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Design of Conformal Helical Antenna with Selective Bands

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Abstract : *The paper presents design of U-shaped partial cavity which backs a 1½ turn helical antenna. The antenna is operating between C-Ku bands. Various selective resonant bands are achieved by varying the orientation of helix with respect to the walls inside the designed cavity and thus making the design reconfigurable in nature. The antenna has a highest bandwidth of 2.77 GHz and a peak gain of 10.8 dB.*
Keywords: *U-shaped partial cavity, 1½ turn helix, re-configurability, Power handling, Helix rotation.*

I. INTRODUCTION

In today's wireless communication since the frequency spectrum is highly congested, so a need arises to design antennas which can be manually tuned to the selective bands and thus will provide a flexible approach to employ various applications with the help of single designed antenna. The helical antenna is one of the selective antenna which commonly used for WLAN, personal wireless communication and satellite communication. In the past decades various approach has been presented [1]-[4] to achieve compact design, multiple bands, more power handling capacity etc.

The paper presents a design of U-shaped partial cavity backed 1½ turn helical antenna which provides a variable gain and bandwidth in the frequency range of 5-15GHz. The re-configurability is antennas important feature here which is achieved by changing the orientation of helix with respect to the walls inside the cavity. So to change the orientation of the helix, the antenna is loaded inside the cavity in such a way that it can be rotated manually to a desired angle. This is done by inserting a hole at the base of the cavity whose diameter is 0.2mm more than SMA connector and which allows the whole antenna assembly to be rotated manually.

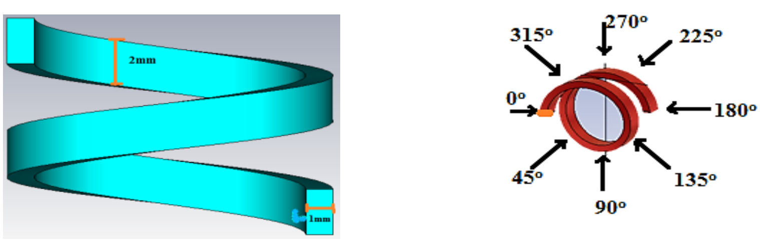
II. ANTENNA DESIGN

The designing begins with the formation of a partial cavity whose top side and front side is left open. This is done to make the design more conformal and will also help to confine the electric fields. The cavity has a height of 22mm and width of 24mm. Fig. 1 shows the geometrical configuration of the designed U-shape cavity.

(a) Perpective view (b) Front view

Fig. 1 Geometry of U-shaped cavity

A rectangular helix is designed having a strip width of 2mm and thickness of 1mm, which is loaded inside the designed cavity as shown in Fig.2a. The helix turns are kept low as 1½ only to make the system more compact. Also the odd number of helix turns will provide an odd symmetry in all the direction inside the cavity with respect to the wall. This will allows to achieve various response in the different orientations of the helix. The helix is rotated by an offset angle of 45^{o} in anticlockwise direction which is shown in Fig.2b.



(a) (b)

Fig. 2 Helix Geometrical dimension and rotation

III. RESULTS AND DISCUSSION

The analysis begins with the extraction of reflection coefficient for various helix rotations inside the designed U-shaped partial cavity. Fig. 3 shows the comparative plot of reflection coefficient.

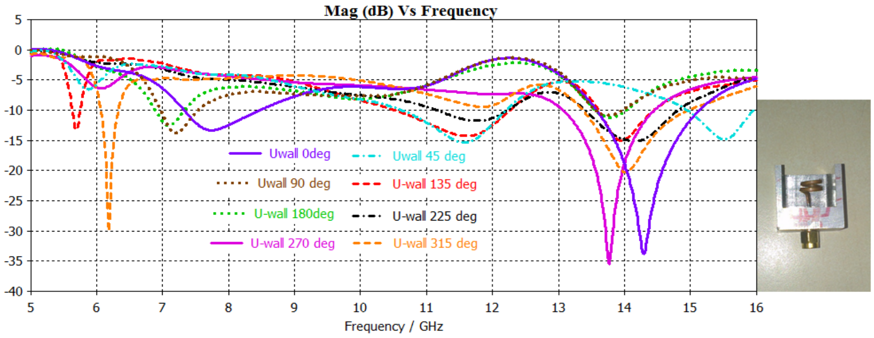


Fig. 3 Comparative plot of reflection coefficient at various rotation angles

It is observed that dual frequency bands are obtained from 0° to 90°, 180° to 225° and at 315° position, whereas at 135° position triple frequency bands are achieved. The multiple bands are resonated due the variation in spacing between the helix and the walls as the antenna is rotated with different offset angles. Now at 270° the helix position points towards the open end of U-shaped cavity and this cause less reflection form the other walls, thereby resulting in only single resonant band. Table 1 shows the complete analysis for bandwidth of U-shaped partial cavity backed helical antenna.

Now the analysis of gain is also done in a similar approach by plotting a comparative plot of gain of U-shaped cavity backed 1½ turn helical antenna at various rotation angles. Fig. 4 shows the comparative plot for gain. A highest gain of 10.8 dB is obtained at 45° position. This interprets that both high gain and high bandwidth can be achieved in this design. Now one of the cause for variation in the gain is orientation of helix tip end, since helix tip end has also significant amount of electromagnetic radiations which are then confined by the cavity walls. So a lowest gain of 8.9 dB is obtained at 135°, since at this position the helix tip end is pointing outwards the wall. The gain at other angle is shown in Table 2.

Table 1 Bandwidth analysis

SR. NO	HELIX	NO. OF BANDS	FREQUENCY BANDS (GHZ)	BANDWIDTH(GHZ)
1	0°	Dual	7.32-8.48 & 13.59-15.14	2.77
2	45°	Dual	10.65-12.21 & 14.94-15.96	2.58
3	90°	Dual	6.97-7.54 & 13.55-13.96	0.98
4	135°	Triple	5.64-5.77 & 10.53-12.26 & 13.59-14.45 13.59-14.45	2.72
5	180°	Dual	6.89-7.32 & 13.54-14.01	0.9
6	225°	Dual	11.15-12.24 & 13.4-14.81 13.07-14.47	2.5
7	270°	Single	13.07-14.47	1.4
8	315°	Dual	6.07-6.33 & 13.36-14.94	1.84

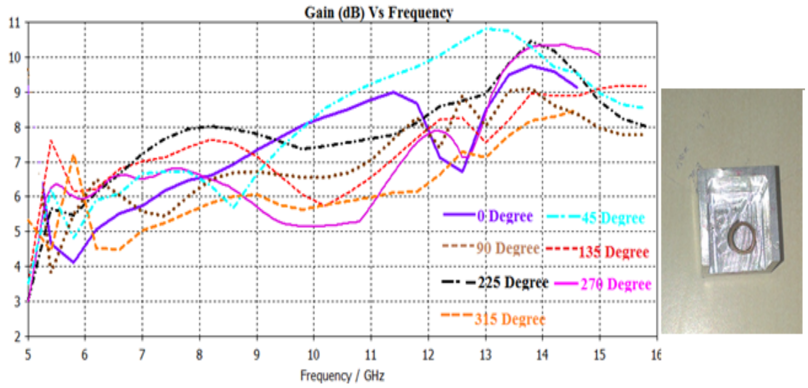


Fig. 4 Gain plot for U-wall configuration at various helix rotation angles

Table 2 Gain analysis

SR. NO	HELIX POSITION	TURNS VISIBILITY	PEAK GAIN(DB)
1	0°	3.5	9.74
2	45°	4	10.8
3	90°	4	9.1
4	135°	2.5	8.9
5	180°	3	10
6	225°	3	10.4
7	270°	2.5	10.3
8	315°	2.5	8.45

The results verification of the antenna designed antenna is done by comparing the measured and simulated plots. The measured results for some of the angles is shown in Fig. 5-7.

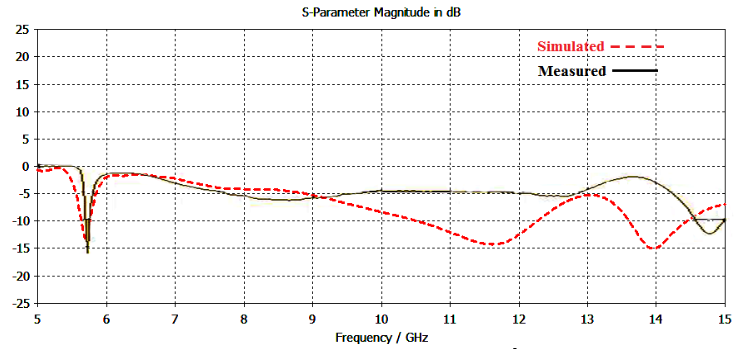


Fig. 5 Plot of reflection coefficient at 135° helix rotation

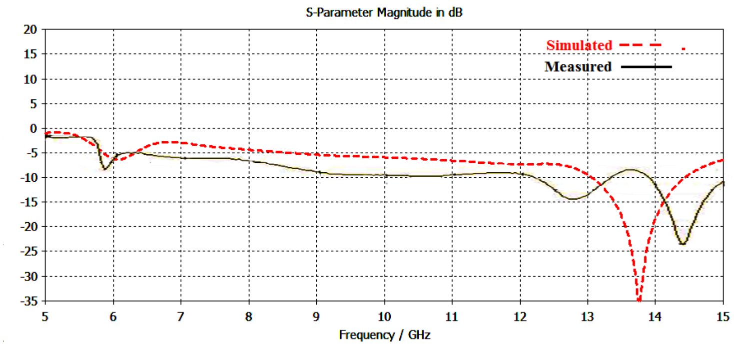


Fig. 6 Plot of reflection coefficient at 270° helix rotation

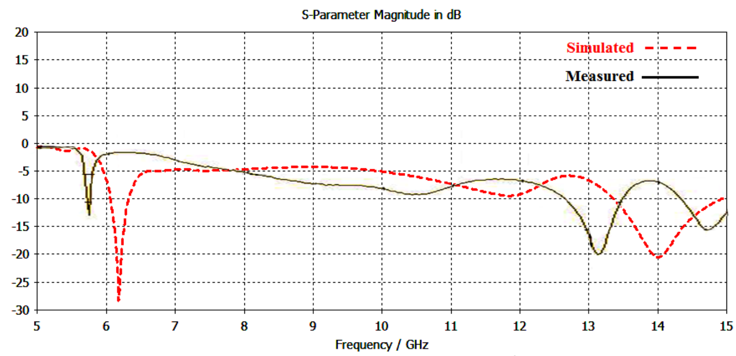


Fig. 7 Plot of reflection coefficient at 315° helix rotation

An important observation is made from the comparative plots of simulated and measured results that there is slight shift in the measured resonant bands. This is due to the fact that the implemented design has lofting between the helix base and feed pin which in case of simulated design has not been taken into consideration. Although there is not much offset in the simulated and measured results which shows that the antenna is working well with the designed specifications.

IV. CONCLUSION

The designed U-shaped partial cavity backed 1½ turn helical antenna is meeting the need of wireless communication to have conformal shape and re-configurability. The orientation of helical antenna and its spacing with respect to the cavity walls plays important role in achieving different resonant bands. The designed antenna radiation characteristic can be raised to excellence level by employing array approach. So the future work will be based on developing wideband feeding network for the array design.

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