On the equation determining current distribution for spherical-type helix antennas

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Electrically small antennas (ESAs) have been analyzed by both analytical and numerical techniques since ESAs play a significant role in modern communication equipment. For instance, a spherical helix antenna (SHA) is regarded as a theoretical model of a typical resonant ESA. SHA can closely reach a theoretical lower limit on the Q factor and radiation efficiency through the radiation of the lowest TM/TE spherical wave [1]. This result is verified by both using numerical simulations and experiments [2]. As indicated in the preceding research on analytical modelling of this antenna [2], the analytical treatment is predicated on the assumption of a sinusoidal distribution of a current along the thin wire.

However, it is crucial to note that merely assuming a sinusoidal current distribution is inadequate for estimating the accurate radiation performance. The accurate evaluation of the current distribution can be achieved through the solution of the boundary value problem concerning both the incident and scattered electromagnetic fields. The employment of a precise solution will facilitate accurate prediction of the radiation performance of SHA, including the resonant frequency, the input impedance, and the operating bandwidth. The radiation mechanism can also be elucidated by investigating how the current distribution changes with antenna miniaturization from a mathematical point of view.

The objective of this research is to present a formulation and solution to the boundary value problem of a thin wire SHA. The equation can relate the current distribution to the incident fields. The solution is obtained by both analytical and numerical methods. The behavior of the solution exhibits slight differences from that of results conducted by conventional numerical methods, such as the Method of Moments (MoM).

The most significant distinction between these results and their conventional counterparts lies in the representation of the solution. In this case, the solution is depicted by means of a series expansion, a method that ensures convergence and elucidates the physical significance of each term. This approach facilitates the analysis of the result by separating the principal term from the perturbation terms.

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2. K. Fujita and K. Noguchi, "Closed-Form Expression of Radiation Characteristics for Electrically Small Spherical Helix Antennas," *IEICE Trans. Commun.*, **E106-B**, 5, pp. May 2023, pp. 459—469, doi: 10.1587/transcom.2022EBP3094.