An Array of Two-port Loop Antennas for Direction of Arrival Estimation

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It has been shown that two orthogonal loops and a reference dipole can accomplish direction finding in the azimuthal plane (M.J. Slater, C.D. Schmitz, M.D. Anderson, D.L. Jones, J.T. Bernhard, "Demonstration of an Electrically Small Antenna Array for UHF Direction-of-Arrival Estimation," IEEE Trans. on Antennas and Propagat., vol. 61, No. 3, March 2013.). Likewise, the dual of this configuration – two orthogonal dipoles and one reference loop – can accomplish the same task. By orienting two sets of these arrangements such that one set accomplishes azimuthal direction of arrival and the other set accomplishes elevation direction of arrival, the entire sphere can be covered. This combination of elements also comprises a three-dimensional vector sensor consisting of three orthogonal loops and three orthogonal dipoles.

In order to reduce the complexity of this design, a reduction in the number of antennas needed to cover the sphere is necessary. A two-port loop antenna can operate in two distinct, orthogonal modes depending on the phases of the excitation of the two sources (R. King, IEEE Trans. Antennas and Propagat., vol. 7, no. 1, 53-61, 1959) – a loop mode when the phases of the two sources are 180 degrees apart and a dipole mode when the phases are the same. By employing the two-port antenna, the number of distinct elements in the array can be reduced by a factor of two. In order to perform direction of arrival estimation, an arrangement of antennas in a direction finding array must produce a diverse set of radiation patterns in order to collect as much information as possible about the incoming signal. It is therefore imperative that arrangements of these two-port loop antennas be investigated to determine the best possible solution. The antenna was modeled in HFSS® and different arrangements of an array of the antenna were evaluated. Factors such as coupling between elements and effects of collocation were investigated in order to determine the optimal arrangement. A further investigation involved the placement of the array in proximity to a ground plane to determine the effects on the performance of the array. Simulation results show that the set of antennas in the optimal configuration – a two-port loop in each orthogonal plane in three-dimensional space – covers the sphere with radiation pattern diversity.