

Source reconstruction based on a multiple multipole algorithm for antenna characterization using phaseless measurements

K. S. Cujia ⁽¹⁾, A. Fallahi ^(1,2), and N. Kuster ^(1,2)
(1) IT'IS Foundation, 8004 Zurich, Switzerland
(2) Department of Information Technology and Electrical Engineering, ETH Zurich, 8092 Zurich, Switzerland

Accurate electromagnetic (EM) exposure assessments in the near-field of millimeter (mm-)wave transmitters are becoming increasingly important with the expansion of 5G technology. The latest measurement standards [1] demand evaluations on flat surfaces as close as 2 mm from the device or on anatomically complex surfaces. However, these power density (PD) evaluations require complete knowledge about the complex EM fields, leading to burdensome measurement procedures. Therefore, methods for field reconstruction from sparse and phaseless electric (E-)field measurements have attracted attention in recent years. The method recently proposed by S. Pfeifer et al., 2019 [2] demonstrated reliable results with bounded uncertainties of 0.6 dB as close as $\lambda/5$ from the transmitting antennas – yet, the method is limited to flat surfaces and not suitable for shorter distances.

Here, we present a strategy based on a multiple multipole expansion for accurate PD evaluation in all field regions out of sparse phaseless E-field measurements. Instead of using expansions in terms of plane-wave basis vectors [2, 3] or numerically-approximated eigenvectors [4] to express the surface equivalent currents, we construct a physically relevant vectorial basis in terms of pairs of elementary electric or magnetic dipoles. In this way, we are able to obtain current distributions that resemble the physical radiation source and accurately reconstruct the EM field in all radiation regions.

Fig. 1 illustrates the performance of our approach on a set of standard validation devices operating in the mm-wave range. We evaluated the peak spatial-average PD (psPD) and compared it against full-wave simulations. The results show that the estimated values from the (reactive) near field to the far field regions are within the uncertainty budget (0.6 dB). Our approach does not pose any geometric requirements to the measurement or evaluation surfaces and thus supports arbitrary shapes, providing a potential solution for accurate PD evaluation of upcoming 5G devices. Furthermore, the reconstructed sources can be readily integrated into computational tools, enabling measurement-based simulation of mm-wave devices in complex geometries, *e.g.* EM phantoms.

A complete validation including a comprehensive uncertainty budget will be presented.



Figure 1. Uncertainty ε_{tot} on the evaluation of the total psPD for various mm-wave validation sources (color-coded) at different distances *z* (in units of wavelength) from the device. Estimates are obtained using both the plane-to-plane phase-retrieval (PTP-PR) [2] method (left) and our proposed source reconstruction approach (right).

References

- [1] IEC/IEEE, IEC/IEEE 63195 ED1, 2019.
- [2] S. Pfeifer et al., IEEE Transactions on Electromagnetic Compatibility, vol. 61, no. 2, pp. 476–486, 2019.
- [3] S. Pfeifer et al., Applied Sciences, vol. 10, no. 14, 2020.
- [4] B. Fuchs et al., IEEE Transactions on Antennas and Propagation, vol. 67, no. 8, pp. 5673–5677, 2019.