Analysis of Ground Plane Effects for a Multi-Source Loop Antenna

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Antennas arrays and configurations used in direction-of-arrival estimation currently require the use multiple antennas to accomplish the estimation. However, due to the necessity of reducing the size of such arrays for various applications, a reduction in the number of antennas required for estimation is needed. The proposed antenna for this new array is a multi-source loop antenna that can operate in two distinct modes (R. King, IEEE Trans. Antennas and Propagat., vol. 7, no. 1, 53-61, 1959), effectively reducing the number of needed antennas by a factor of two.

A multi-source loop antenna was designed using HFSS®. The antenna consists of a square planar loop interrupted on opposite sides by a balanced source located in the center of the side. The two sources can be excited in phase or out of phase. The mode in which the antenna operates depends upon the relative phases of the excitations of the sources. When the two sources are in phase, the antenna is said to be in the "dipole" mode because of the radiation pattern exhibited by the antenna in this mode. Conversely, when the two sources are out of phase by 180 degrees, the antenna is said to be in the "loop" mode for the same reason.

The antenna was oriented on the XY-plane with the center at the origin and with the sources on the Y-axis, such that each quadrant of the XY-plane contained one quarter of the antenna and that the X and Y axes bisected each side of the antenna. During the design process, simulations were created in which a single ground plane was positioned near the antenna in the XY- , XZ- , or YZ- planes. The effects of the ground plane addition will be the focus of the presentation. The ground plane was square (half-wavelength on each side) and was positioned at varying distances from the antenna. For purposes of construction, the ground plane was modeled as a 16-mil-thick copper plate. The effect of the presence of the ground plane depends on which mode the antenna employed – dipole mode or loop mode.

When the ground plane was located in the XY-plane and positioned along the Z-axis, the radiation pattern while in the dipole mode consisted of a single lobe directed along the positive Z-axis. While in loop mode, the radiation pattern resembled that of a monopole oriented in the positive Z direction. The same result occurred when the ground plane was located in the YZ plane and positioned along the X-axis. However, the two radiation patterns correspond to the opposite modes of the previous ground plane location. When the ground plane was positioned along the Y-axis, each mode produced a single lobe in the positive Y-direction.

As expected, the addition of a half-wavelength ground plane served as a reflector for each configuration and mode of the antenna. This information will be exploited to implement this element in a practical direction-finding array.