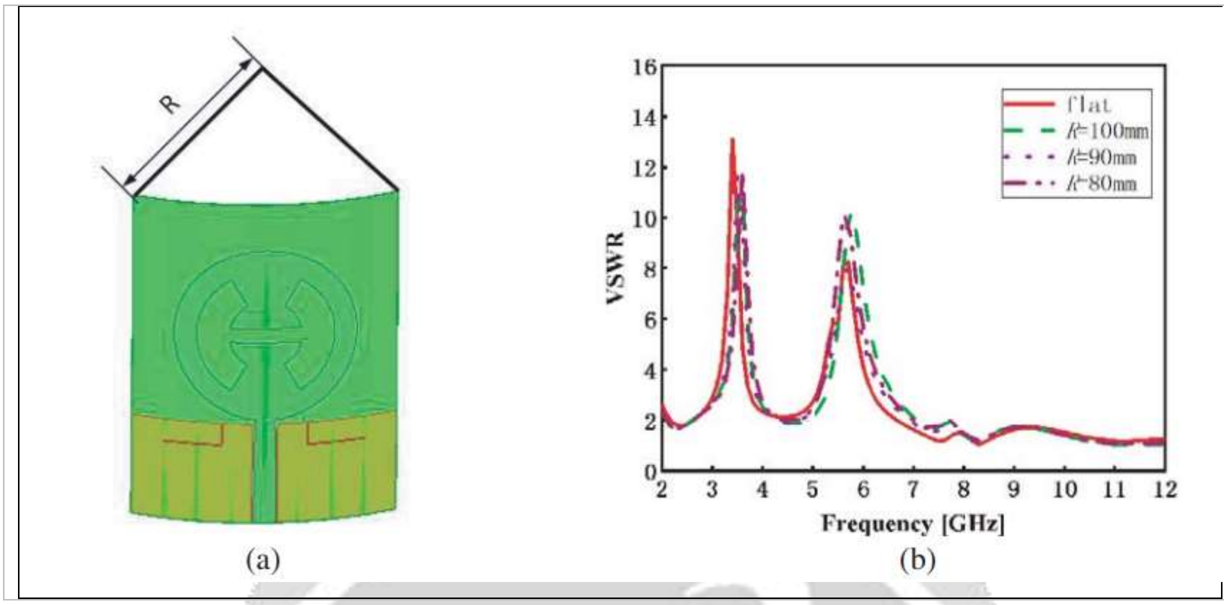

Figure 1. Performance of the bent antenna. (a) Diagram of the bending test. (b). Simulated VSWRs with different R.

2.1 VSWR

Voltage standing wave ratio (VSWR) is defined as the ratio between transmitted and reflected voltage standing waves in a radio frequency (RF) electrical transmission system. It is a measure of how efficiently RF power is transmitted from the power source, through a transmission line, and into the load. A common example is a power amplifier connected to an antenna through a transmission line. SWR is, thus, the ratio between transmitted and reflected waves. A high SWR indicates poor transmission-line efficiency and reflected energy, which can damage the transmitter and decrease transmitter efficiency. Since SWR commonly refers to the voltage ratio, it is usually known as voltage standing wave ratio (VSWR).

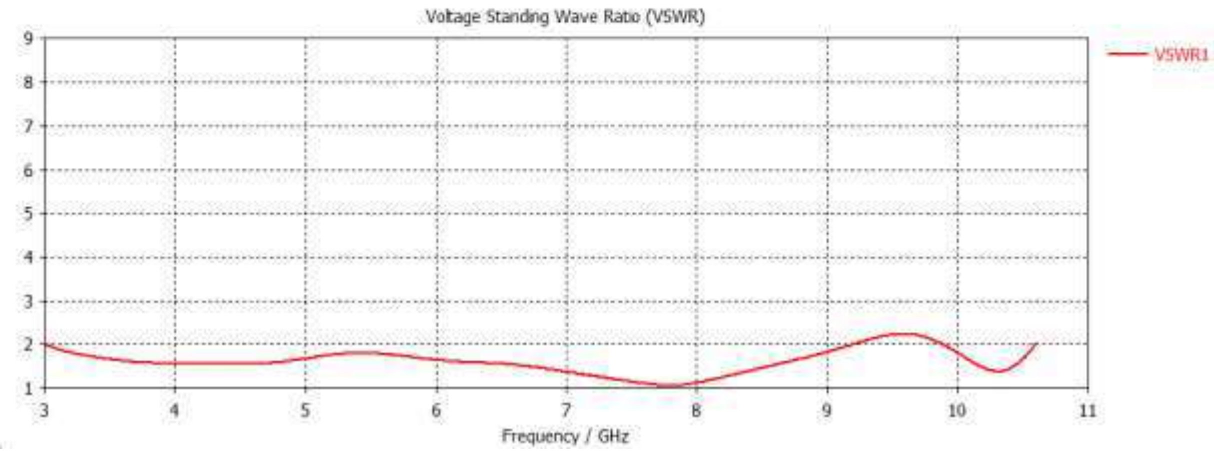

Figure 2. VSWR of Ultra Wide Band (UWB) Antenna

2.2 S-Parameters

Scattering parameters or **S-parameters** (the elements of a **scattering matrix** or **S-matrix**) describe the electrical behavior of linear electrical networks when undergoing various steady-state stimuli by electrical signals. The parameters are useful for several branches of electrical engineering, including electronics, including electronics, communication systems design, and especially for microwave engineering, including electronic, communication systems design, and especially for microwave engineering. The parameters are useful for several branches of electrical engineering, including electronics, communication systems design, and especially for microwave engineering. The term 'scattering' is more common to optical engineering than RF engineering, referring to the effect observed when a plane electromagnetic wave is incident on an obstruction or passes across dissimilar dielectric media. In the context of S-parameters, scattering refers to the way in which the traveling currents and voltages in a transmission line are affected when they meet a discontinuity caused by the insertion of a network into the transmission line. This is equivalent to the wave meeting an impedance differing from the line's characteristic impedance.

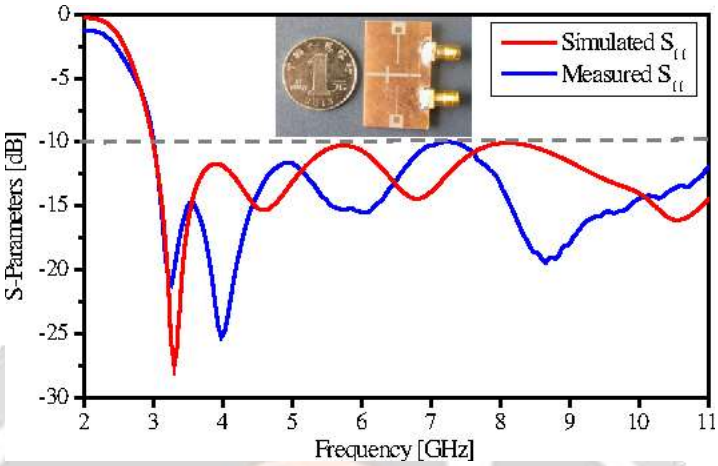

Figure 3. S-Parameters plot of Ultra wide band Antenna

3. MEASURED RESULTS AND DISCUSSIONS

Measured results show the simulated and the measured VSWRs, reflection coefficients (the standard with VSWR ≤ 3 corresponds to S11 ≤ −6 dB), and the peak gains of the antenna, respectively. There are some differences between the test results and simulation results, which may be caused by fabrication accuracy. However, they still agree well. The measured results show that the working frequency band of the antenna is 1.95–35 GHz with rejection bands of 3.5 GHz (3.2–3.8 GHz) and 5.5 GHz (4.8–5.7 GHz). The peak gain of the antenna ranges from 1.7 dBi to 10.02 dBi in the UWB of 3.1–10.6 GHz. However, the gains of the two notch band segments sharply decrease to −3.87 dBi and −13.6 dBi, respectively, which indicates that the proposed antenna has a good dual stopband characteristic. The performance comparisons between the proposed antenna and the other notched-band antennas in [7, 11, 14, 15] are listed in Table 2. It shows that the presented antenna has better performance in terms of bandwidth, gain, and flexibility.

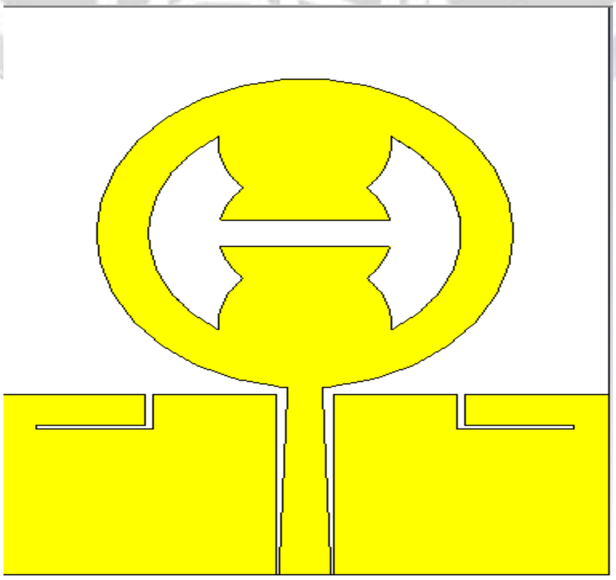

FIG: DESIGNED ANTENNA SIMULTED IN CST SOFTWARE

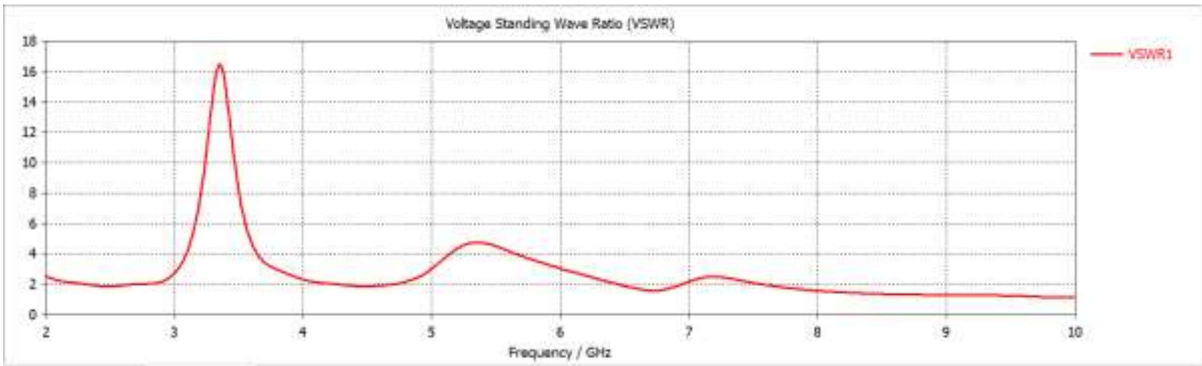

FIG: VSWR obtained for the Designed Antenna with Notch Bands at 3.5GHz and 5.5 GHz

RADIATION PATTERNS:

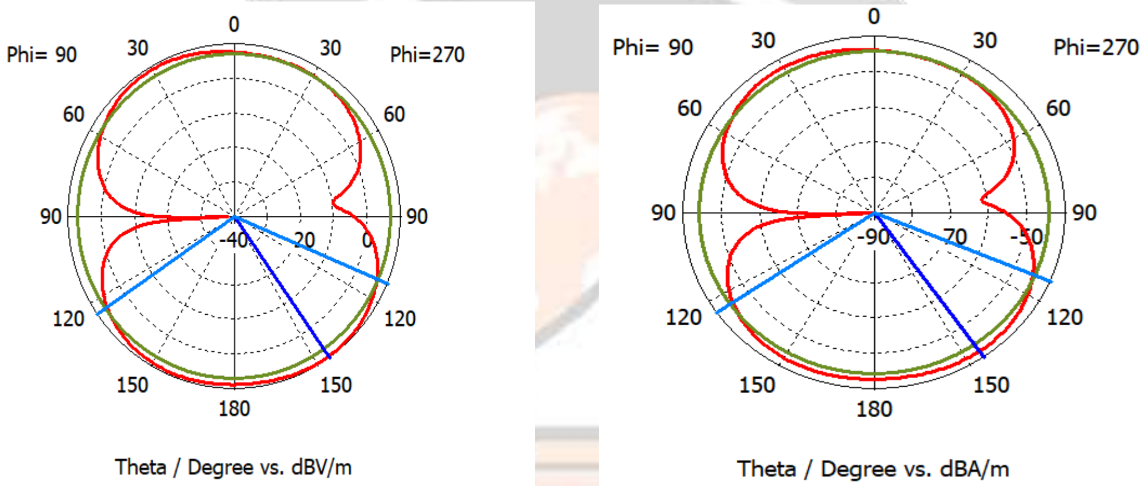

FIG: E-field and H-field patterns at 3.5GHz

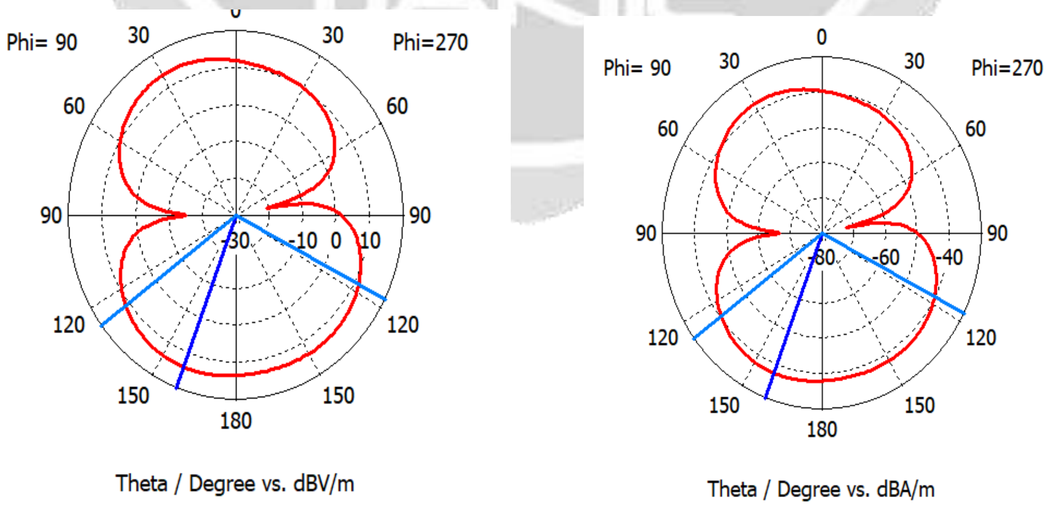

FIG: E-field and H-field patterns at 5.5GHz

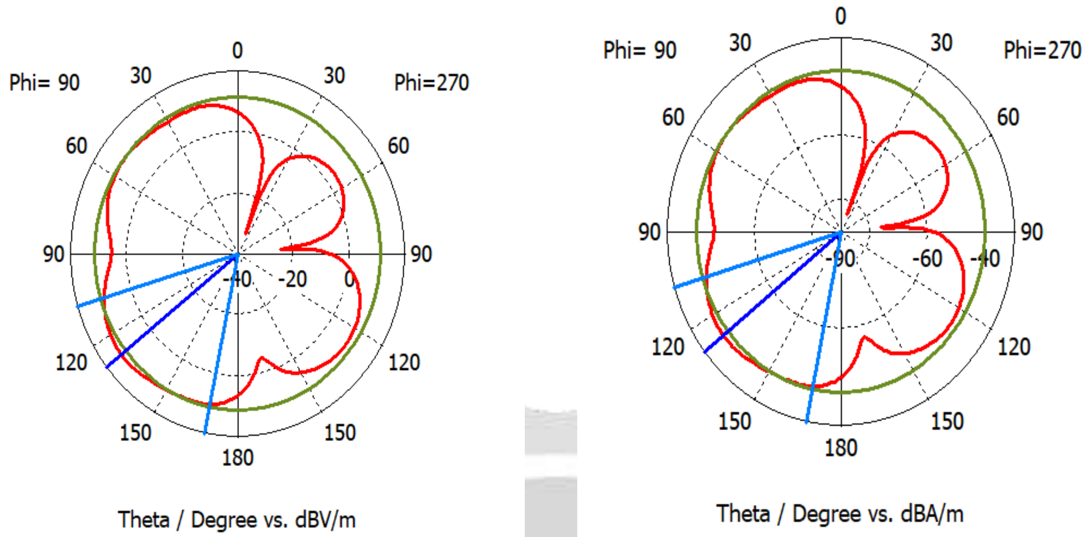

FIG: E-Field and H-field patterns at f=10GHz

4. CONCLUSION

Finally, we designed a useful dual band UWB antenna in this letter, by cutting two symmetrical C-shaped Slots on the Circular Patch, and two L-shaped Slots on the ground plane. Two Notch bands are realized at 3.5GHz (3.2- 3.8) and 5.5GHZ (4.8-5.7) as we intended. The measured results prove that the proposed antenna performance is well in UWB systems without the hindrance of WiMAX (3.5 GHz) and WLAN (5.5 GHz).

5. ACKNOWLEDGEMENT

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6. REFERENCES

1. Rahman, M. U., M. Nagshvarianjahromi, S. S. Mirjavadi, and A. M. Hamouda, "Compact UWB band-notched antenna with integrated bluetooth for personal wireless communication and UWB applications," Electronics, Vol. 8, 1–13, 2019.

2. Hood, A. Z., T. Karacolak, and E. Topsakal, "A small antipodal Vivaldi antenna for ultrawide-band applications," IEEE Antennas and Wireless Propagation Letters, Vol. 7, 656–660, 2008.

3. Guo, Z., H. Tian, X. Wang, et al., "Bandwidth enhancement of monopole UWB antenna with new slots and EBG structures," IEEE Antennas and Wireless Propagation Letters, Vol. 12, 1550–1553, 2013.

4. Wang, Z., L. Qin, Q. Chen, et al., "Flexible UWB antenna fabricated on polyimide substrate by surface modification and in situ self-metallization technique," Microelectronic Engineering, Vol. 206, 12–16, 2019.

5. Simorangkir, R. B. V. B., A. Kiourti, and K. P. Esselle, "UWB wearable antenna with a full ground plane based on PDMS-embedded conductive fabric," IEEE Antennas and Wireless Propagation Letters, Vol. 17, 493–496, 2018.

6. Khaleel, H. R., H. M. Al-Rizzo, D. G. Rucker, and S. Mohan, "A compact polyimide-based UWB antenna for flexible electronics," IEEE Antennas and Wireless Propagation Letters, Vol. 11, 546– 567, 2012.

7. Zhang, Y., Y. Zhang, and D. Li, et al., "Compact vertically polarized omnidirectional ultrawideband antenna and its band-notched filtering application," IEEE Access, Vol. 7, 101681–101688, 2019.

8. Chuang, C., T. Lin, and S. Chung, "A band-notched UWB monopole antenna with high notchband-edge selectivity," IEEE Transactions on Antennas and Propagation, Vol. 60, 4492–4499, 2012.

9. Lee, C., J. Wu, C. G. Hsu, et al., "Balanced band-notched UWB filtering circular patch antenna with common-mode suppression," IEEE Antennas and Wireless Propagation Letters, Vol. 16, 2812– 2815, 2017.

10. Deng, J. Y., S. Hou, L. Zhao, and L. Guo, "Wideband-to-narrowband tunable monopole antenna with integrated bandpass filters for UWB/WLAN applications," IEEE Antennas and Wireless Propagation Letters, Vol. 16, 2734–2737, 2017.

11. Bong, H., N. Hussain, S. Rhee, S. Gil, and N. Kim, "Design of an UWB antenna with two slits for 5G/WLAN-notched bands," Microwave and Optical Technology Letters, Vol. 16, 1295–1300, 2019.

12. Abu Safia, O., M. Nedil, L. Talbi, and K. Hettak, "Coplanar waveguide-fed rose-curve shape UWB monopole antenna with dual-notch characteristics," IET Microwaves, Antennas and Propagation, Vol. 12, 1112–1119, 2018.

13. Li, W. T., X. W. Shi, and Y. Q. Hei, "Novel planar UWB monopole antenna with triple bandnotched characteristics," IEEE Antennas and Wireless Propagation Letters, Vol. 8, 1094–1098, 2009.

14. Mohamadzade, B., R. B. V. B. Simorangkir, R. M. Hashmi, et al., "A conformal band-notched ultrawideband antenna with monopole-like radiation characteristics," IEEE Antennas and Wireless Propagation Letters, Vol. 19, 203–207, 2020.

15. Zhang, X. and G. Wang, "A flexible monopole antenna with dual-notched band function for ultrawideband applications," International Journal of Antennas and Propagation, Vol. 2014, 1– 5, 2014.

16. Xiaoyan Zhang*, Huihui Xu, Yan Xie, and Qiutong Wu, "A Dual Band-Notched Antenna for UWB Applications," Progress In Electromagnetics Research Letters, Vol. 96, 105–111, 2021.