3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Analysis on Near Field of Spherical Helix Antennas with Vector Spherical Harmonics

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1 Introduction

Electrically small spherical helix antennas (SHA) can be utilized to realize an optimal current on the small spherical surface. Although the theory on the radiation characteristics of a spherical current distribution has been well analyzed by the Vector Spherical Harmonics (VSH), some differences between the performance of the theoretical result and that of a SHA are still remained [1]. The distinction may be explained by an effect from the near-field of higher-order modes of the VSH which was neglected in previous researches focused on the far-field radiation.

In this paper, the electric near-field of SHA which is assumed to have a sinusoidal current distribution is calculated with the VSH including higher-order modes. Computed electric field with the different truncated mode number of the VSH are compared with each other, and the results are validated by using results conducted by the numerical simulator.

2 Near-field calculation by VSH

Near electric fields of the SHA are shown in Fig. 1 with the various truncated mode number $N_r = 1, 3$ and 10. The SHA has the size parameter $\gamma = 0.22$ and the antenna size $R = 0.015$m. Observation points are set to the radius $r = 0.03$m and the plane on $\theta = \pi/2$. The gray solid lines in the figure indicates the numerical result conducted by the method of moments. It can be observed that the results of VSH is converging to the value obtained by the simulator as N_r increases. This result clearly tells us that higher-order modes of the VSH play a significant roll in the near-field region though they have been neglected at the far-field zone.

Focusing on the E_θ and E_φ components at $\varphi = 0$, the error between the value of the numerical simulation and that of VSH are still remain even if $N_t = 10$. The error can be explained by the singularity of the delta-function-like current distribution on the infinitesimally thin wire of the proposed calculation. Thanks to the completeness of the VSH under the appropriate norm in the function space, one may optimistically expect that this error will decrease as $N_r \to \infty$. The rate of convergence and the error estimation for near fields are still uncleared and would be investigated in a mathematical point of view.

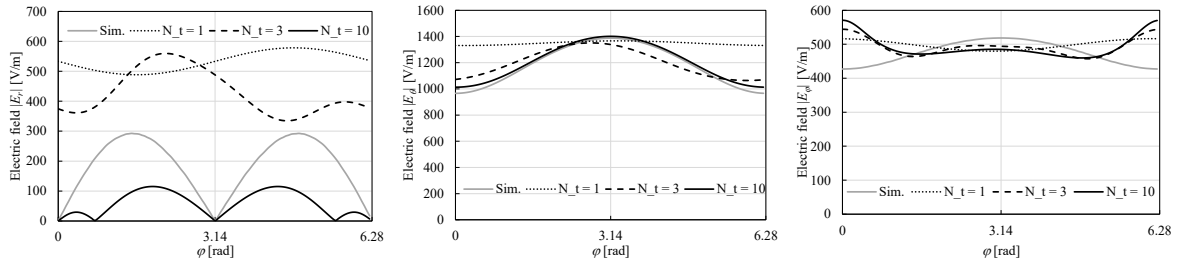

Figure 1. Electric near-field **E** radiated by the SHA in the spherical coordinates (r, θ, φ). The E_r (a), E_θ (b) and E_φ (c) component, respectively.

References

[1] K. Fujita, "Effective Q factor formula for small spherical surface antennas," *IEICE Communications Express*, **9**, 4, Apr. 2020, pp. 111–116.