Design of Compact Coaxial-Fed Meander Slot Multiband Antenna for Wireless Applications

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Abstract: *In this research work, a novel design of compact coaxial fed meander slot microstrip antenna for the wireless application has been proposed. The designed antenna consists of a rectangular patch with dimension 25 x 23 and placed over substrate which has four meander shaped slots to achieve Quad band operation with frequency bands 2.1 GHz, 2.4 GHz, 3.4 GHz and 4.7 GHz with S_{11}≤10dB and respective VSWR≤2. Stimulated results demonstrate the good radiation patterns for proposed antenna with a narrow impedance bandwidth at lower band with good performance in terms of isolation and suggest that the proposed antenna is suitable for the wireless application including Fixed Mobile, WLAN, WiMAX and other applications.*

Keywords: *Meander slot, Quad band, WLAN, WiMAX.*

I: INTRODUCTION

With instant of time and requirements, the communication devices become portable and smaller, and as the process of miniaturisation of devices is in full swing, antennas cannot stay behind as standalone devices. It would be demanded, the microstrip element to have gain characteristics that potentially incommensurate to its size or frequency bandwidth greater than the element could give, taking into account that it operates as a resonant cavity [1] [2]. The meander slot antenna is one of the categories of microstrip antennas which allows designing of an antenna with small size and provides wideband performance [3]. Having the advantage to miniaturize antenna in proposed methods [4] [5] [6], meander slot antenna is chosen because it is able to reduce the size of the antenna. It is smaller and very flexible to be repositioned [7]. The functioning of the meander slot antenna depends on various factors such as the number of turns and position of meander slots in the patch [8].

A) Meander slot

Apart from meander patch antenna which folds and bends the patch to reduce the size the meander slot radiator is the complementary structure of it. So its electromagnetic characteristics are dual to the meander patch antennas. As shown in Figure 1, the radiation is mostly produced from the turnings and to generate different polarizations the values of H, L and D can be adjusted [7].

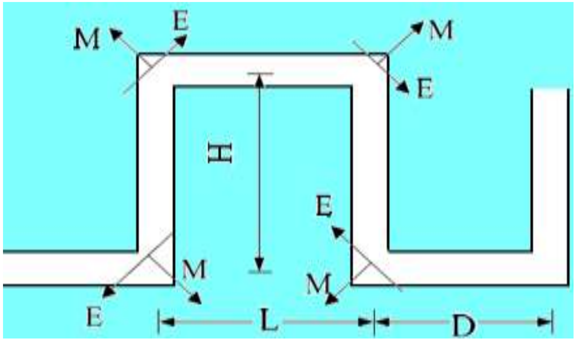


Figure 1: The Schematic diagram of meander slot

The meander slots are bilaterally symmetrical and folded into a number of sections. The Meander slot antenna is designed into considerations of length and width of vertical and horizontal lines and the number of turns in the slot also plays an important role, as the increase in the number of turn will results in increase efficiency, better return loss and better antenna operation.

In general, horizontal slots of the meander slot antenna provide inductance effects, while vertical slots exhibit capacitive characteristics [9]. Thus, the resonant frequency can be regulated by controlling the meander slot's lengths.

II: ANTENNA DESIGN

For all designed structure, the width of the vertical and horizontal lines is fixed to 1mm and length of the vertical and horizontal lines is fixed to 3mm.

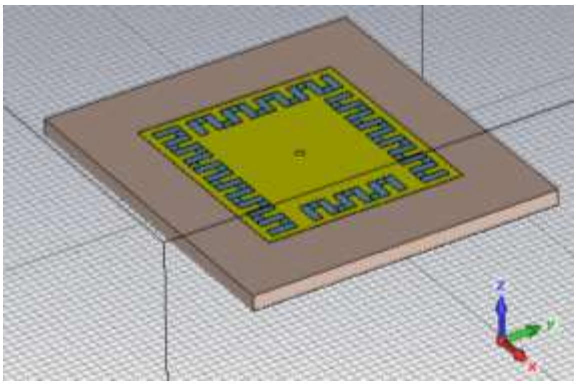
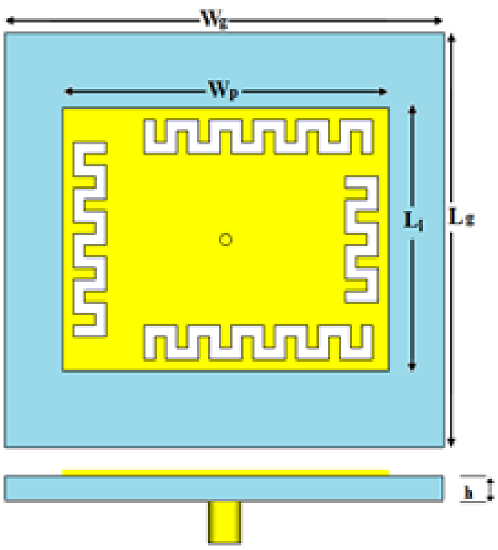


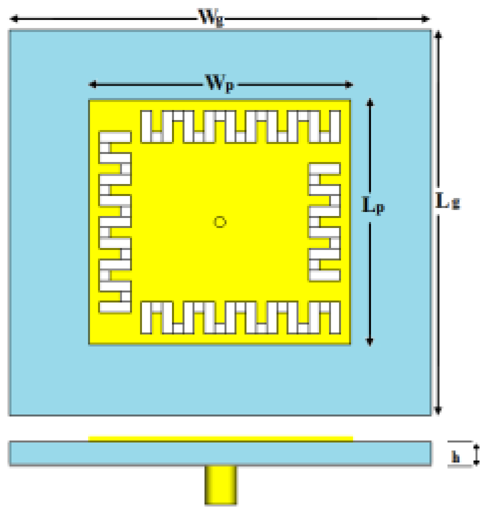
Figure2: Coaxial feed proposed compact meander slot antenna

As shown in Figure 2, the configuration of the wideband meander slot antenna is designed on a substrate with FR4, relative permittivity of 4.4, and a loss tangent of 0.025. A simple and compact Coaxial fed Meander slot antenna for quad band operation is designed and simulated. The operations are achieved by etching four Meander shaped slots on rectangular metal radiating patch of dimensions 25 × 23 × 0.035 mm^3. It is found that by adjusting the position of meander slots the resonance frequency is easily tuned and as the number of turns in meander slots increases its efficiency increases [11][12].

Without loss of generality, a coaxial feed line with a radius of 1 mm is given for centrally feeding the antenna. Four Meander slots are etched on the patch to give all the work bands. The slots S1, S2, S3 and S4 have Six, Five, Four and Three number of turns respectively. Figure 3 shows the geometry and configuration of the all three Antennas.

The Antenna Design 1 has four meander slots etched on the rectangular metal patch having six, five, four and three number of turns respectively. With Antenna Design 1 the frequencies with return loss (S11) are on higher frequency range supportable for WLAN and WiMAX. But the Antenna 1 has no resonance frequency in the lower band frequency ranges around 2.4GHz. In the Antenna Design 2, patch width Wp is reduced by 5mm, the number of turns from meander slot S1 and S3 are reduced which results in the resonance condition at frequencies 2.4GHz, 3.4GHz and 4.7GHz which are supportable for WLAN and WiMAX applications. The Antenna design 2 has good performance over the Antenna design 1, but the reconfigured antenna does not provide resonant frequency at lower bands which is supportable for fixed mobile communication. In the Antenna Design 3 there is some variation in slot S2 by repositioning it and the number of turns is increased in Slot S1. All these changes results in the four resonant frequencies at 2.1 GHz, 2.4 GHz, 3.4 GHz and 4.7 GHz. The four bands includes 2.1 GHz lower band for fixed mobile communication. The Antenna design 3 has good performance over the Antenna design 1 and design 2 by reduction of return loss at lower band as well as at higher band of frequencies.





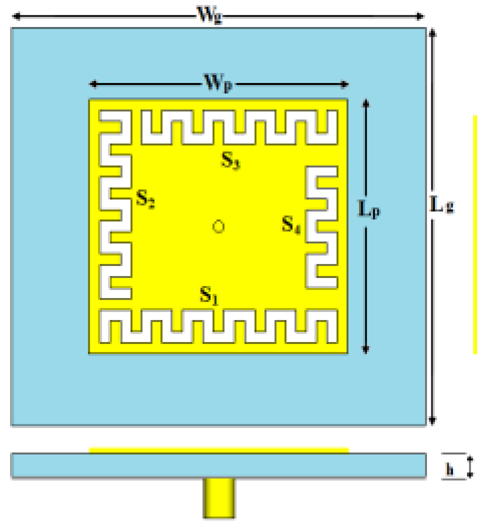
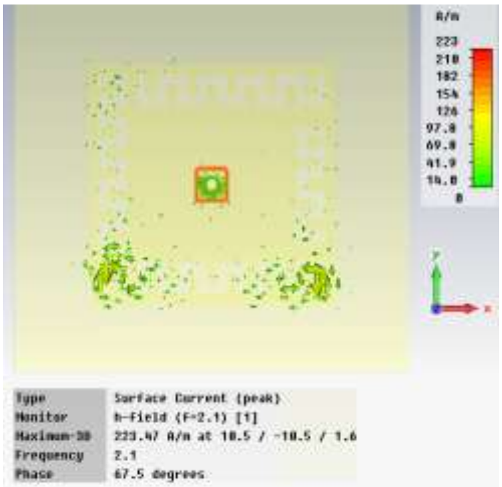


Figure 3: Geometry of (a) Antenna 1, (b) Antenna 2 and (c) Antenna 3(Proposed).

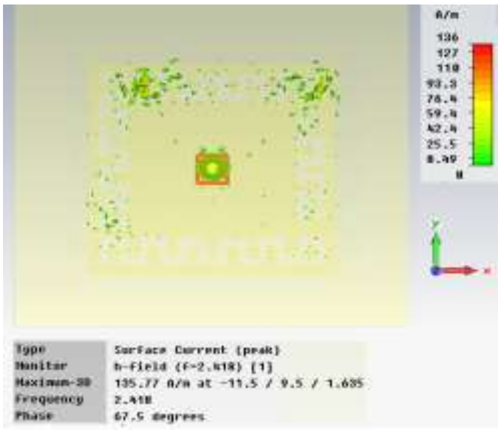
TABLE 2: THE OPTIMIZE DIMENSIONAL (MM) AND PERFORMANCES OF THE THREE ANTENNAS

Parameter	**Antenna 1**	**Antenna 2**	**Antenna 3**
Wg	40	40	40
Lg	36	36	36
Wp	30	25	25
Lp	23	23	23
h	1.6	1.6	1.6
Tp	0.035	0.035	0.035
Tg	0.035	0.035	0.035
Wh	03	03	03
Lh	01	01	01
Wv	01	01	01
Lv	03	03	03

Figure 4 shows the surface current distributions of the proposed antenna. The current is mainly distributed on the edge of the meander slot S1, which means that the longest current path along the meander slot determines the first resonant frequency 2.1 GHz. Around the edge of the meander slot S2 resonant frequency 2.4GHz for WLAN exists. Current concentrated around the meander slot S3 has influence of the frequency of 3.4 GHz for WiMAX. At last, the surface current exists around the edge of the meander slot S4 has influence of the frequency of 4.7 GHz.



(a)



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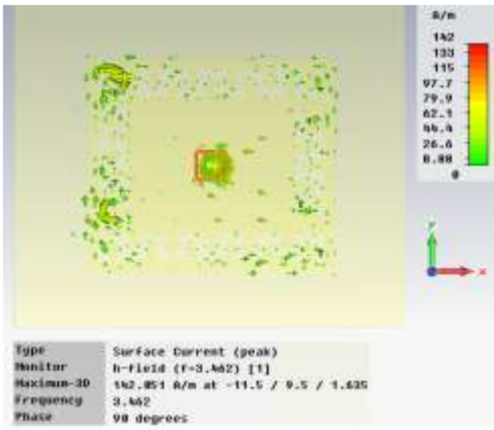
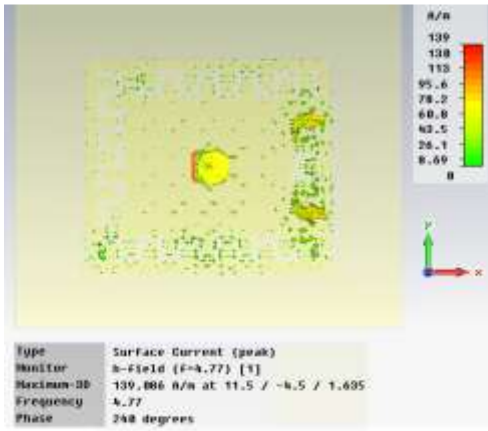


(c)



(d)

Figure 4: Surface current distributions on different resonant frequencies for Antenna

Good impedance matching is also achieved by coaxial-fed. The Coaxial feed line has a diameter of 1 mm with 0.5 mm centre conductor. Numerical analysis and optimization of the antenna have been performed using CST simulation software.

III: RESULT

A) Validation

To prove the reliability of the design and tool used, we have to validate the results and accuracy of the present method by comparing our obtained results with simulated results of [10]. Validation of present result is given in table 2, where the values of Band Width and Return Loss are compared with the base paper results.

TABLE 2: RESULT COMPARISON FOR VALIDATION (SIMULATION BASED)

Antenna	Dual Meander Slot Antenna		Triple Meander Slot Antenna	
Position	M. Z. A. Abd Aziz [3]	Current	M. Z. A. Abd Aziz [3]	Current
Freq (GHz)	2.4	2.4	2.4	2.4
S11(dB)	-24.54	-15.03	-16.52	-13.51
BW(MHz)	29.48	41.6	43.01	58.6
Gain (dB)	1.46	-0.69	-0.74	0.4344
Radiation Efficiency (η)	-3.932 dB	-5.89	-2.147	-4.767

B) Gain Vs Frequency

The gain performance of the Antenna Design 3 is moderate between frequency range 2.0 GHz to 2.6 GHz and from frequency range 2.6 GHz to 4.6 GHz the gain of antenna 3 is higher than the other two antenna designs and further antenna 3 has moderate gain from 4.6 GHz to

6.4 GHz. All these values show that the Antenna Design 3 has better performance in all the antenna designs. The simulated gain results for all the three antenna designs are shown in Figure 5.

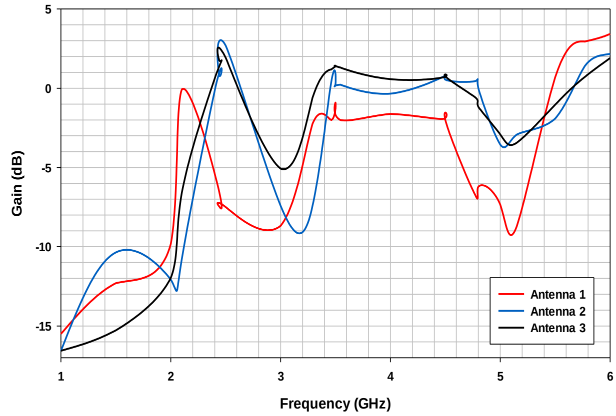


Figure 5: Plot between Gain and Frequency

C) *Directivity Vs Frequency*

The directivity of the Antenna Design 3 is higher than the other two antenna designs between frequency range from 1.6 GHz to 2.4 GHz and also between frequency range from 3.1 GHZ to 4.5 GHz and further antenna 3 again has better directivity from 4.7 GHz to 5.2 GHz frequency range. All these values show that the Antenna Design 3 has better performance in terms of directivity in all the antenna designs. The simulated results with directivity for different antenna designs are shown in Figure 6.

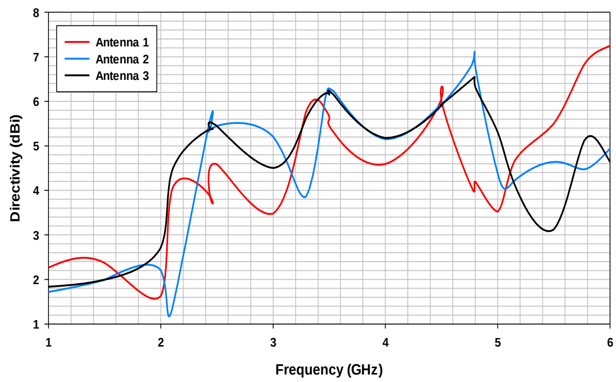


Figure 6: Plot between Directivity and Frequency

D) *Return loss (dB) versus frequency*

The simulated return losses for different antenna designs with frequencies are shown in Figure 7.

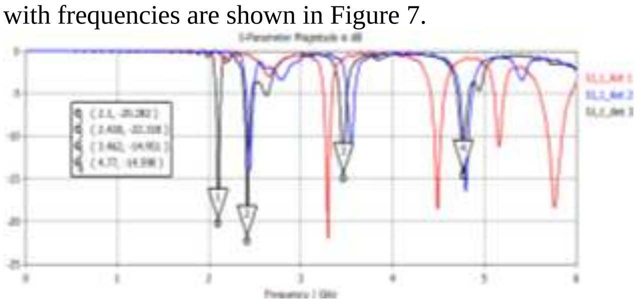


Figure 7: Return loss versus frequency plot

The -10dB impedance bandwidths for the lower frequency bands reach 28 MHz (2.086-2.114 GHz) for 2.1 GHz i.e. for Fixed mobile with -20.282 return loss and 41 MHz (2.398–2.439 GHz) for 2.4 GHz i.e. for the 2.4/5.2/5.8 GHz (2.4–2.485 GHz/5.15–5.35 GHz/5.725–5.825 GHz) WLAN band with -22.318 return loss. The -10dB impedance bandwidths for the upper bands reach 40 MHz (3.44-3.48 GHz) for 3.4 GHz i.e. for 2.5/3.5 GHz (2.5–2.69 GHz/3.3–3.7 GHz) WiMAX band with -14.951 return loss and 53 MHz (4.741-4.794 GHz) for 4.7 GHz which is able to cover the (4.7-4.75 GHz) for fixed satellite (space-to-Earth) (SHF) band [13] with -14.598 return loss.

E) *VSWR versus frequency*

The results of simulated VSWR for different antenna designs with frequencies are shown in Figure 8. For proper impedance matching and transmission of power the VSWR should always equal or less than 2 (VSWR≤2) and from the result we see that at all the resonant frequencies (2.1 GHz, 2.4 GHz, 3.4 GHz and 4.7 GHz) the value of VSWR<2.

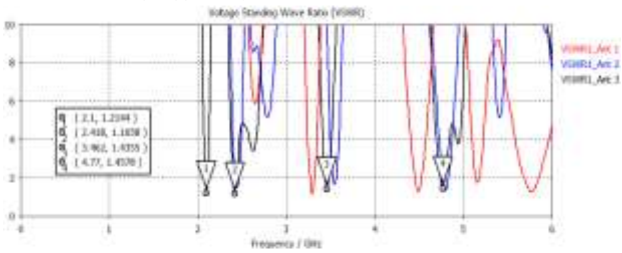


Figure 8: VSWR versus frequency plot

F) *Effect of Feed Position on Return Loss*

The optimum feed position has been determined for better return loss at desired resonant frequencies in Antenna Design 3 shown in Figure 9.

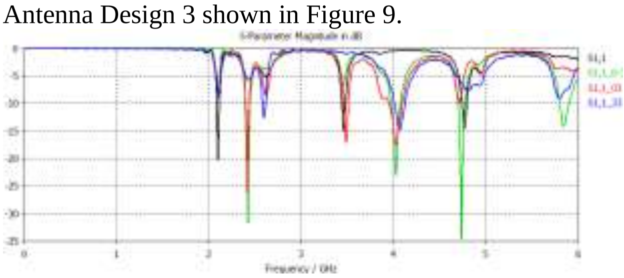


Figure 9: Input impedance versus frequency

From all the result comparisions above we see that the Antenna Design 3 is best suitable for the wireless application as it covers Quad band operation at desired frequencies. So we optimize the feed's positon and it illustrate that to achive proper desired frequency band the feed postioon is at coordinate (x=0, y=0) and due to symmetry the power is distributed equally into the patch.

G) *Radiation pattern*

The radiation pattern of proposed antenna is shown in Figure 10. It is clearly seen that the antenna show a radiation pattern in the H-plane nearly as Omni-directional and a dipole-like radiation pattern in the Eplane. However, the Omni-directional property is degraded when operating frequency increases. This may result as a increase in the difference of horizontal and vertical current distributions on the slotted patch when operating frequency increases.

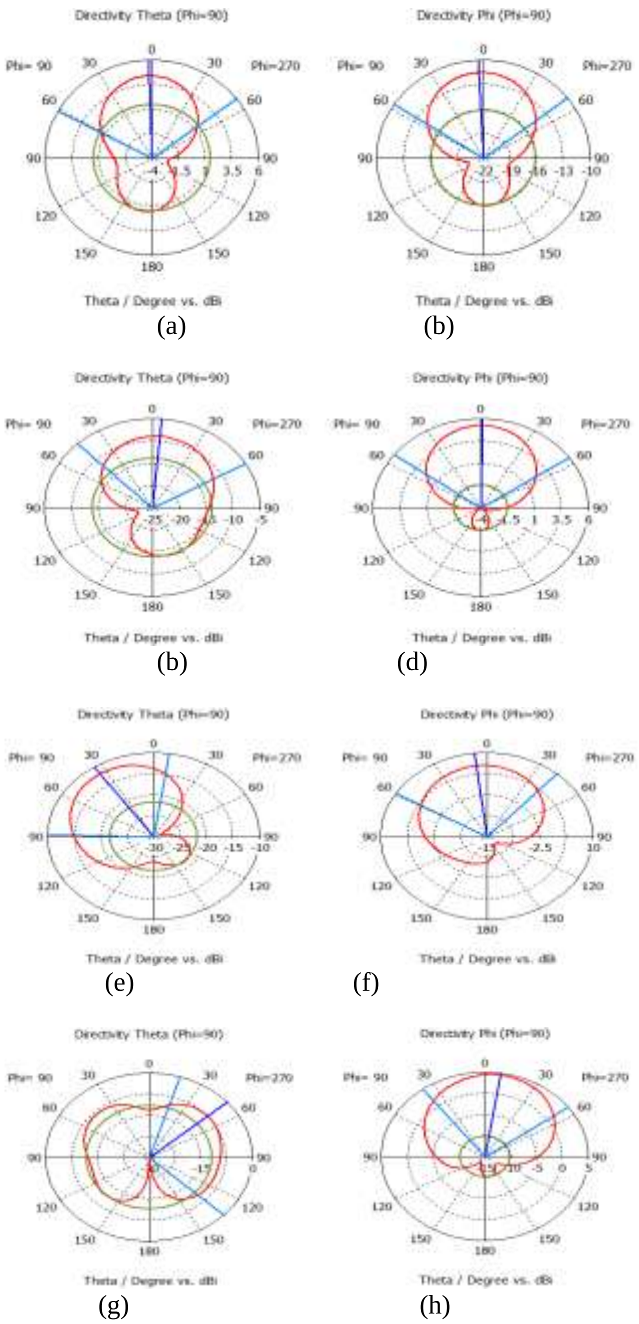


Figure 10: Simulated radiation pattern for the proposed antenna

XZ (Theta)	a	c	e	g
	2.1 GHz	2.4 GHz	3.4 GHz	4.7 GHz
YZ (Phi)	b	d	f	h
	2.1 GHz	2.4 GHz	3.4 GHz	4.7 GHz

IV: CONCLUSIONS

The meander slot antenna resonates at 2.1 GHz with return loss -20.282 dB, 2.4 GHz with return loss -22.318 dB, 3.4 GHz with return loss -14.951 dB and 4.7 GHz with return loss -14.598 dB. The resonance frequency bands lies in between the frequency band designated for Fixed Mobile, WLAN, WiMAX and Fixed Satellite (Space-to-Earth) wireless applications systems respectively. This antenna yields a good impedance bandwidth and return loss in the following frequency ranges. The stable radiation patterns and constant gain are also obtained.

V: FUTURE WORK

In the field of Coaxial fed Meander slot wireless antenna, different type of feed techniques can be used to calculate the overall performance of the antenna without missing the optimized parameters in the action as well as the bandwidth can be further enhanced by incorporated the slots with increase number of turns.

REFERENCES

[1] Constantine A. Balanis, “Antenna Theory, Analysis and Design”, 2nd Edition, John Wiley & Sons, New York, 2005.

[2] Thomas A. Milligan, “Modern Antenna Design”, 2nd Edition, John Wiley & Sons, 2005.

[3] Girish Kumar, K. P. Ray, “Broadband Microstrip Antennas”, 1st Edition, Artech House, 2003.

[4] Richard C. Johnson, “Antenna Engineering Handbook”, 3rd Edition, MGH, 1993.

[5] Zhi Ning Chen and Michael Y. W. Chia, “Broadband Planar Antennas Design and Applications”, 1st Edition, John Wiley & Sons, 2006.

[6] A. Khalegi A. Azooulay. J. C. Bolomey, "A Dual Band Back Couple Meandering Antenna For Wireless LAN Applications", Gof Survvette, France, 2005.

[7] G. T. Jeong, W. S. Kim, K. S. Kwak, Design of a corner-truncated square-spiral microstrip patch antenna in the 5-GHz band, Microwave and Optical Technology Letters, Volume 48, Issue 3, pp: 529-532

[8] L. C. Godara, Handbook of Antennas in Wireless Communication. Boca Raton, FL: CRC Press, 2002.

[9] D'Amico, M. ; Fasolo, F.M., “Multi-trap CPW-fed wide slot antenna for UWB applications” EUCAP, 2012 , Page(s): 1860 - 1864 IEEE Conference Publications.

[10] M. Z. A. Abd Aziz, Z. Zakaria, M. N. Husain, N. A. Zainuddin, M. A. Othman, B. H. Ahmad, “Investigation of Dual and Triple Meander slot Microstrip Patch Antenna” 13th Conference on Microwave Techniques COMITE, pp. 36-39, 17-18 April 2013.

[11] Omrane Necibi, Abdelhak Ferchichi, Tan-phu Vuong, Ali Gharsallah, "A Discussion of a 60GHz Meander Slot Antenna for an RFID TAG with Lumped Element", I.J. Wireless and Microwave Technologies, 2014, 2, Pp 1-11.

[12] Gourav kumar Mehta, S.Raghavan, “Design of Quadruple Meander slot to microstrip patch antenna for RF energy scavenging system”, IEEE International Conference on Electronics and Communication Engineering 2015 (ICECS'15).

[13] A. Verma, D. Punetha and D. Pant, "A Novel Quad Band Compact Meandered PIFA Antenna for GPS, UMTS, WiMAX, HiperLAN/2 Applications," Advances in Computing and Communication Engineering (ICACCE), 2015 Second International Conference on, Dehradun, 2015, pp. 404-408.

[14] CST STUDIO Help menu.