Wide Band Whip Antenna for Public Safety 700, 800 and GPS Bands

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Introduction

With the increasing importance of inter-operability and added GPS feature on Public Safety radios, wide band antennas covering major Public Safety bands are required to fulfil the market demand. In this paper, the design of a whip antenna covering the new 700 Public Safety and the traditional 800 MHz band, with the addition of linear GPS antenna feature is presented.

The design utilizes the concept of helix-driven wide band monopole antenna consisting of a half wave conductor driven by a quarter wave helical antenna element [1], with the adaptation from ground plane mount to radio chassis mount, previous reported in a feasibility study covering 760 – 870 MHz [2]. Using the concept of dual pitch helix [3], linear-polarized GPS antenna functionality is added by manipulating the driven helix to resonate at the GPS frequency of 1575 MHz.

Design Considerations

The design is for a chassis measuring 60 mm x 160 mm x 20 mm. As the length of the chassis exceeds quarter wave length for both 760 MHz and 1575 MHz, the chassis would become the dominant part of the radiator if an antenna element with quarter wave in electrical length is used. Therefore the antenna element must be either three quarter or half wave length. The concept of choice is chosen based on such criteria.

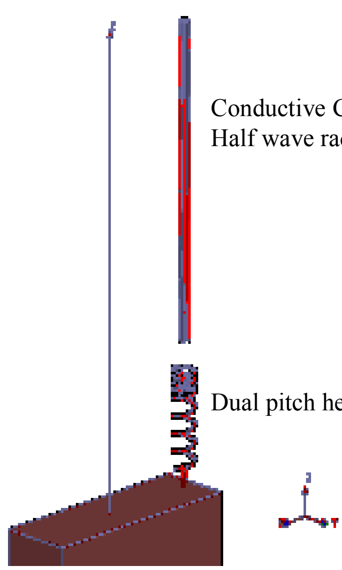

Figure 1. Antenna dimensions.

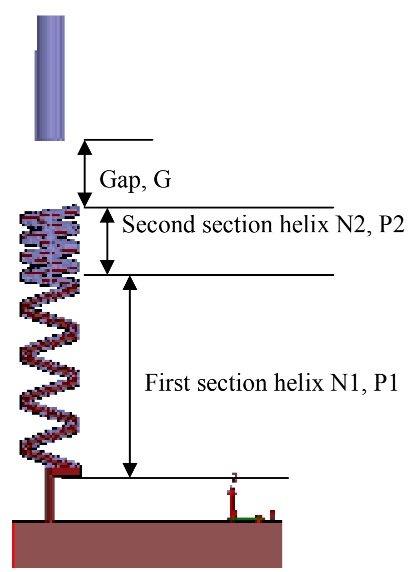

Figure 2. Basic Structure of the antenna.

Antenna Structure

The antenna consists of a dual-pitch helix and a flexible conductive cable, held together with a place holder or separator between the helix and the cable. The antenna is enclosed in a polyurethane sheath. This is shown in Figure 1. The dimensions of the antenna are shown in figure 2. The helix consists of two sections; the bottom section has N1 number of turns with the pitch of P1, and the higher section with the number of turns N2 with pitch of P2. The diameter of both helix sections is uniform, with D over the whole helix. The size of the wire is d. The flexible conductor with the length L and diameter J is mounted with a separation of G using an insulator spacer, not shown in the figure. The antenna is designed on a chassis measuring 60 mm x 160 mm x 20 mm.

Antenna Tuning

The design began with the manipulation of the helix to resonate at both 800 and GPS frequencies. This is done by setting the total number of turns N1+N2 with initial pitch to arrive at the 800 MHZ frequency. A second section is then created by compressing the number of turns N2 to pitch P2 to create the second resonance frequency at 1575 MHz, while keeping the 800 MHz resonance. This method is previously used in the works for dual band cellular phone antennas [3]. Electrically, the length of the helix is quarter wave at 800 MHz, and three quarter wave length in the GPS band. A systematic approach in designing such helix can be found in previous work by Ooi [4]. The electrical length of the conductive cable is around half wave length. The actual length of the half wave radiator is finalized experimentally to provide broad band match over the 760 – 870 MHz range of frequencies, following the method described by Nakano et al [1]. The radiation patterns of the antenna at both 760 and 870 are also monitored during the tuning to ensure radiation concentration on the Azimuth plane.

Results

In the actual realization of the design, the dimensions are optimized to obtain the best compromised performance considering the matched bandwidth of both bands. This is achieved with diameter J=3mm brass-finished stainless steel cable L=137 mm mounted G=6 mm above the helix. The dimensions of the helix are, N1=3, P1= 4mm, N2= 4, P2= 2 mm, D= 6 mm and d=0.7 mm. The material for the sheath is TEXIN 950U.

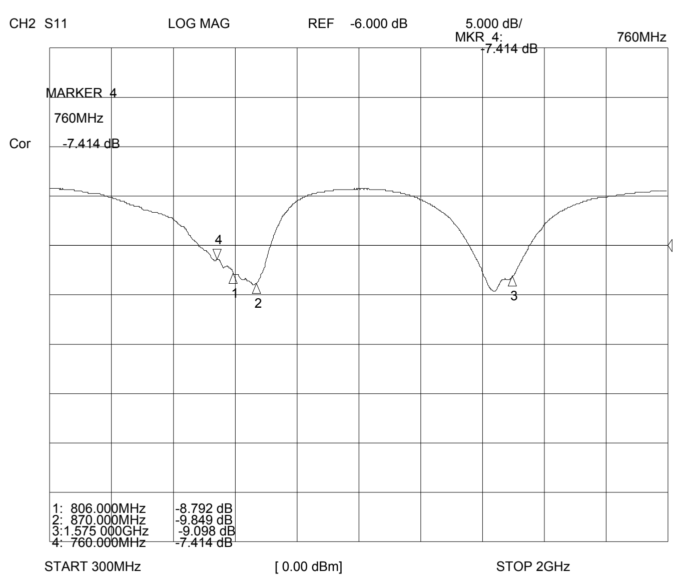

Figure 3. S11 Return Loss Plot of the antenna.

Figure 3 shows the measured return loss plot of the antenna on the chassis measured in free space. The antenna shows matched bandwidth of 760 – 870 MHz with S11 better than – 7 dB. The return loss at the GPS frequency is – 9 dB, indicating that the antenna is well matched.

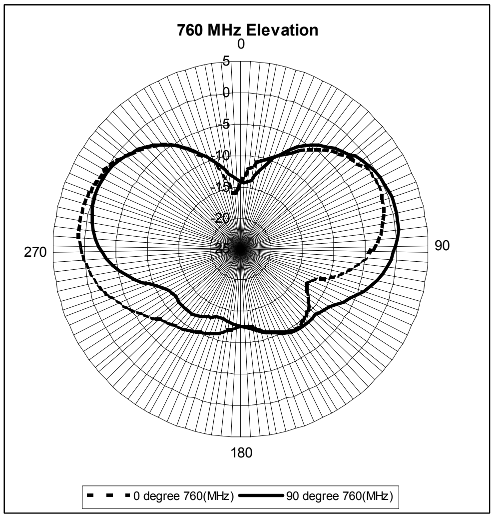

Figure 4. Elevation patterns at 760 MHz.

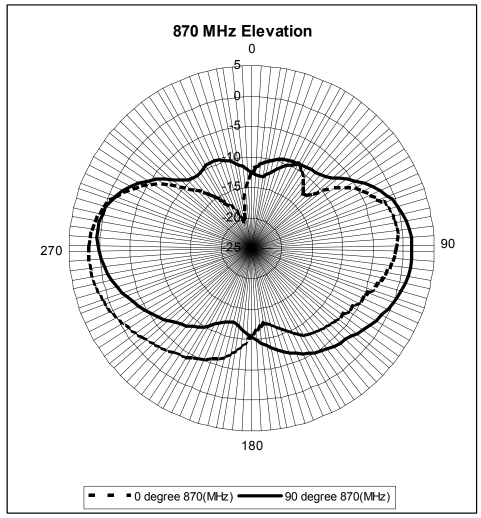

Figure 5. Elevation patterns at 870 MHz.

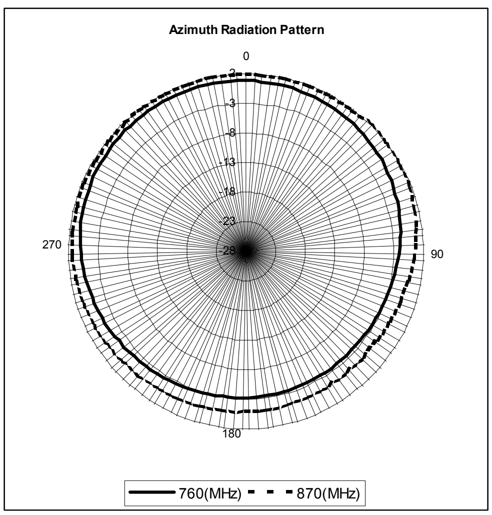

Figure 6. Azimuth patterns for 700/800.

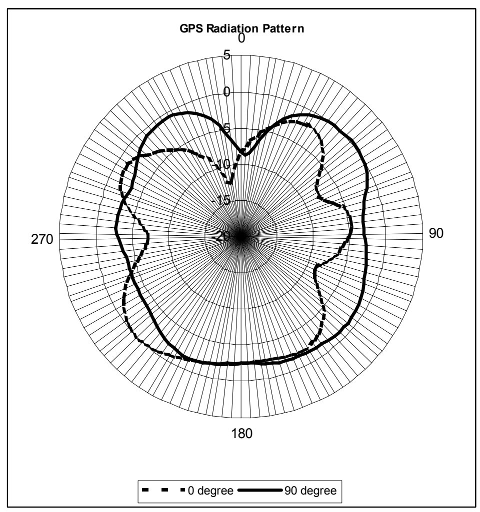

Figure 7. Elevation patterns in GPS band.

The measured elevation radiation pattern plots shown in Figures 4 and 5 indicating good concentration of energy on the Azimuth plane and the radiation is not downward-tilting. The measured gain of the antenna is typically 0 dBi across the band. The Azimuth radiation pattern in Figure 6 shows that the antenna has omni-directional pattern. In terms of efficiency, the measured total efficiency across the 700/800 MHz band is better than 50%, while the GPS band efficiency is better than 40%. The GPS radiation patterns in Figure 7 showed upward pointing radiation characteristics, which a requirement for hand held autonomous GPS antenna [5].

Conclusion

A wide band antenna covering the public safety 700, 800 and GPS bands has been fabricated and measured. Figure 8 shows the completed antennas described. The measured data from the prototype antennas shows that antenna meets the performance criteria of matched band width from 760 MHz to 870 MHz, and the GPS 1575 MHz. The radiation patterns are well concentrated on the Azimuth plane, and upward for the GPS band. With the measured total efficiency of better than 50% in the 700/800 MHz bands and 40% in the GPS 1575MHz, the antenna should provide reasonable Gain and Efficiency performances for commercial applications.

Figure 8. Completed 8 inches whip antenna prototype enclosed in TEXIN 950U sheath.

References

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