Compact sectoral UWB antenna with WLAN (5.2/5.8 GHz) and WiMAX (5.5 GHz) filtering characteristics

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CONTENTS

ABSTRACT

- This paper presents a compact circular sectored microstrip antenna embedded with two symmetric circular slots and a sectoral ground plane embedded with an open-ended rectangular slot for enhancement of bandwidth and its applicability for UWB communications.
- In addition, it produces a notch band centered at around 5.30 GHz (4.26 GHz – 6.34 GHz) which effectively filters out WLAN(5.2/5.8 GHz) and WiMAX(5.5 GHz) bands.
- It exhibits an equivalent Fractional Bandwidth of 157.38 % (2.38 GHz – 19.96 GHz) using Rogers RT Duroid 5880 as a substrate for lower surface wave loss and attaining broader bandwidth.
- The gain of the antenna ranges from 5.34 – 5.73 dBi throughout the resonant frequency band through the gradual stages of development of Antenna 3.
- The results obtained from measurement have good accordance with simulated solutions in terms of return loss, gain, polarization and far field patterns.

INTRODUCTION

- Due to the development of various wireless standards in the telecommunication standards there has been increment in the requirement of wideband and multiband antennas.
- The Federal Communication Commission (FCC) incorporated the use of 3.1-10.6 GHz frequency band for use in UWB applications in 2002.[1]
- Various UWB antennas have been presented in [2-9], which allows covering various narrow frequency bands like WLAN (5.1-5.9 GHz), WiMAX (3.25-3.75 GHz), HIPERLAN/2 IEEE 802.11a (5.15-5.35 GHz/5.47-5.725 GHz) and Multichannel Video and Data Distribution Service (MVDDS) (12.2-12.7 GHz).
- Researchers, till now have designed several UWB antennas because of their capabilities. As a result, these wideband and UWB structures are common now a day because of its multifunctional capability
- The proposed structure improves the bandwidth ratio and FBW by embedding two symmetric circular slots in the patch and an open-ended rectangular slot in the ground substrate.

ANTENNA DESIGN

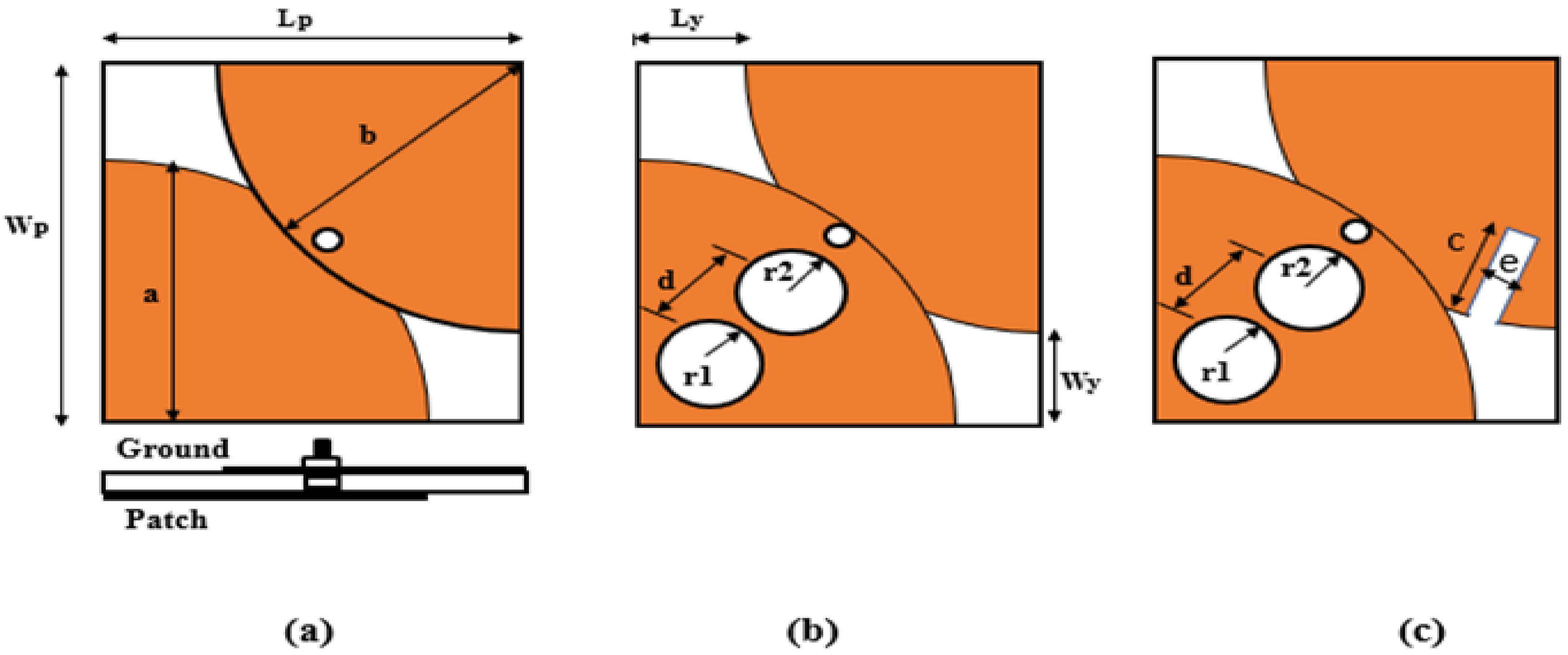

Figure 1. (a) Reference antenna (Antenna 1), (b) Antenna 2, (c) Antenna 3 (Proposed prototype).

Table 1. Parametric Dimensions

Parameters	Value (mm)
W_p	40
L_p	40
L_y	5.35
Wy	5.35
a	25
b	34.65
d	14.30
r1	5.00
r2	5.00
C	6.413
e	1.847

- The proposed structure is achieved by embedding an open -ended rectangular slot in the ground plane. RT Duroid 5880 substrate having thickness of 0.787mm, dielectric constant (Ɛr) of 2.2 and loss tangent (tan δ) = 0.002 is used for the structure.
- The antenna is simulated in IE3D software and the results are analysed.

RESULTS AND ANALYSIS

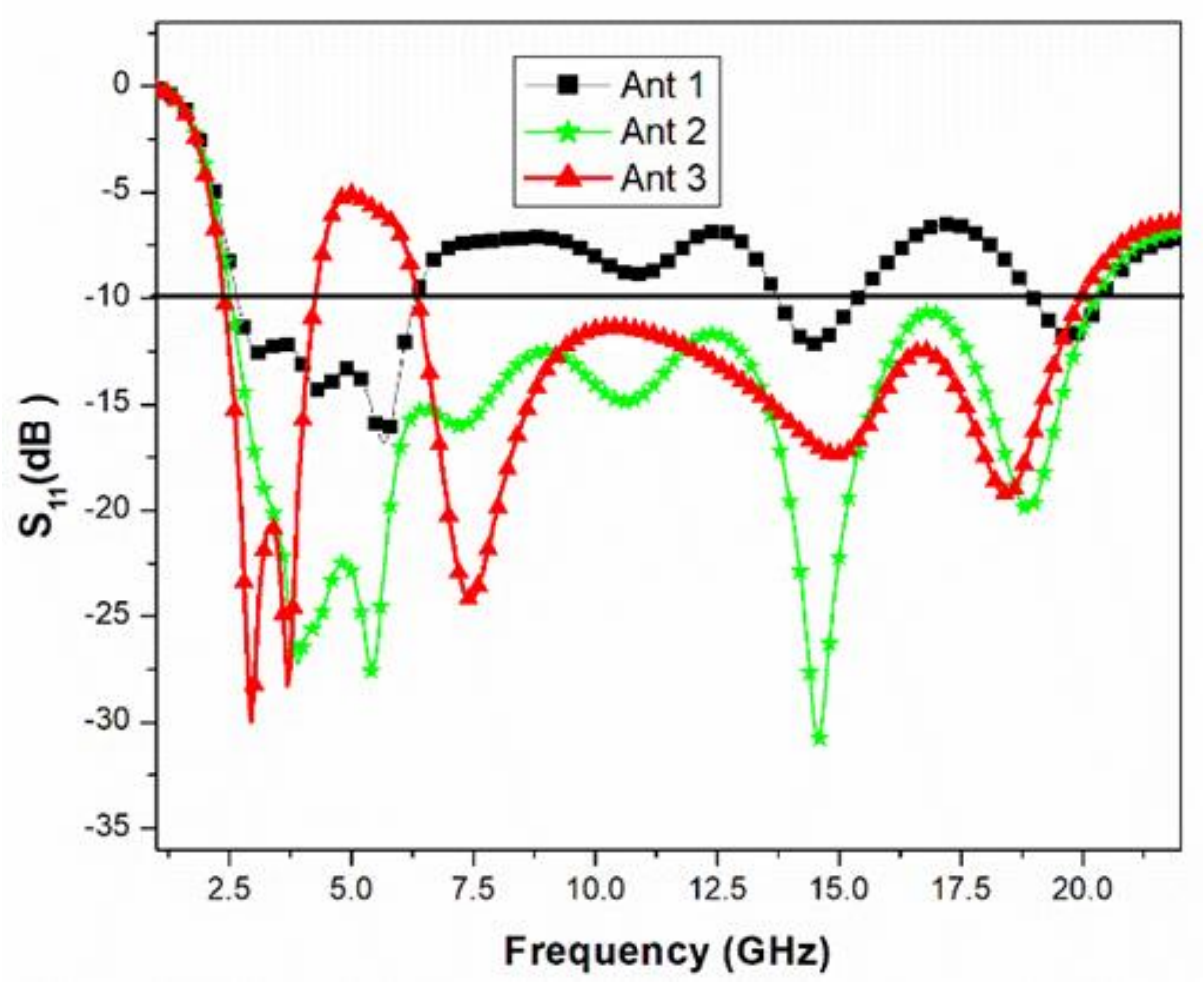

Figure 2. Comparison of S_{11} V/S Frequency Plot for all antennas

Table 2. Frequency response characteristics of Ant.1-3

Type	Resn. Freq bands (GHz)	Notch Bands	Notch Band Freqs (GHz)	-10 dB BW (GHz)	FBW (%)	Max Peak Gain (dBi)
Ant 1	(2.65-6.32), (13.74-15.19) and (19.05-20.33)	✓	(6.33-13.73), (15.2-19.04)	6.40	153.87	5.34
Ant 2	2.5-20.25	×	N.A.	17.75	156.04	6.1
Ant 3	(2.38-4.25, 6.35-19.96)	✓	(4.26-6.34)	15.48	157.38	5.73

$$d = 2a - 2(r1 + r2) - \frac{\pi}{2}(r1 + r2) \qquad (1)$$

- From Eq.1, it is found that the value of d =14.30 mm (r1, r2=5.0 mm).
- Similarly a relation can be obtained for f_u and f_l with respect to d where f_l is the lower resonant frequency level and f_u is the upper resonant frequency level from Equation 2 and 3 respectively.
- By changing the value of 'd', the bandwidth of final antenna can also be changed accordingly and the frequency range can be fixed to maintain a particular value of 'd'.

$$f_l \cong \frac{c(r1+r2)}{2a\sqrt{\varepsilon_r}} \times \frac{\pi^2}{d} \qquad (2)$$

$$f_u \cong \frac{c(r1+r2)}{2a\sqrt{\frac{(\varepsilon_r+1)}{2}}} \times \left(\frac{d}{\pi}\right) \qquad (3)$$

- The notch is centered at 5.30 GHz (4.26 – 6.34 GHz) and can be calculated from the given formula

$$f_{notch} \approx \frac{1.5c}{4(2C+e)\sqrt{\varepsilon_{reff}}} \qquad (4)$$

fnotch = centre frequency of the notched band.
c = velocity of light
C = length of the open ended rectangular slot in the ground
e = width of the open ended rectangular slot in the ground.
Ɛreff = Effective di-electric constant.

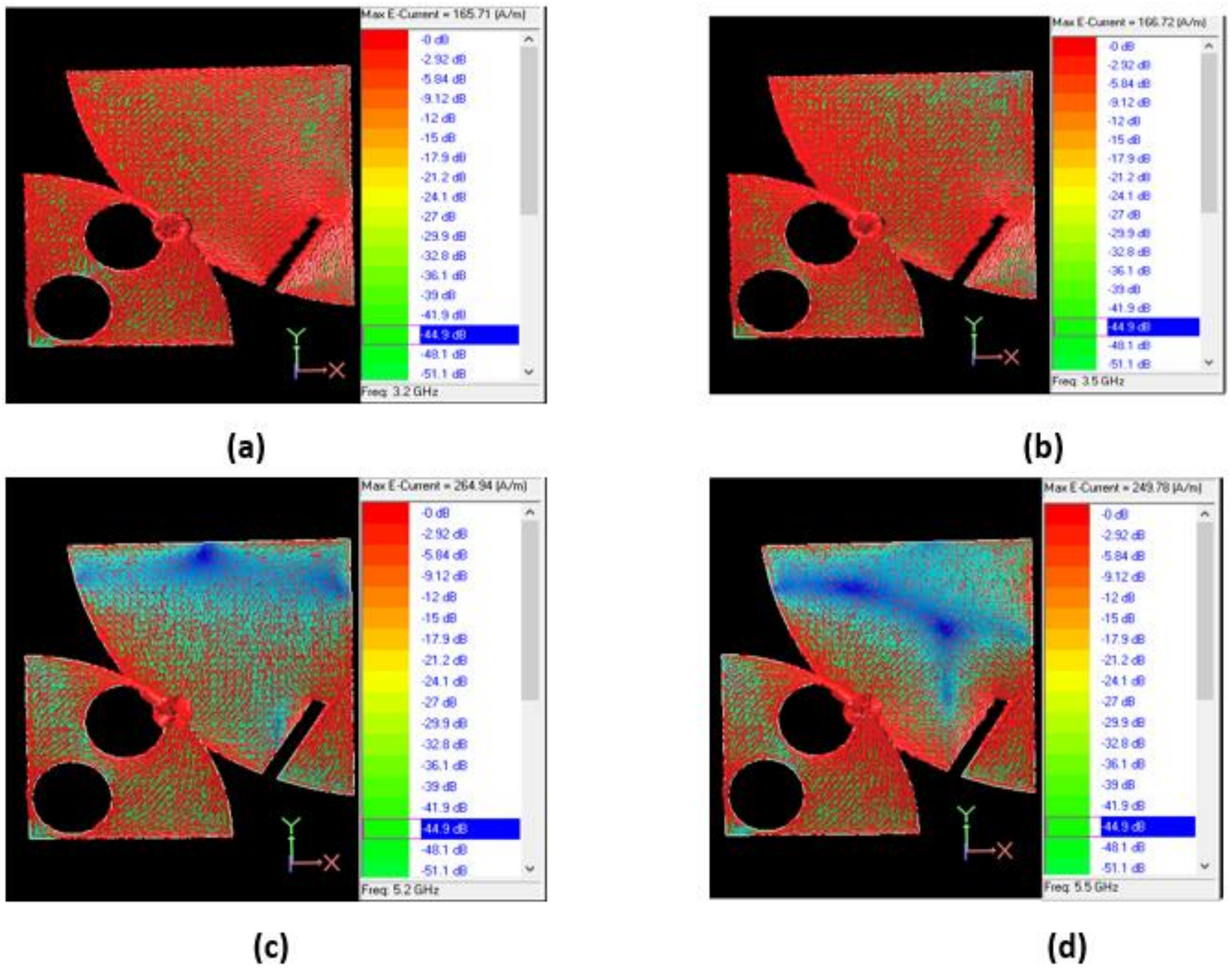

Figure 3: Current distribution pattern of proposed antenna (Antenna 3) at (a) 3.2 GHz (b) 3.5 GHz (c) 5.2 GHz and (d) 5.5 GHz

- The surface current flow pattern of Antenna 3 is shown in Figure 3, where 3(a) and (b) represents current distribution pattern at pass band frequencies of 3.2 GHz and 3.5 GHz respectively whereas 3(c) and 3(d) represents current flow at 5.2 GHz and 5.5 GHz respectively.

- It can be clearly observed that the gain falls below the 0 dB line in case of Antenna 3 ranging from 4.26 – 6.34 GHz.
- The maximum gain of Antenna 3 is found to be **5.73 dBi**.

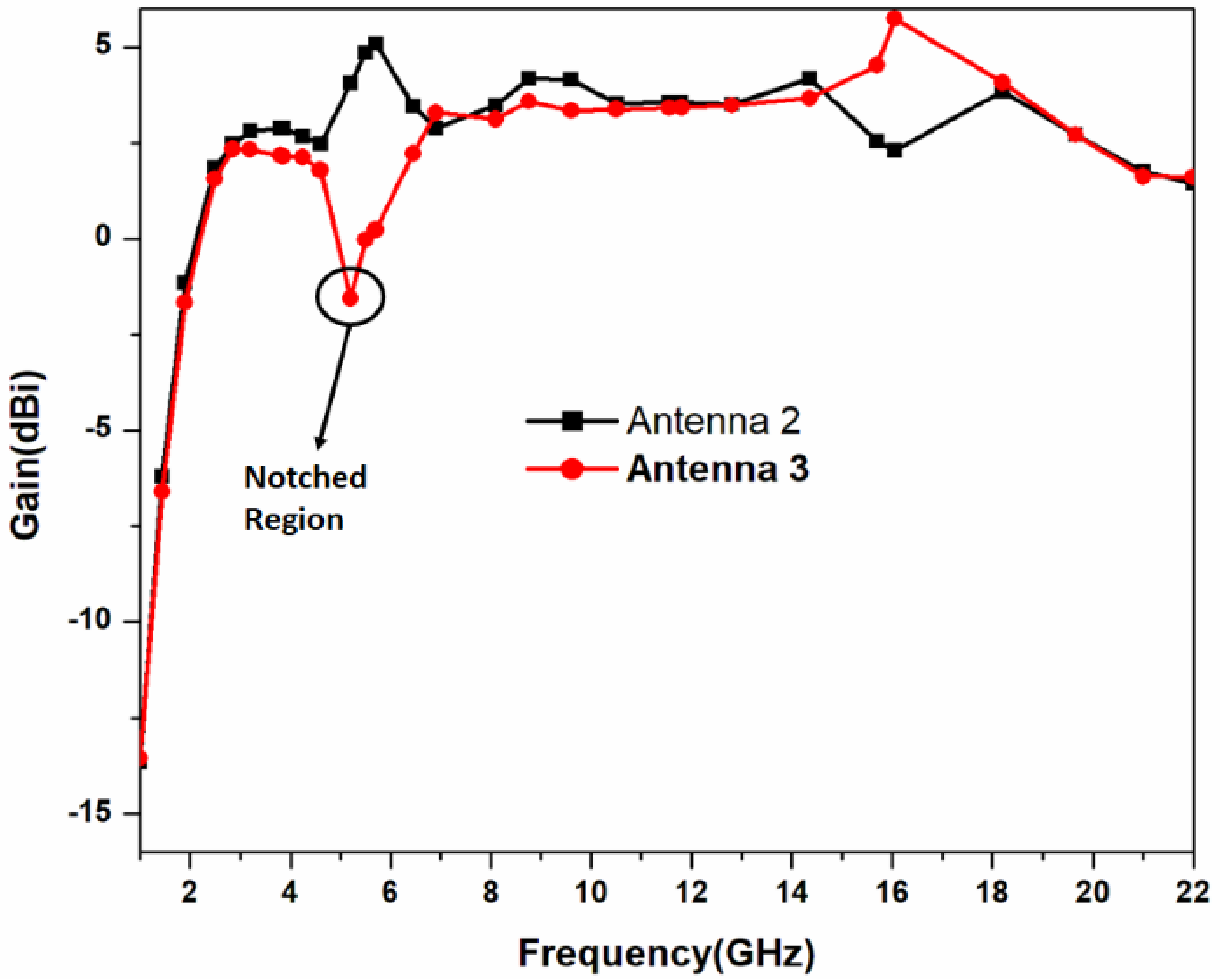

Figure 4: Gain v/s Frequency graph of Ant. 2 and Ant. 3.

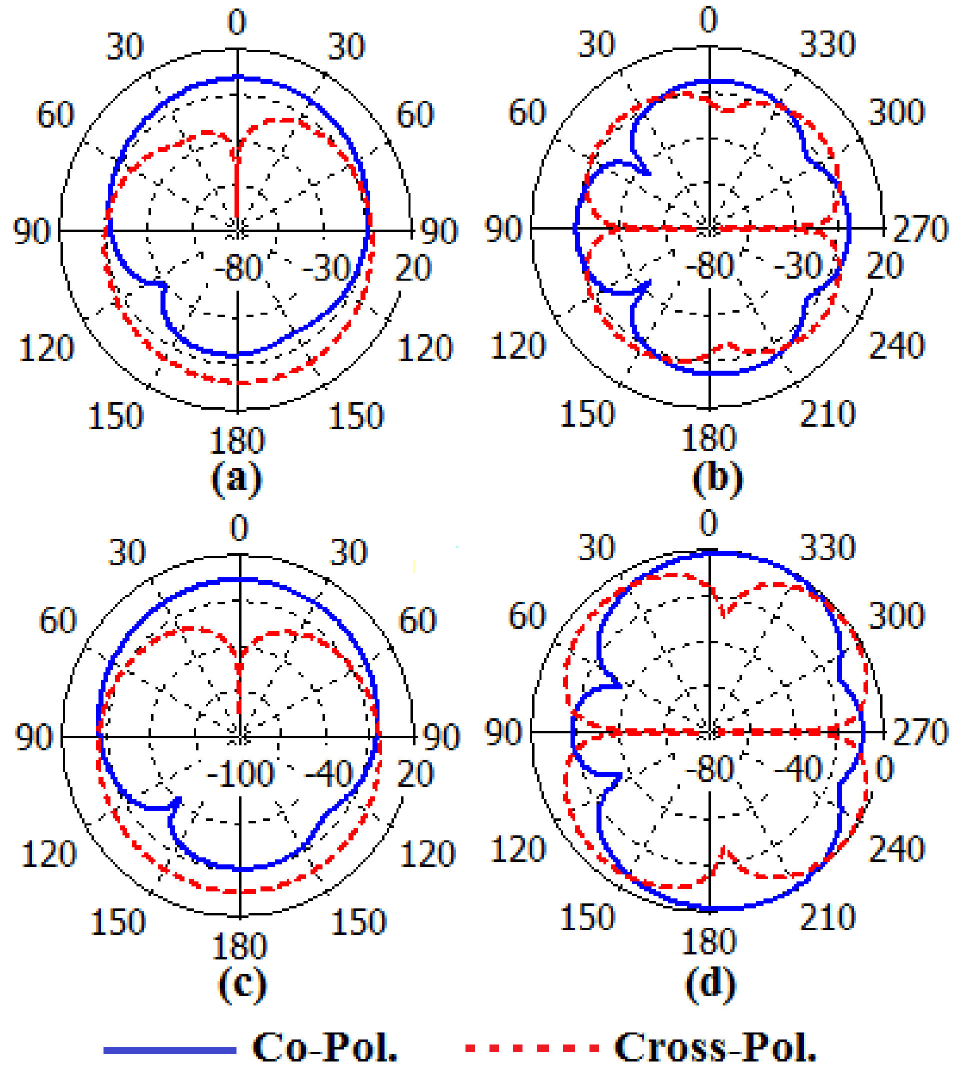

Figure 5: Measured Co-pol. and Cross-pol. radiation patterns at (a) 3.20 GHz, (b) 3.50 GHz, (c) 5.20 GHz and (d) 5.50 GHz.

Table 2. Frequency response characteristics of Ant.1 - 3

Type	Resonance Frequency bands (GHz)	Notch Bands	Notch Band Frequency (GHz)	-10 dB Bandwidth (GHz)	FBW (%)	Max Peak Gain (dBi)
Ant1	(2.65-6.32), (13.74-15.19) and (19.05-20.33)	✓	(6.33-13.73), (15.2-19.04)	6.40	153.87	5.34
Ant 2	(2.6-4.3), (5.14-5.6)	✓	(4.4-5.04)	4.62	126.8	4.7
Ant 3	2.5-20.25	×	N.A.	17.75	156.04	6.1
Ant 4	(2.38- 4.25, 6.35-19.96)	✓	(4.26-6.34)	15.48	157.38	5.73

Figure 6: Fabricated Prototype (a) Front View , (b) Rear View

- The proposed antenna is fabricated as depicted in Figure. 6 and the results are analyzed using Rohde and Schwarz (ZVA-40) VNA.

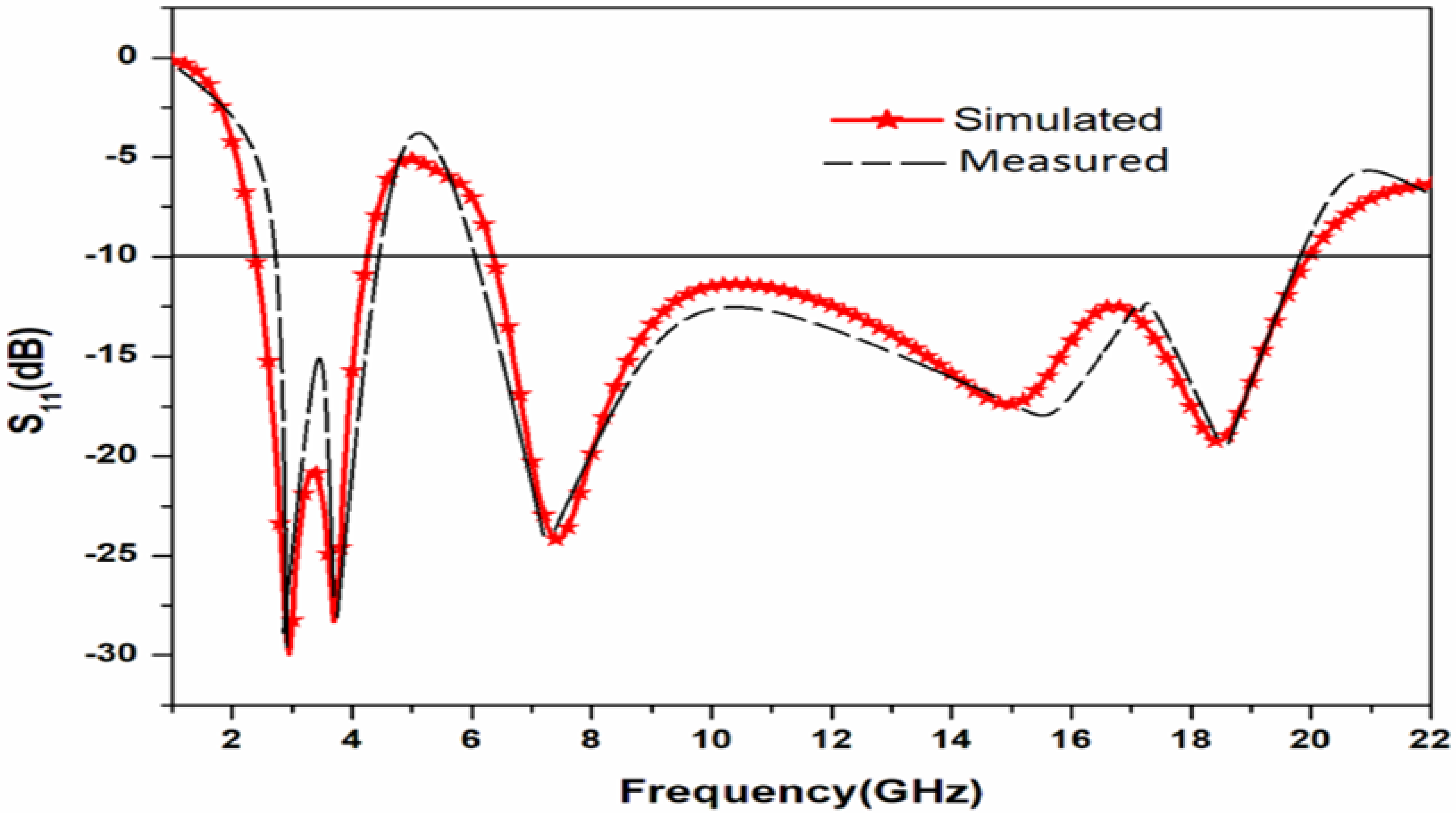

Figure 7: Simulated versus measured results

- It has been found that there is a good concurrence between the experimental and measured values.

Table 3. Comparison of various antennas with respect to our designed prototype

Ref	Dimension (mm^2)	Resonant Bands (GHz)	Notch Bands (GHz)	FBW %	Max Gain (dBi)
[7]	35×36	2.52-10.68	(3.3-3.7) (5.15-5.825)	123.6	7.1
[8]	30×35	2.7-16.9	(3.3-3.7) (4.6-5.9)	144.89	2.0
[9]	40×30	2.68-17.50	(3.3-3.7) (5.2-5.825)	136	3.69
[10]	32×38	3-20	(3.5-5.3)	147.83	4.0
[11]	50×50	2.4-11.2	(4.6-6.2)	129.41	5.1
This work	**40×40**	**2.38-19.96**	**(4.26-6.34)**	**157.38**	**5.73**

CONCLUSION

- The research work presented here has been initiated because of the need for small sized, compact, inexpensive, easy to manufacture and rugged multifrequency antennas typically for radiating throughout UWB while simultaneously filtering WLAN and Wi-MAX.
- In this presentation a compact circular sectored microstrip antenna has been presented.
- The proposed structure exhibits fractional bandwidth of 157.38 % (2.38 GHz –19.96 GHz).
- Effective filtering of the WLAN (5.2/5.8 GHz) and WiMAX (5.5 GHz) bands have been performed.

FUTURE WORK

- The current research work presents a thorough study and design of a UWB antenna with filtering features.
- In future this particular research work can be carried out to the Super Wide Band (SWB), where the operation can be extended from 20 GHz to 30 GHz and also for 5G spectrum.
- Also, efforts can be made to reduce the size of the final antenna as compactness is one of the major requirement of the ever-growing world of electronic systems.
- Efforts can be carried out to improve the gain of the antenna by various techniques.

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YOU
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