Novel Triple Band Helical Antenna for Gain and Bandwidth Enhancement

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ABSTRACT
In this paper a design of triple band one turn helical antenna without ground plain for center frequency of 2.4 GHz, 3.6 GHz, and 5.4 GHz is discuss. These frequencies are selected such that the antenna radiate for continuous band of 2 GHz to 6.8 GHz frequency with variable gain. The purpose of this novel design is to enhance the gain as well as bandwidth. The triple band is achieved by three concentric helix of circumference equal to respective wavelength. The comparative analysis of radiation pattern of each frequency and gain with respect to one turn single helical antenna is done. Gain enhancement is up to 7 dB as compare to one turn single helical antenna and total bandwidth is 2.5 GHz. The antenna design is the prototype model for axial mode radiation. As it is one turn helical antenna it radiate in normal mode, after increasing the number of turns it will radiate in axial mode.

General Terms
Design, measurement, enhancement

Keywords
Triple band, helical antenna, gain, and bandwidth

1. INTRODUCTION
The important requirements for almost all the applications of the antenna are higher gain and larger bandwidth. All scientist, engineer and research scholar are struggling to enhance the gain and bandwidth of antenna so that the multiple antennas used in aircraft, satellite and other application can be replaced by single antenna.

The gain can be enhancing by using the antenna array [2] but there may not be the significant increase in the bandwidth and size is much larger as compare to simple helical antenna. Another way of gain enhancement is compact size helical loaded cavity backed antenna [4-6]. The size of this antenna is reduced by a factor of 10, compared to a conventional helical antenna. The helix circumference to wavelength ratio is reduced to 0.2, according to the classical design data for axial mode operation it is 0.8 to 1.2. The same size helical antenna radiate in normal mode without cavity. The compact size makes this antenna very attractive for satellite communications and aerospace applications. A helicone [3] is combined by the helix and the conical horn. Because the helix has a traveling wave device, the helicone operates in a broad bandwidth. Due to the conical horn has a high gain and low sidelobe level, the helicone has the same characteristics. Compared with the simple helical antenna, the gain of the helicone is enhanced, but the sidelobe and backlobe levels are down. The gain enhancement of helical antennas by shaping the ground conductor [1], the size and shape of the ground conductor of axial mode helical antennas have significant impact on the antenna gain. Some other methods are also there which enhance the gain or bandwidth.

In this paper the prototype design of single turn triple band helical antenna is proposed. The design of antenna is for axial mode radiation, circumference of antenna (C) is equal to the wavelength (λ). The center frequencies are 2.4 GHz, 3.6 GHz, and 5.4 GHz. The center frequencies are selected such that the antenna should radiation from 2.0 GHz to 6.8 GHz in continuous band. The gain enhancement of tripe band helical antenna as compare to one turn single helical antenna is due to the three different helix for three center frequencies.

2. DESIGN OF TRIPLE BAND HELICAL ANTENNA
One turn triple band helical antenna of 125 mm, 88 mm, and 56 mm circumference with 1.3 mm thick copper conductor without ground plain is shown in fig 1. According to the classical design [2], helical antenna radiates in axial mode for $0.8\ \lambda \leq C \leq 1.2\ \lambda$. Using this design concept if $C = \lambda$, axial mode radiations for 125mm circumference is from 2.0 GHz to 3.0 GHz similarly for 88 mm circumference is from 3.0 GHz to 4.5 GHz and for 56 mm circumference is from 4.5 GHz to 6.8 GHz. The extended leads in the design are for impedance matching. The satisfactory VSWR of triple band helical antenna is in the frequency range of 2.3 GHz to 2.5 GHZ and from 3.3 GHz to 5.6 GHz as shown in fig 2. The second center frequency 3.6 GHz and third center frequency 5.4 GHz merged and form 3.3 GHz to 5.6 GHz band. The bandwidth is of 0.2 GHz and 2.3 GHz from two bands.

The gain of the triple band helical antenna is shown in fig 3, for the frequency from 2.0 GHz to 7.2 GHz in interval of 0.1 GHz, it is found that the gain is 4.68 dB for 2.4 GHz frequency, 1.69 dB for 3.6 GHz, -1.15 dB for 5.4 GHz and 0.17 dB for 6.0 GHz frequency. From the gain observation the gain is higher for small frequencies and it reduces for higher frequencies, but for 6.0 GHz it starts increasing. This is due to the interference of radiation in the helix, as helixes are concentric and outer helix is for lower frequency.

3. COMPARISION OF TRIPPLE BAND HELICAL ANTENNA WITH SINGLE HELICAL ANTENNA
The one turn triple band helical antenna is compare with simple one turn helical antenna of same circumference to know the improvement in the various parameters.

3.1 Single Helical Antenna of 125 mm Circumference
The 125 mm circumference single helical antenna and its scattering parameter are shown in fig 4 and fig 5 respectively. The center frequency of 2.4 GHz is shift to 3.6 GHz in simple helical antenna. As in triple band helical antenna it appears with bandwidth of 0.2 GHz. The gain of single helical antenna at 2.4 GHz frequency is -1.11dB as compare to triple ban 4.68 dB, 5.79 dB higher.

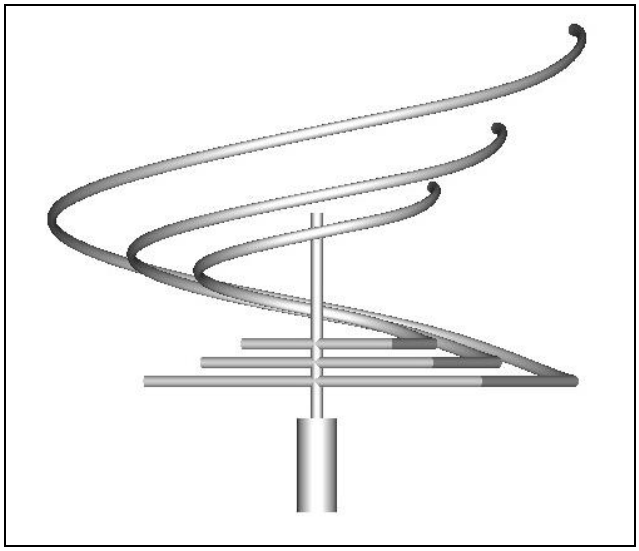

Fig 1: One turn triple band helical antenna

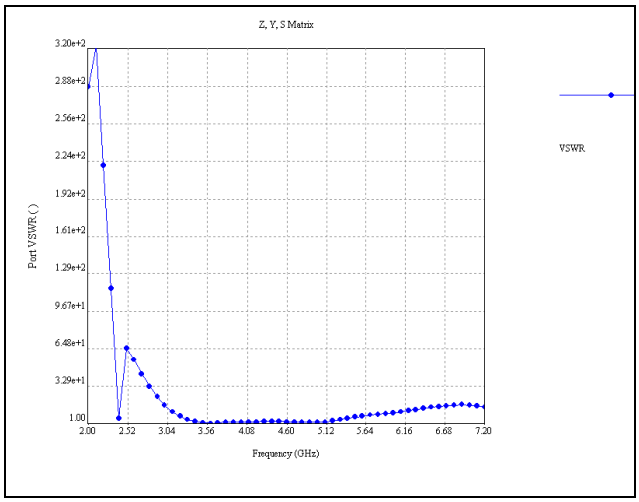

Fig 2: VSWR of One turn triple band helical antenna

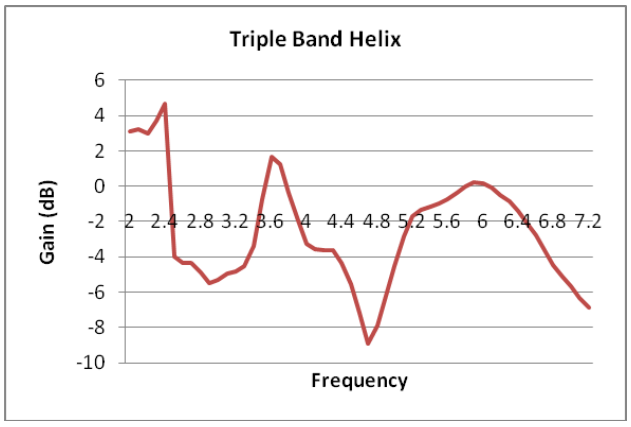

Fig 3: Gain plot of triple band helical antenna

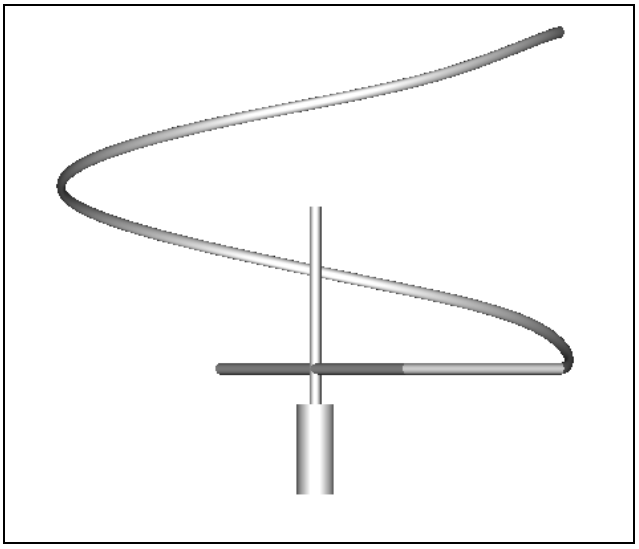

Fig 4: One turn single helical antenna of 125 mm circumference (f_0=2.4 GHz)

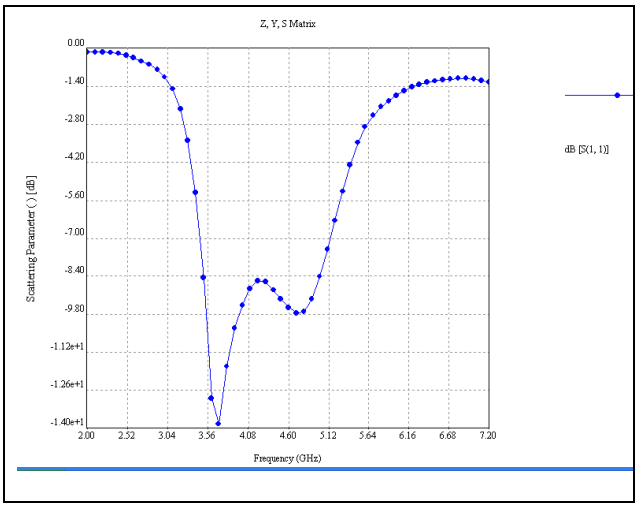

Fig 5: VSWR, One turn single helical antenna of 125 mm circumference (f_0=2.4 GHz)

3.2 Single Helical Antenna of 88 mm Circumference

The 88 mm circumference single helical antenna and its scattering parameter are shown in fig 6 and fig 7 respectively. The center frequency of 3.6 GHz is shift to 4.8 GHz in simple helical antenna. As in triple band helical antenna it appears with bandwidth of 2.3 GHz. The gain of single helical antenna at 3.6 GHz frequency is -5.31dB as compare to triple ban 1.69 dB, 7.0 dB higher.

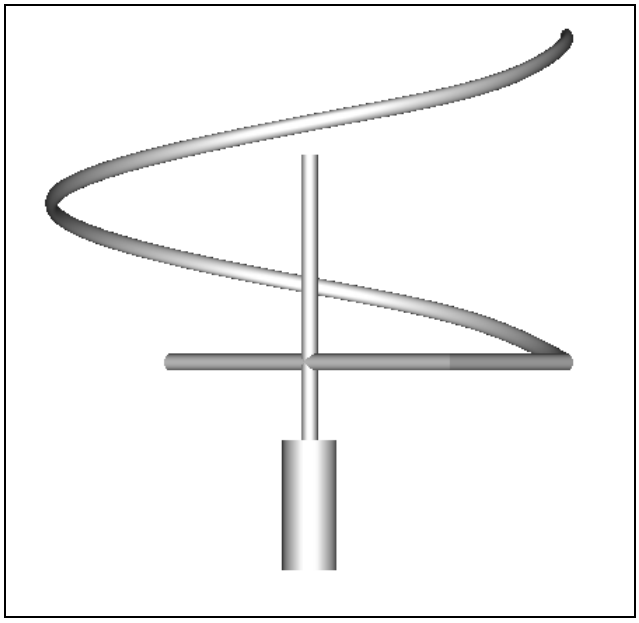

Fig 6: One turn single helical antenna of 88 mm circumference (f_0=3.6 GHz)

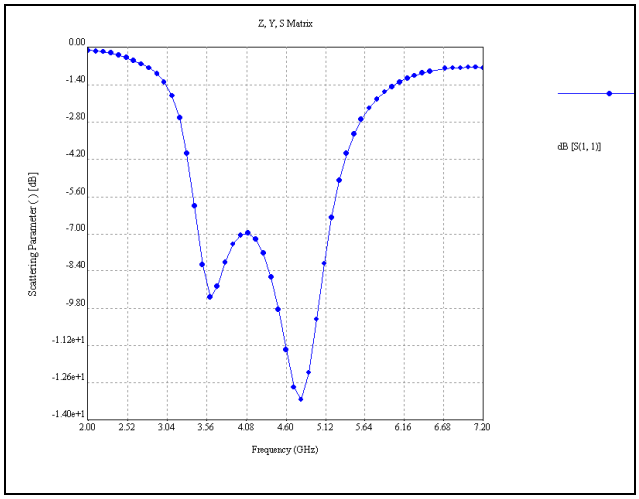

Fig 7: Scattering parameter (dB), One turn single helical antenna of 88 mm circumference (f_0=3.6 GHz)

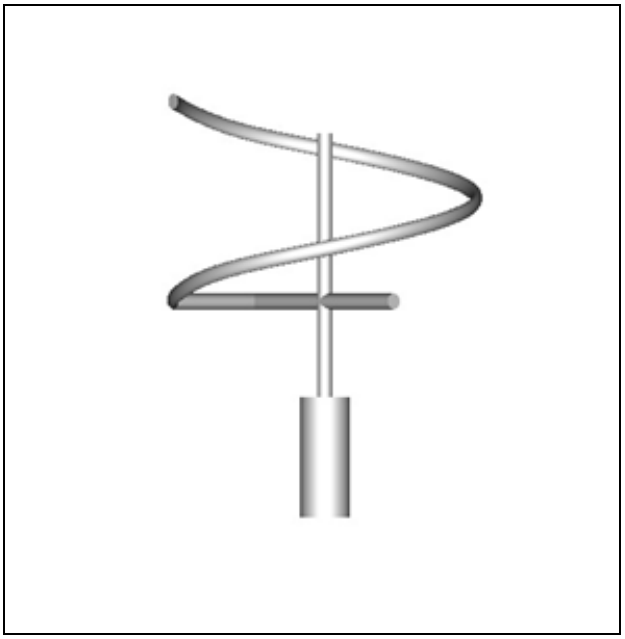

Fig 8: One turn single helical antenna 56 mm circumference (f_0=5.4 GHz)

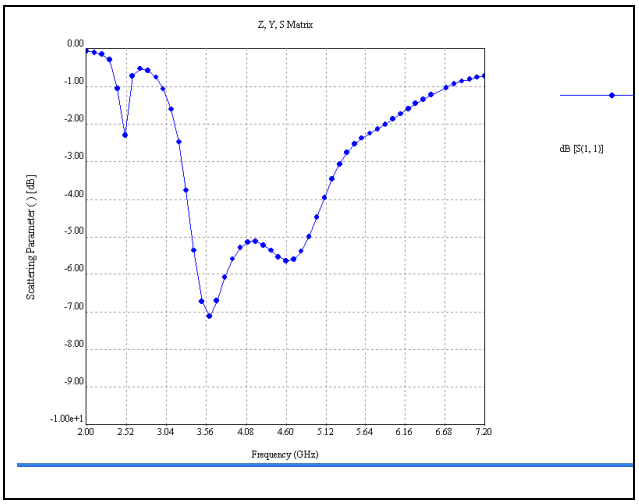

Fig 9: Scattering parameter (dB), One turn single helical antenna 56 mm circumference (f_0=5.4 GHz)

3.3 Single Helical Antenna of 56 mm Circumference

The 56 mm circumference single helical antenna and its scattering parameter are shown in fig 8 and fig 9 respectively. The center frequency of 5.4 GHz is not appears in simple helical antenna. As in triple band helical antenna it appears with bandwidth of 2.3 GHz. The gain of single helical antenna at 5.4 GHz frequency is -4.54 dB as compare to triple band -1.15 dB, 3.39 dB higher.

4. RESULT AND DISCUSSION

After doing 424 simulations in method of moment solver and analyzing the results it is found that the bandwidth of triple band antenna is 0.2 GHz and 2.3 GHz from two bands with frequency range of 2.3 GHz to 2.5 GHZ and from 3.3 GHz to 5.6 GHz. The second center frequency 3.6 GHz and third center frequency 5.4 GHz merged and form from 3.3 GHz to 5.6 GHz band. This may be due to the electromagnetic interference of the concentric helix.

The gains of triple band helical antenna are 4.68 dB for 2.4 GHz frequency, 1.69dB for 3.6 GHz, -1.15dB for 5.4 GHz as compare to one turn single helical antenna -1.11dB for 2.4 GHz frequency, -5.31 dB for 3.6 GHz, -4.54 dB for 5.4 GHz, as shown in fig 10, fig 11 and fig 12. All though triple band helical antenna is one turn without ground plain the

enhancement in the gain at 2.4 GHz frequency 5.79 dB, 3.6 GHz frequency 7.0 dB

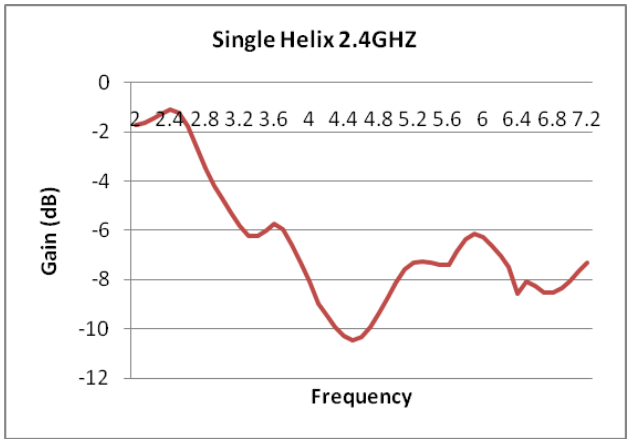

Fig 10: Gain plot of single helical antenna of 125 mm circumference (f_0=2.4 GHz)

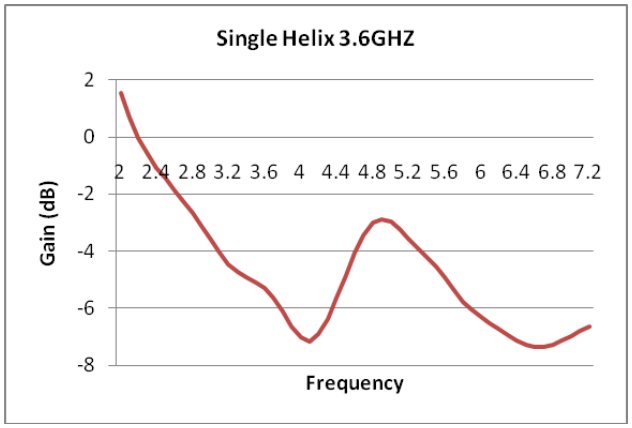

Fig 11: Gain plot of single helical antenna of 88 mm circumference (f_0=3.6 GHz)

and 5.4 GHz frequency 3.39 dB. Fig 13 is the plot of the gain difference of triple band helical antenna with higher gain of one turn single helical antenna at respective frequencies.

The radiation pattern of triple band helical antenna and the single helical antenna with electric field normalize values in theta and phi angle variations are shown in fig 14 to fig 19. It is seen from these figures the radiation pattern of single helical antenna at 2.4 GHz, 3.6GHz and 5.4 GHz is omnidirectional but radiation pattern of triple band helical antenna at the same frequencies are comparatively distorted. This distortion is due to the interference of concentric helix with each other, using electromagnetic interference technique the interference can be reduced.

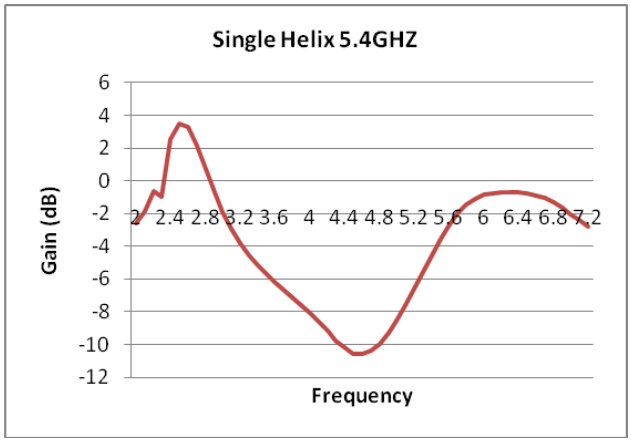

Fig 12: Gain plot of single helical antenna of 56 mm circumference (f_0=5.4 GHz)

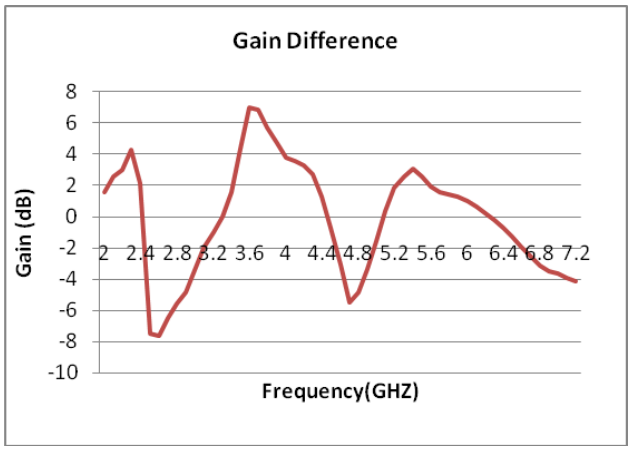

Fig 13: Gain difference of triple band helical antenna with higher gain single helical antenna at the respective frequencies

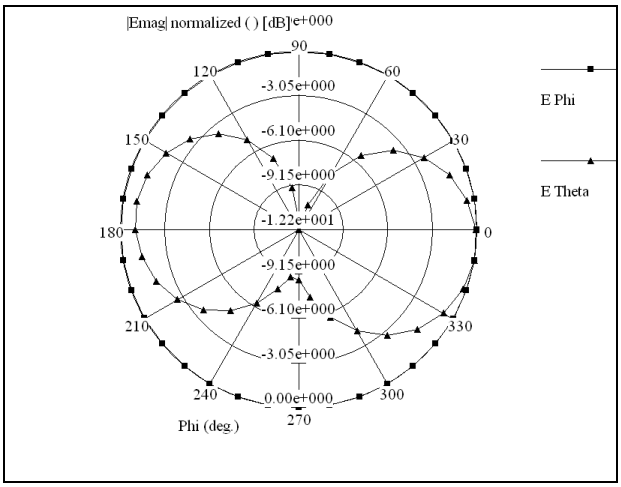

Fig 14: Radiation pattern of triple band helical antenna at 2.4 GHz frequency

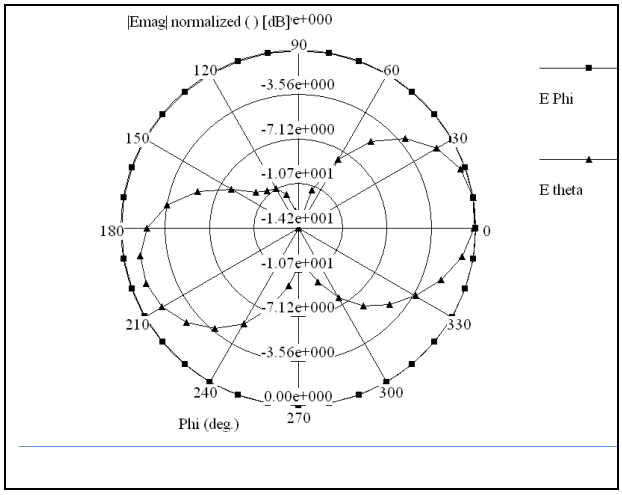

Fig 16: Radiation pattern of triple band helical antenna at 3.6 GHz frequency

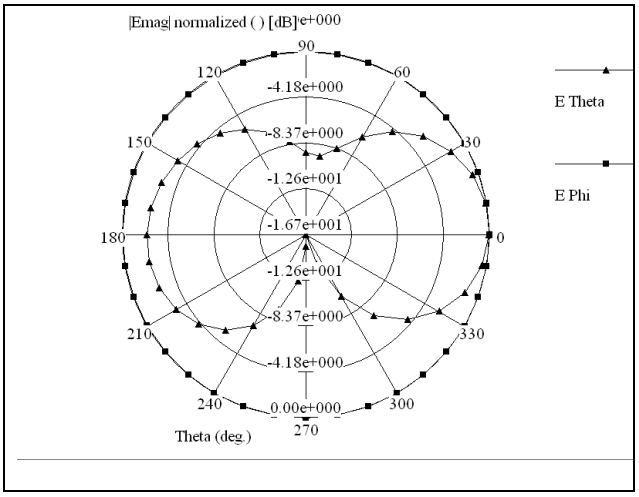

Fig 17: Radiation pattern of single helical antenna of 88 mm circumference at 3.6 GHz frequency

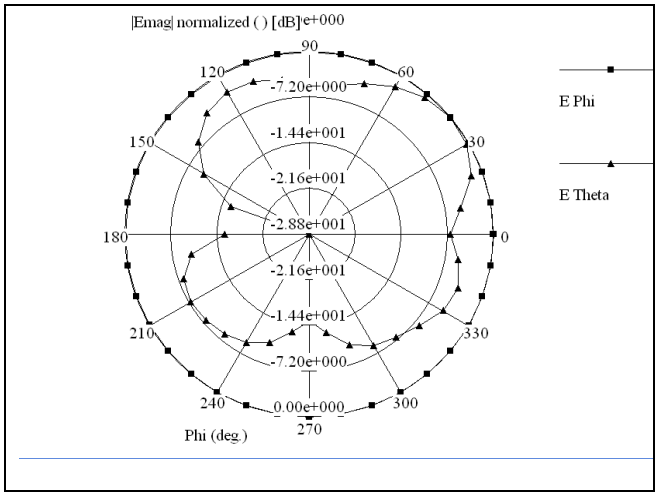

Fig 18: Radiation pattern of triple band helical antenna at 5.4 GHz frequency

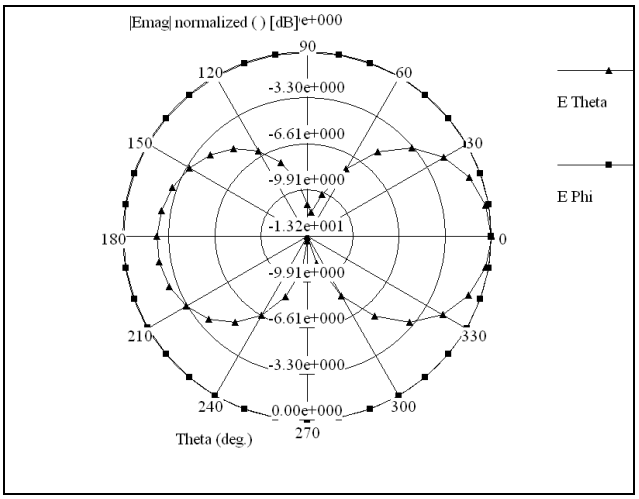

Fig 19: Radiation pattern of single helical antenna of 56 mm circumference at 5.4 GHz frequency

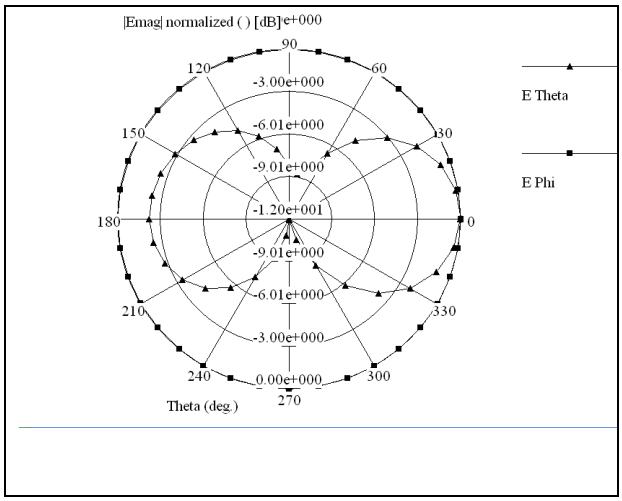

Fig 15: Radiation pattern of single helical antenna of 125mm circumference at 2.4 GHz frequency

5. CONCLUSION

This is the novel design method for triple band helical antenna. The gain of triple band one turn helical antenna is enhance up to 7 dB as compare to one turn single helical antenna of same design. The bandwidth of 0.2 GHz and 2.3 GHz are achieved. One turn helix without ground plain is selected to reduce the simulation time so that the number of simulation cannot be limited.

This is a prototype design, by using the ground plain and increasing the number of turns the gain can be increase also the normal mode radiation pattern can be convert to axial mode radiation pattern. The reduction in gap between the center frequencies will result the continuous broad band with constant gain.

6. REFERENCES

[1] Djordjevic, A. R., Zajic, A.G., Ilic, M. M., "Enhancing the Gain of Helical Antennas by Shaping the Ground Conductor", Antennas and Wireless Propagation Letters, IEEE, 2006.

[2] Kraus, J. D. 1997 Antennas. Tata McGraw Hill Publishing Company Ltd.

[3] K. R. Carver, "The helicone-a circularly polarized antenna with low sidelobe level," Proceedings of the IEEE, 1967.

[4] Vinitkumar Jayaprakash Dongre, B.K. Mishra, "Axial Mode Helical Antenna using Cylindrical Cavity", International Journal of Computer Applications, 2011, in USA.

[5] Vinitkumar Jayaprakash Dongre, B.K. Mishra, "Compact Size Helical Loaded Cavity Backed Antenna by Helical Resonator Filter", Springer Communications in Computer and Information Science, 2011, in Verlag Berlin Heidelberg.

[6] Vinitkumar Jayaprakash Dongre, B K Mishra, "Novel Mode Conversion Technique of Helical Antenna using Cavity", International Journal of Computer Applications, 2011, in USA.