6. Concluding Remarks and Recommendations for Future Work

An in-depth analysis of spherical and truncated spherical helical antennas has been carried out. New variations of the spherical helix, particularly the hemispherical helix and the double spherical helix, have been developed and investigated numerically and experimentally. Radiation properties of these two antennas, including far-field patterns, directivity, polarization, and input impedance, have been examined. The numerical analysis of the antennas was performed using the ESP code.

6.1 Summary of Results

The double spherical helix was investigated with the aim of improving the directivity of the spherical helix. An improvement of about 2 dB was achieved. However, this increase in directivity is at the cost of increasing the size of the antenna. In general, the double spherical helix is elliptically polarized. Nearly circular polarization can be achieved over a beamwidth of about 50° but in a narrow bandwidth. A 3 dB axial-ratio bandwidth of 30 MHz has been attained. This antenna provides a directivity of about 11 dB.

The hemispherical helix was studied quite thoroughly. The effects of the number

of turns on radiation characteristics were investigated. It was found that a 4.5 turn hemispherical helix provides an overall best performance, considering the directivity, axial ratio, and input impedance. In general, the shape of the far-field patterns does not vary significantly with the number of turns. When designed to operate at a center frequency of about 2.85 GHz, the 4.5-turn hemispherical helix provide a bandwidth of about 300 MHz (2.65 GHz-2.95 GHz). Over this bandwidth the directivity is more than 9 dB with less than 0.5 dB variations, the axial ratio is less than 3 dB, and the real part of the input impedance is relatively constant. The real part of the input impedance is about 150 ohms. The far-field pattern exhibits a broad main beam and no distinct side lobes. The half-power beamwidth is about 90 degrees, [21].

Compared to a full spherical helix, the hemispherical helix has comparable radiation properties, but also has the advantage of occupying half the volume. This antenna may find useful applications in wireless communication systems with low to medium capacity requirements.

The radiation properties and the geometries of the modified spherical helices compared to those of the conventional helix are summarized in Table 6.1. The data in Table 6.1 shows the optimum antenna properties received from the entire works. It is

Table 6.1 Comparison of antenna properties and geometry parameters of modified helices

	AR bandwidth below 3 dB	Mid band gain	Side lobe level	3 dB beamwidth	Axial Length	Diameter	Volume
Conventional Helix	~500 MHz	>9 dB	~10 dB down	~50^o	2.195 l	0.350 l	0.211 l^3
Double Spherical Helix	~30 MHz	>10 dB	~10 dB down	~35^o	0.500 l	0.318 l	0.027 l^3
Hemispherical Helix	~250 MHz	>9 dB	~20 dB down	~70^o	0.189 l	0.379 l	0.014 l^3

noted that the properties of the double spherical helix in Table 6.1 are of 7-turn spherical helix topped with 4-turn truncated spherical helix. While, the properties of the conventional helix and hemispherical helix are of 9-turn cylindrical helix with the pitch angle of 12.5 degrees and 4.5-turn hemispherical helix, respectively.

6.2 Recommendations for Future Work

There are several areas that further investigation on hemispherical helix is worth pursuing. Other feed mechanisms should be explored. The feed segment is likely to have a significant effect on the input impedance. With the present design, the input impedance has a nonzero (although not large) imaginary part. A feed mechanism resulting in very small imaginary part would be desirable. The measurement of the input impedance and gain should also be considered in further development of the hemispherical helix.

Another interesting aspect is to explore the possibility of multiband operation. The investigation of the hemispherical helix over a larger frequency range indicated that this antenna actually has a rather wide gain bandwidth. Further simulation and experimental studies are required to find out if multiple windows of low axial ratio exist.