Fourier Iteration between Antenna Aperture Plane and Measurement Plane with Limited Data

Sembiam R. Rengarajan* and Ronald J. Pogorzelski
Department of Electrical and Computer Engineering
California State University
Northridge, CA 91330, USA

The Gerchberg-Papoulis (GP) iterative algorithm has been employed successfully in constructing the front half space far-field antenna pattern using truncated planar near field data (Martini et al., IEEE Trans. Antennas Propagat., 56, 11, pp. 3485-3493, 2008). In some applications, there is a need to determine the transfer function of an antenna in the far field main beam peak direction using limited measured data in the Fresnel region. The GP algorithm as implemented by Martini et al. fails to provide the far field value accurately along the main beam peak direction if the near field scan region size is less than the size of the antenna aperture (Rengarajan and Pogorzelski, IEEE APS/USNC-URSI Symposium, 2014).

In this paper, we present the results of an investigation on Fourier iteration between the Fresnel region field in the measurement plane and the antenna aperture plane field. The objective is to determine accurately the far field along the main beam peak direction using as small a size for the measured fields as possible. The iterative method starts with the measured fields in frequency domain from the Fourier transform of the time domain measurements. The plane wave spectral domain fields are obtained using the Fourier transform, which are back-translated to find the plane wave spectrum in the antenna aperture region. The fields in the antenna aperture plane are easily obtained from the inverse transform. The fields are then truncated to the physical aperture of the antenna and then Fourier transformed to obtain a new plane wave spectrum. This spectrum is forward translated to the measurement plane and then inverse transformed to find the fields in the measurement plane. In this set of measurement plane fields, the original measured fields then replace the fields in the original scan plane region. We then iterate between these two planes. Once convergence is reached, the antenna aperture fields and the far field patterns are generated. It has been found that this iterative technique yields accurate far field main beam peak value, even when the measurement scan range size is $1/4^{th}$ the antenna aperture size. The distances between the antenna aperture plane and the measurement plane are in the order of $0.3D^2/\lambda$ to $0.5D^2/\lambda$ where λ is the wavelength at the highest frequency and D is the largest dimension of the antenna aperture.

For an antenna with the main beam at an angle from the broadside, the antenna aperture plane is tilted such that the measurements are carried out around the strongest field values. In this case Fourier iteration has been successfully carried out between tilted planes (Pogorzelski, IEEE Antennas and Wireless Prop. Lett., pp. 25-30, 2005).