Multipath Mitigation in Antenna Pattern Measurements Based on the Singularity Expansion Method

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This paper presents results that push the limits of outdoor/indoor antenna ranges due to multipath from unavoidable adjacent scatterers including buildings, range walls, floors, and ceilings. Based on the singularity expansion method, three different approaches are presented to mitigate multipath in antenna pattern measurements.

The singularity expansion method (SEM, Baum, 1971) offers a general methodology for modeling antennas and evaluating performance. SEM-based antenna models have been successfully used to provide a complete and compact description of antenna characteristics in both frequency and time domains. In essence, SEM describes the response of an antenna as a sum of complex exponentials. In practice, the response can be modeled accurately with a few dominant complex poles due to the band-limited nature of typical sources.

In order to find the complex poles and the corresponding residues in an SEM-based model, various methods can be used, such as a frequency domain search, Prony, and Matrix pencil methods. Among these methods, the Matrix pencil method has been known to be computationally efficient and effective even in the presence of noise (Hua and Sarkar, 1990).

Based on the SEM-based model, the entire time-domain data corresponding to free space data will be restored from time-windowed data that are not contaminated with multipath effects. Initially, the Matrix pencil method was investigated with time gating in order to eliminate the multipath effects and restore the corrupted late time response. The poles were estimated at boresight with a strong signal. However, not all the poles could be observed due to the limited size of the time window. An optimization process may improve the accuracy of the radiation pattern off boresight.

In order to overcome the drawbacks of the previous approach, two new techniques were developed. One is a multi-angle Matrix pencil approach and the other extracts the poles from the reflection coefficients on both the AUT and probe antennas. The effectiveness and usefulness of these new techniques are shown through simulations and measurements.

The developed techniques can be used for challenging far-field measurement ranges having scatterers close to the measurement path. The techniques can also be used to clean up near-field data before the far-field conversion process in near-field ranges.