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Fast Method for Exposure Assessment of Beam-Forming Millimeter-Wave Devices

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Exposure assessment of beam-forming millimeter-wave 5G equipment consists primarily in evaluating the maximum averaged power density on surfaces close to the transmitter [1]. This represents a significant technological challenge but is also, increasingly, becoming a requirement for regulatory approval.

Array antennas can typically form beams by a weighted combination of the electromagnetic fields (EMF) radiated by *n* individual antenna elements. The weights are taken from a predefined codebook, representing all possible configurations of the array antenna. The number of beams in commercial devices can be arbitrarily high, as more complex designs tend to have more radiating elements and to allow for more configurations.

In this paper, we provide a complete practical workflow to evaluate the maximum power density that can be achieved by an array antenna on surfaces in the near- or far-field from *n+1* planar measurements, regardless of the size of the codebook or the shape of the evaluation surface.

Power density evaluation requires phasor knowledge about the electric and magnetic fields.
To avoid measuring these quantities in the full volume of interest, this paper presents a method to reconstruct these quantities on any evaluation surface from measurements at very close distances, i.e., at a fraction of the wavelength, from the antenna [2]. This new method is based on field integral equations and electric field measurements with SPEAG's EUmmWVx probe at a distance of 2 mm from the antenna.
The method is evaluated in simulations with emulated measurement data. A successful reconstruction in the near and far-field is achieved both qualitatively and quantitatively. The deviation of reconstruction from simulation reference is less than 0.4 dB for the peak spatial-average power density.

From the measurement data of *n+1* beam configurations and knowledge of the codebook, an optimization-based algorithm determines upper bounds of maximum power density for all configurations. The method uses only EMF of the device under test operating at configurations taken from the actual codebook and does not require absolute reference phase to be preserved between configurations.

In all cases, the algorithm provides a conservative estimate of worst-case power density with limited overestimation. The proposed method therefore provides a practical way to assess compliance of millimeter-wave array antennas with as few as *n+1* planar field measurements and is a valuable step forward for the standardization of RF EMF exposure compliance procedures of 5G devices.

References

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