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A Novel Approach for Gain and Bandwidth Re-Configurability in Helical Antenna

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ABSTRACT: A Pi-wall shaped partial cavity backed 1½ turn helical antenna has been designed. The helix turns are kept low to provide compact design. The gain and bandwidth re-configurability is achieved by placing the helix in center of the Pi-wall shaped partial cavity which thus can be rotated about its axis providing reflections from the walls at various rotation angle. The rotational angles of the helix are varied with the incremental step size of 45^o in anticlockwise direction. The odd number of turns will provide asymmetry of the helix with respect to the cavity walls and will thus excite various resonant bands as the helix is rotated inside the designed cavity. A Computer Simulation Tool is used for the design verification. The antenna is operating in the range of 5-15 GHz and has a peak gain of 7.5 dB and a highest bandwidth of 3.69 GHz. The Pi-shaped partial cavity is fabricated with lightweight aluminum metal and the helix is made of copper. Slight geometrical modification was made during the process of fabrication to improve the bandwidth response of the antenna. The antenna being conformal and robust in design may find its application for personal wireless communication and rough terrain areas.

KEYWORDS: Pi-shaped Partial Cavity, Antenna, Rotation Angles, Re-configurability, Return Loss.

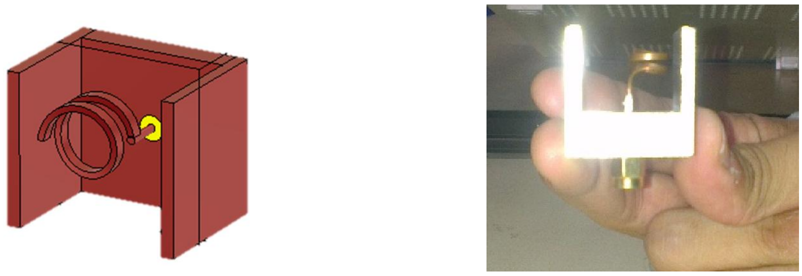
1 INTRODUCTION

The helical antenna was first introduced by Kraus in 1946 [1] and in the past five decades it has gone through various design modifications with aim of improving basic antenna parameters. Now a days helical antenna finds its application in WLAN, satellite communication, military applications etc. and therefore a demand arises to employ a design with conformal shape, reconfigurable characteristics and robustness which can significantly help in communication at various bands as and when application demands. So to incorporate all such features, a partial cavity has been designed in the shape of “Pi” which back a 1½ turn helical antenna.

It is important to find the best suited orientation of helix inside the cavity which results in desirable resonating bands. This is done by rotating the helical antenna with an offset angle of 45^o degree in anticlockwise direction inside the cavity. At these various angles, the antenna response is extracted using Computer Simulation Tool.

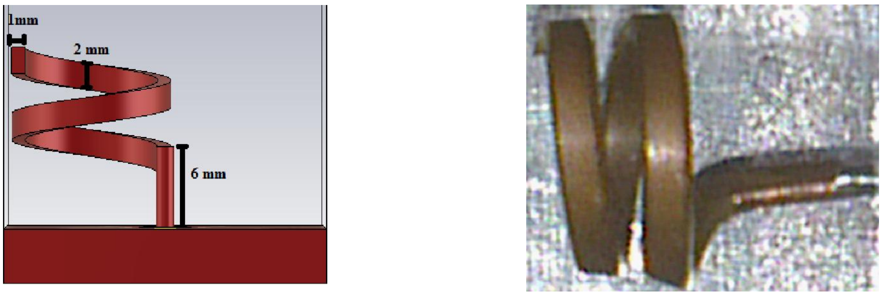
2 ANTENNA DESIGN

Initially a Pi-wall shaped partial cavity has been designed as shown in Fig. 1. The cavity has a width of 24mm, wall height of 20mm and wall thickness are kept as 2mm. With the employment of Pi shaped for the design of cavity, not only it provides conformability but also helps to confine the electric field vector and thus improves the resonant bands. A rectangular helix with strip width of 2mm and thickness of 1mm is designed which is loaded inside the cavity. Fig. 2 shows the helix geometrical configuration. Here the turns of helical antenna are compromised and limited to values 1½ only. This is done to provide compactness to the design and also 1½ turn will provide an odd symmetry with respect to the cavity walls and will help in achieving different resonant bands as it is rotated inside the partial cavity. Fig. 3 shows the various rotation angle performed inside the partial cavity.



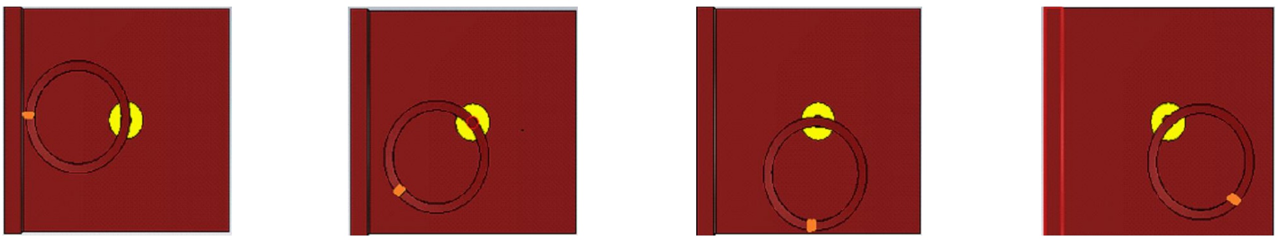
(a) (b)

Fig. 1. ***Design of Pi-wall partial cavity backed 1½ turn helical antenna***

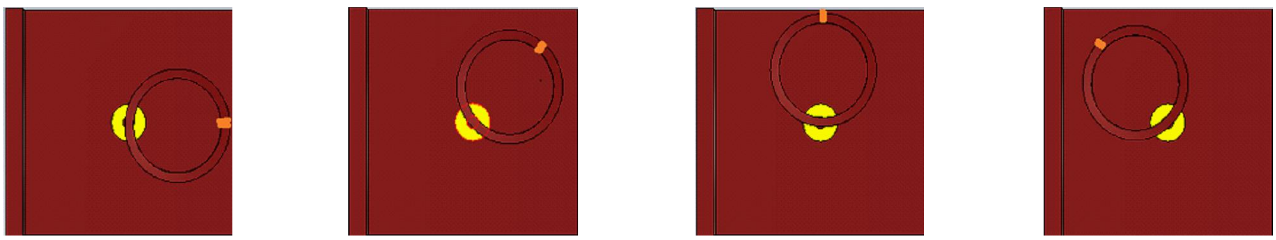


(a) (b)

Fig. 2. ***Helix geometrical configuration***



(a) 0^o position (b) 45^o position (c) 90^o position (d) 135^o position



(e) 180^o position (f) 225^o position (g) 270^o position (h) 315^o position

Fig. 3. ***Top view of helix rotation inside the Pi-wall shaped cavity***

3 RESULTS AND DISCUSSION

This section illustrates the response of helical antenna as it is rotated inside the partial cavity. The extraction of antenna basic parameters like gain, reflection coefficient, near E-field distribution etc. are done using time domain solver of CST Microwave Studio Suite. The analysis begins with the extraction of reflection coefficient plot as shown in fig.4. From Fig. 1b, as the walls location are at 0^o and 180^o facing opposite to each other, reflection from both the metallic walls give appreciable bandwidth. At 0^o position, the frequency bands are at 7.72-9.2 GHz and 13.39-15.3 GHz with a total bandwidth of 3.39 GHz, whereas at 180^o position the frequency bands are at 7.75-9.94 GHz and 13.38-15.38 GHz possessing a bandwidth of 3.69 GHz which is the highest bandwidth available in this design.

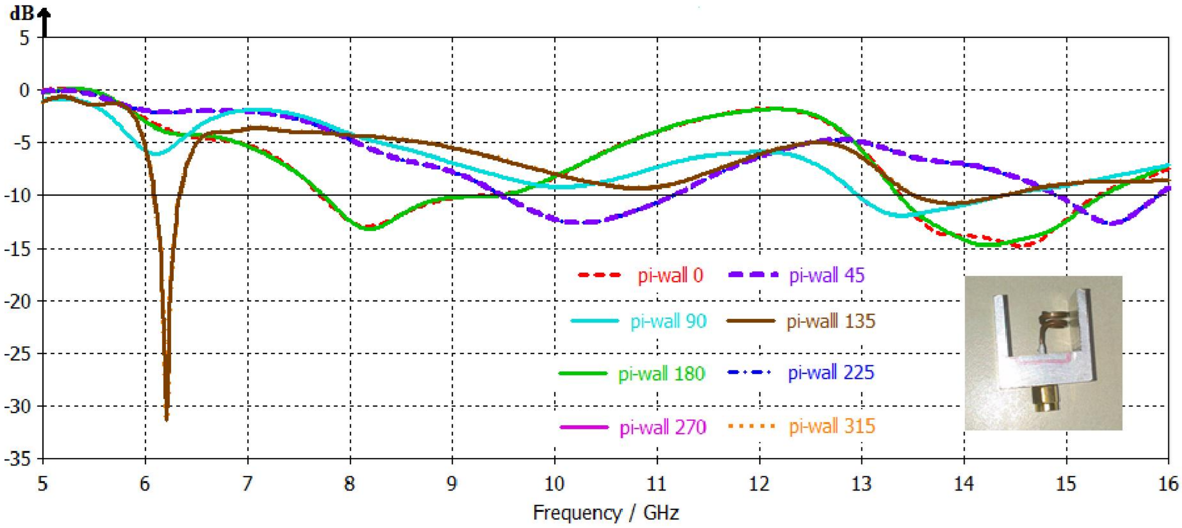


Fig. 4. Comparative plot of reflection coefficient at various helix rotations

The other dual bands are comparable at 45^o and 225^o with a bandwidth of 2.71 GHz and 2.62 GHz respectively as shown in Fig.4. The next pair is comparable at 90^o and 270^o with a bandwidth of 1.39 GHz and 1.45 GHz respectively. The last pair of similar frequency response is at 135^o and 315^o with a bandwidth of 1.10 GHz and 1.09 GHz. It is important to note that the highest bandwidth is at 0^o and 180^o position due to the fact that spacing between walls and the helical antenna is less and thereby increasing the reflections from the walls. The intermediate bandwidth which is at 90^o and 270^o position is due to orientation of helix end towards the open space. So an observation has been made that along with the spacing parameter, helix tip end orientation also plays significant role in bandwidth variation. The complete bandwidth analysis is shown in Table.1

Table 1. Bandwidth analysis of Pi-wall partial cavity

Sr. No	Helix Position	No. of Bands	Frequency Bands (GHz)	Bandwidth(GHz)
1	0^o	Dual	7.72-9.2 & 13.39-15.3	3.39
2	45^o	Dual	9.48-11.19 & 14.9-15.9	2.71
3	90^o	Single	12.98-14.37	1.39
4	135^o	Dual	6.09-6.34 & 13.526-14.385	1.10
5	180^o	Dual	7.75-9.44 & 13.38-15.38	3.69
6	225^o	Dual	9.53-11.19 & 14.94-15.9	2.62
7	270^o	Single	12.98-14.43	1.45
8	315^o	Dual	6.10-6.35 & 14.37-13.53	1.09

Similar to bandwidth analysis, a comparative gain plot is also extracted at various helix rotations inside the cavity as shown in Fig.5. It is found that a highest gain of 7.5 dB is available at 45^o position and a similar gain is available at 225^o position. So taking the diagonals into consideration, the gain is at 45^o and 225^o. Similarly at 90^o and 270^o the gain is 7.2 dB, and at 135^o, 315^o the gain is 6.6 db.

The gain is symmetrical in the diagonals due to symmetry of the walls which can be observed from the Fig. 1a. The complete gain analysis is shown in Table.2.

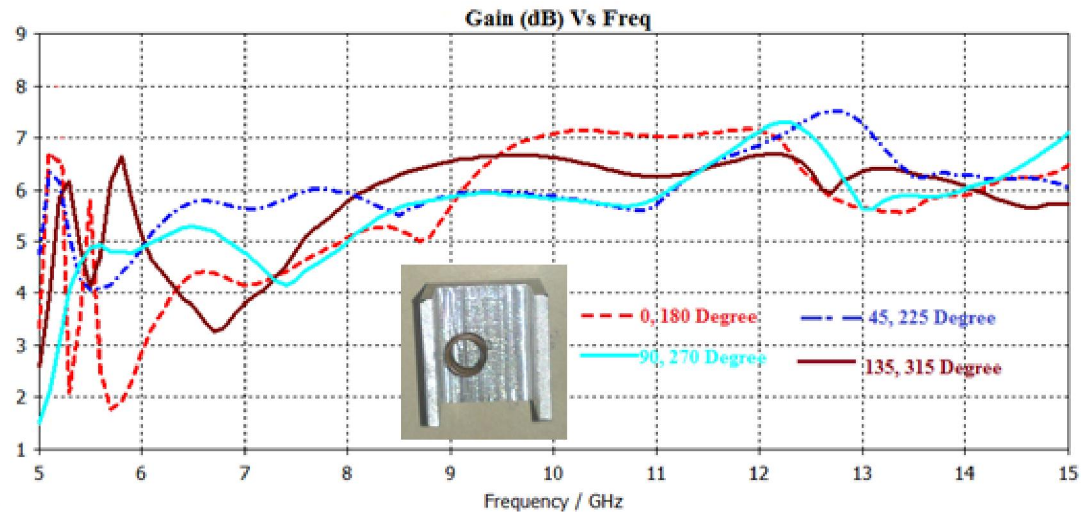


Fig. 5. Comparative gain plot at various helix rotation angles

Table 2. Comparative Gain analysis

Sr. No	Helix Position	Peak Gain (dB)
1	0^{o}	7.1
2	45^{o}	7.5
3	90^{o}	7.2
4	135^{o}	6.6
5	180^{o}	7.1
6	225^{o}	7.5
7	270^{o}	7.2
8	315^{o}	6.6

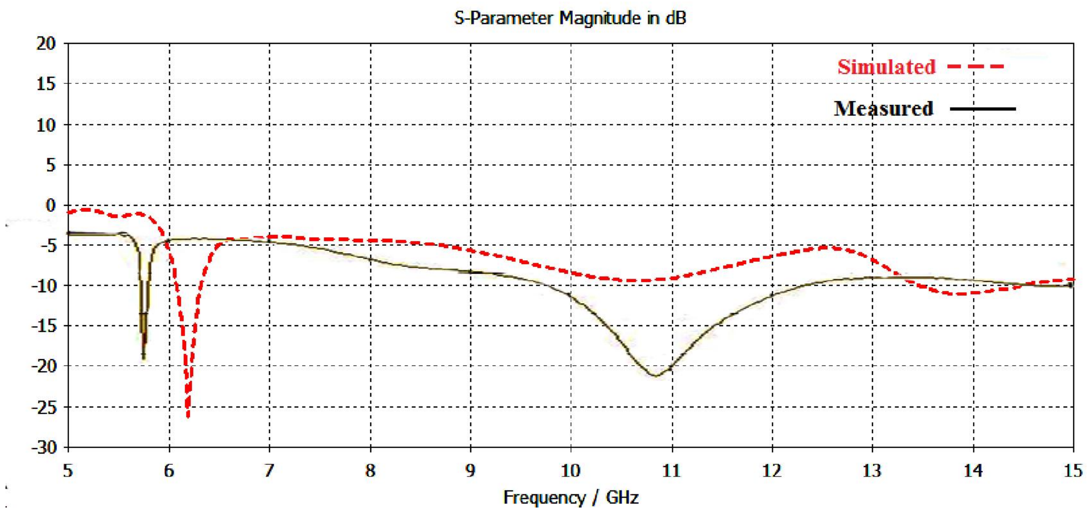


Fig. 6. Plot of reflection coefficient at 135^{o} helix rotation

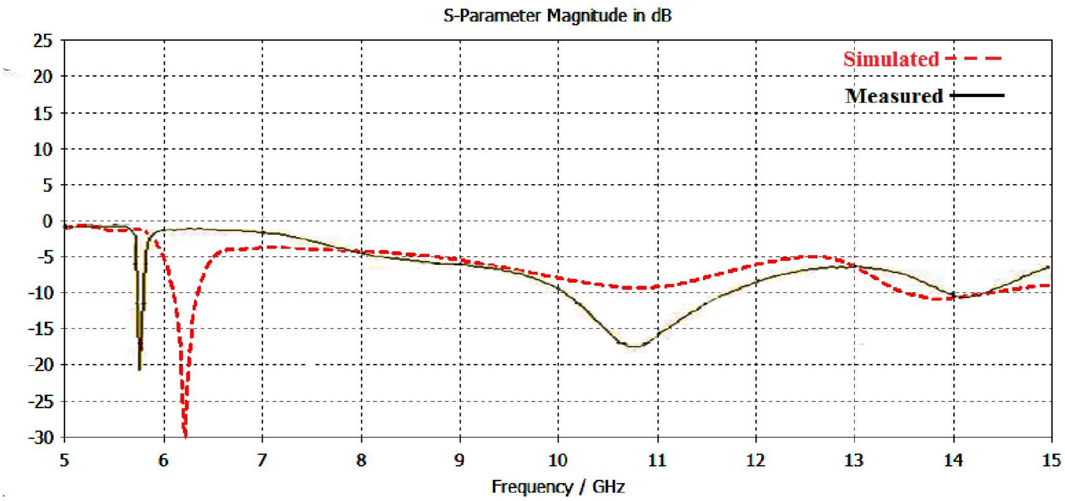


Fig. 7. Plot of reflection coefficient at 315° helix rotation

The comparative plot of measured and simulated results for some the helix rotation is shown in Fig. 6-7. It is observed that, the measured bandwidth for 135° helix rotation is 2.9 GHz whereas the simulated bandwidth is found to be 1.10 GHz only. So an increase of 1.8 GHz in the bandwidth is observed and similar is the case of 315° position where the measured bandwidth is 1.9 GHz and the simulated bandwidth is 1.09 GHz only. This increase in the measured bandwidth is due to the lofting of helix base and feed pin joint in practical implementation whereas in simulation, the joining point between feed pin and helix base is abrupt which can be clearly seen in Fig.2a-2b. So a peculiar observation has been noted down that, lofting between helix base and feed pin helps to improve the geometry continuity and thereby improves the current distribution along the antenna.

The maximum power handling capacity of the antenna is also investigated here. With the intensity of near field electric vector as 10692 V/m as shown in Fig.8 and assuming breakdown threshold of copper as 50 MV/m, the maximum power handling capacity comes out to be 21.86 MW which is given by [2]-[13].

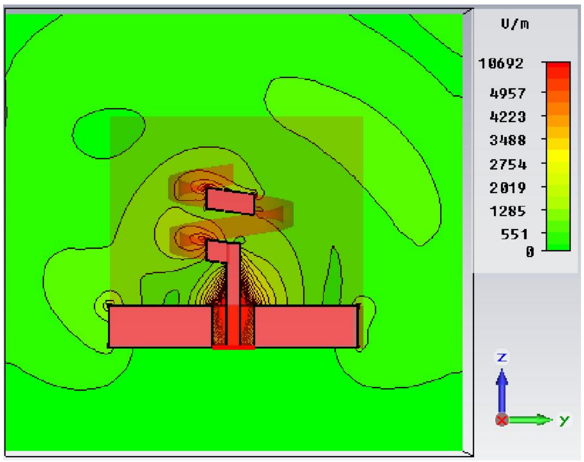


Fig. 8. Near E-field distribution in Pi-wall cavity

4 Conclusion

The designed Pi-wall partial cavity backed 1½ turn helical antenna meets the requirement of re-configurable gain and bandwidth, conformability and robustness making it suitable to use for the applications which demands such features. It is found that by varying the spacing between helical antenna and the walls, an application oriented response can be achieved. Also it observed that the practical results were having improvement over simulated results.

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REFERENCES

[1] J. D. Kraus and R. J. Marhefka, *Antenna: For All Applications*, 3rd ed. New York: McGraw-Hill, 2002.

[2] Xiang- Qiang Li, Qing-Xiang Liu, Xiao-Jiang Wu, Liu Zhao, Jian-Qiong Zhang, Zheng-Quan Zhang, "A GW Level High-Power Radial Line Helical Array Antenna", *IEEE Trans. Antennas Propag.,* vol. 56, pp. 2943 –2948, 2008.

[3] Rabih Rahaoui and Mohammed Essaaidi, "Compact Cylindrical Dielectric Resonator Antenna excited by a Microstrip Feed Line," *International Journal of Innovation and Applied Studies*, vol. 2, no. 1, pp. 1–5, January 2013.

[4] Mohammed Younssi, Achraf Jaoujal, Yacoub Diallo, Ahmed El-Moussaoui, and Noura Aknin, "Study of a Microstrip Antenna with and Without Superstrate for Terahertz Frequency," *International Journal of Innovation and Applied Studies*, vol. 2, no. 4, pp. 369–371, April 2013.

[5] M. I. Hasan and M. A. Motin, "New slotting technique of making compact octagonal patch for four band applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 1, pp. 221–227, May 2013.

[6] Tajeswita Gupta and P. K. Singhal, "Ultra Wideband Slotted Microstrip Patch Antenna for Downlink and Uplink Satellite Application in C band," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 680–684, July 2013.

[7] Sonali Kushwah, P. K. Singhal, Manali Dongre, and Tajeswita Gupta, "A Minimized Triangular – Meander Line PIFA Antenna for DCS1800/WIMAX Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 714–718, July 2013.

[8] Tajeswita Gupta, P. K. Singhal, and Vandana Vikas Thakre, "Modification in Formula of Resonating Frequency of Equilateral TMPA for Improved Accuracy and Analysis," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 727–731, July 2013.

[9] Anshul Agarwal, P. K. Singhal, Shailendra Singh Ojha, and Akhilesh Kumar Gupta, "Design of CPW-fed Printed Rectangular Monopole Antenna for Wideband Dual-Frequency Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 758–764, July 2013.

[10] Manali Dongre, P. K. Singhal, Sonali Kushwah, and Tajeswita Gupta, "Triple Band Hexagonal Meander-line Monopole Antenna for Wireless Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 4, pp. 953–958, August 2013.

[11] Alak Majumder, "Design of an H-shaped Microstrip Patch Antenna for Bluetooth Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 4, pp. 987–994, August 2013.

[12] Pawan Shakdwipee, "Design and Simulation of Edge-Coupled Stripline Band Pass Filter for U band," *International Journal of Innovation and Applied Studies*, vol. 3, no. 4, pp. 1033–1044, August 2013.

[13] B R Koushik and B Ajeya, "Design of Rectangular Microstrip Antenna with Metamaterial for Increased Bandwidth," *International Journal of Innovation and Applied Studies*, vol. 3, no. 4, pp. 1094–1100, August 2013.