Compact Wide Band Double Helical Antenna for Public Safety VHF Band

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Introduction

The VHF band for Public Safety radios covering 136 MHz to 174 MHz is a popular continuous band for the public safety market. Popular models in the market includes Motorola XTS5000, Kenwood TK272G, TK2160, RELM BK KNG P150, iCom IC-F50V, and Datron SC-VHF1, just to name a few, are VHF wide band radios covering the whole of 38 MHz bandwidth. However, very few of these radios are equipped with narrow band antennas covering a third of the required bandwidth. This paper describes the concept and implementation of a iconic design covering the 24.5% bandwidth factor, using the concept of double helix. The measured result of a relatively short (17 cm) version of the design is presented.

Design Considerations

The helical antennas are used for the range 136 to 174 MHz simply due to the fact that the quarter wave length at that frequency is longer than 50 cm, and the antennas at this frequency and kept to about 18 cm. However, a normal-mode helical antenna of that size can cover up to half of the public safety VHF band. The solution to increase the bandwidth of a helical antenna is to couple two helixes together, with one helix being driven, while the other is mounted on the chassis, at close proximity to the driven helix. This trick of bandwidth enhancement has been well explored and can be seen in handset antennas applications and WLAN antenna applications alike. Figure 1 shows the examples of such concept [1-2].

Antenna Structure

The implementation of similar concept using helixes is shown in Figures 3 and 4. Figure 3 shows the basic structure of the antenna and figure 4 shows the dimensions. The design of this antenna is work [3] of Garay et al. The inner helix is the driven element is it is designed for work at lower frequency while the outer helix is the parasitic element mounted on to the outer conductor of the coaxial feed and subsequently to the chassis ground, in a similar manner to the concepts in Figure 1. Figure 4 shows the basic dimensions of the antenna. The outer helix is designed with the diameter of Do, pitch of Po and number of turns No. The inner helix is designed with the diameter of Di, pitch of Pi and number of turns Ni. In the basic design procedure, the inner helix is first designed on the chassis to resonate at a frequency at the lower band edge. The second helix is then mounted optimizing the number of turns to obtain the bandwidth, and the diameter of outer helix is varied to optimize the impedance matching of the antenna. To ensure robustness of the antenna, a spacer is usually used between the two helices to maintain the stability of the dimensions. A commercial version of such design covering 136 – 174 MHz. is currently available at the length of 21 cm.

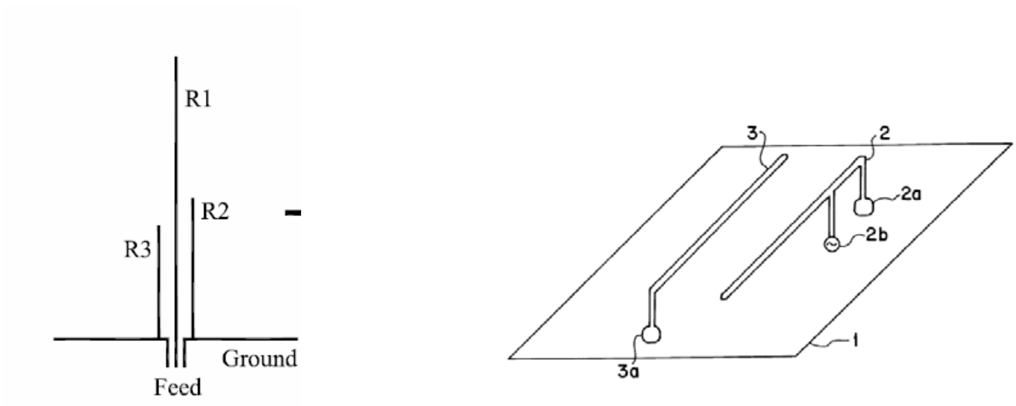

Figure 1. Concept of coupling parasitic elements to broaden the bandwidth.

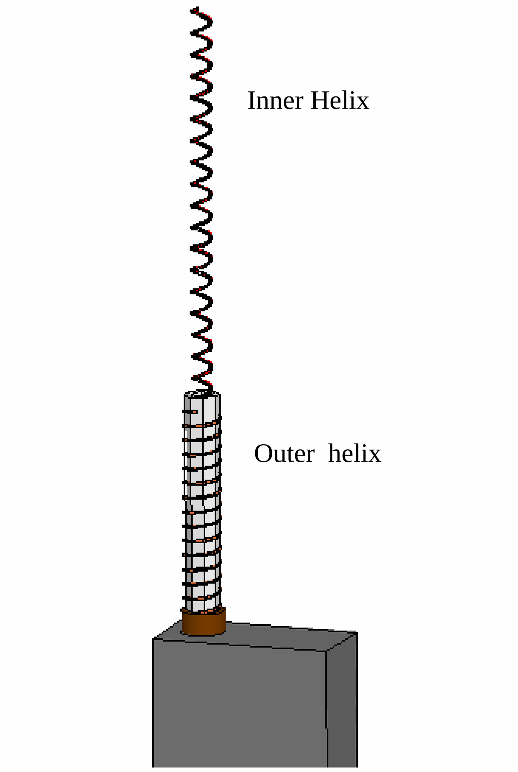

Figure 3. Basic Structure of double helix antenna.

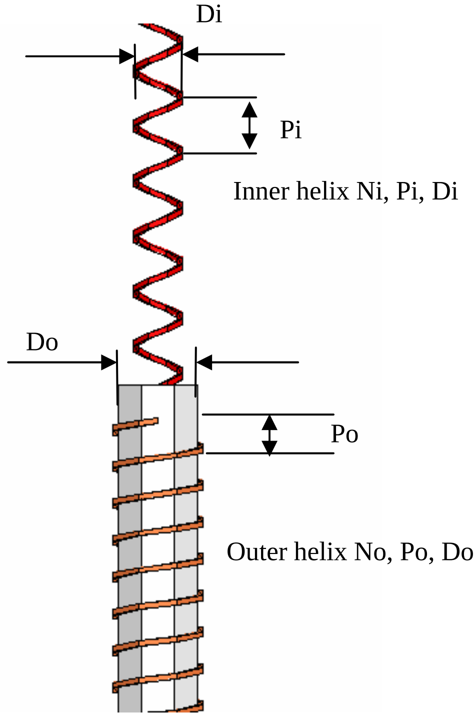

Figure 4. Dimensions of the antenna.

Antenna Prototype

In this project, an attempt is made to make a reduced size version of the same concept covering 136 – 174 MHz. The antenna was designed with 0.9 mm wire. The inner helix was first kept at 16 cm. The outer helix is then added with a Texin spacer between the helixes. Design iterations are done manually to arrived at reasonable matched bandwidth. The antenna is to be covered with a Texin shroud. A single helix trimmed to the centre of the band was used as reference to compare the performance of the double helical antenna.

Results

In the final design, the dimensions are optimized to obtain the best compromised performance considering the matched bandwidth for the whole of 136 – 174 MHz range. This is achieved with Do=8mm, No= 12, and Po=4mm for the outer helix and Ni=84 mm, Pi=2mm and

Di=4.5mm for the inner helix. The pictures of the reference single helix antenna and the double helix antenna are shown in figures 6 and 7. Both helixes are covered with Texin 950 shroud.

Figure 6. A 15 cm long single helix antenna used as reference.

Figure 7. The final double helix antenna.

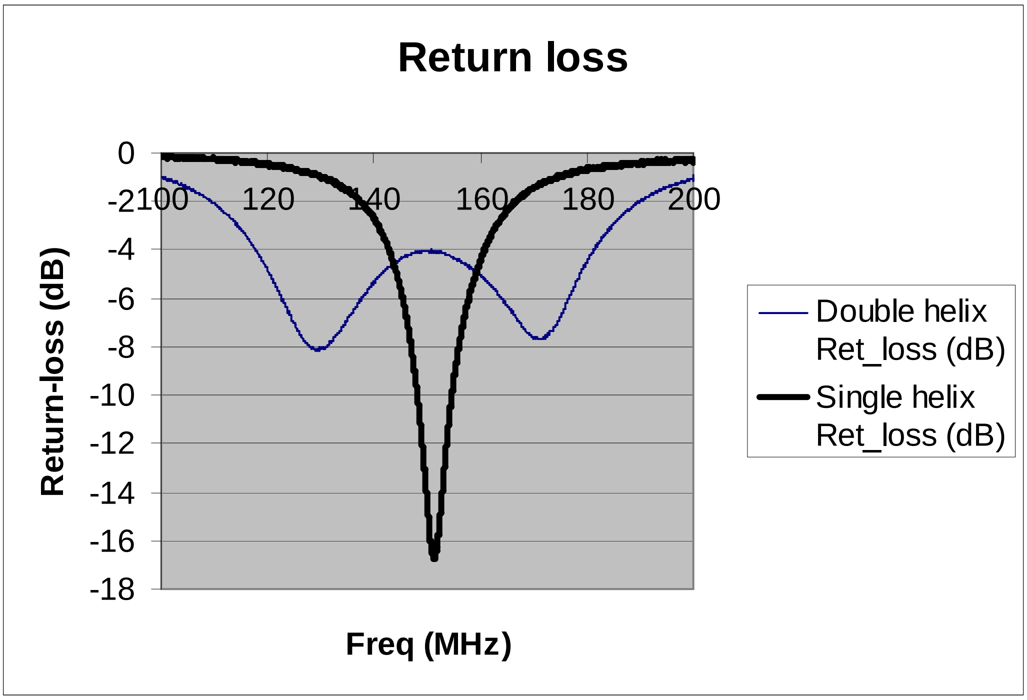

Figure 8. Return loss plot of the single and double helix antenna.

Figure 8 shows the measured return loss plot of the antennas on the chassis measured in free space. The double helical antenna achieves matched bandwidth of 136 – 174 MHz with a wide, W-shaped distribution with the worst S11 being – 4 dB in the middle of the band. The return loss of the single helix, on the other hand, shows a deep, narrow plot covering only 20 MHz, using S11<-4 dB as the line of reference. Figure 9 shows the Gain comparison between the double helix and the single helix measured in free space. The gain of the double helix shows a steady line of > -11 dBi gain, while the single helix shows maximum gain of – 8 dBi within narrow band of 10 MHz. The single helical antenna shows batter gain then the double helical antenna within the frequency where the antenna is well matched only. The double helical antenna gives better over- all gain bandwidth.

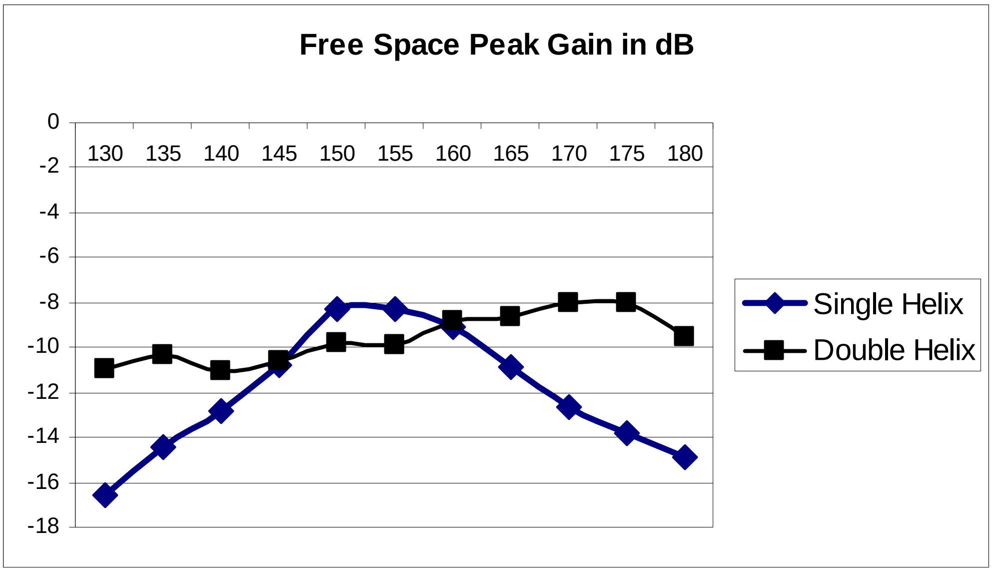

Figure 9. Free Space Peak Gain comparison between single and double helix.

Conclusion

A 17 cm wide band double antenna covering the public safety VHF band 136 – 174 MHz has been designed. Measured results shows better over all gain bandwidth compared to a single helix antenna of around the same length. The concept of the double helical has proven to be a good solution in improving the gain bandwidth of portable radio antenna in the VHF band. The design procedure of the double helical antenna involves a lot of manual iterations. Some attempts were made to tune the antenna with simulations but it was found to be far too time consuming than the manual work at the frequency of 136 MHz.

References

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