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Effect of Feed Model on Exposure Assessment for Beamforming Array Antenna

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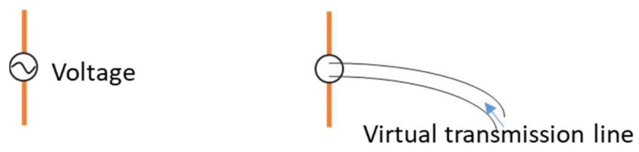
With the advancement of technology, there has been a trend of adopting higher frequencies to achieve larger bandwidths, and hence, higher data transfer rates. In 5G wireless communication, frequency bands beyond 6 GHz have been allocated. Particularly, beamforming techniques, which directs the signal transmission in a concentrated beam created by relative amplitudes and phase shifts to each array antenna elements, will be used to reduce interference from nearby users and to achieve higher data throughput.

The finite-difference time-domain (FDTD) method has been widely adopted for the electromagnetic exposure assessment. There are different types of feed models to excite the antenna in FDTD simulations [1]. Voltage feed (as shown in Fig. 1 a)) has been extensively adopted in dosimetry studies. Transmission-line feed (as shown in Fig. 1 b)) that contains a one-dimensional virtual transmission line attached at the drive gap is another commonly adopted feed model. The excitation is produced by a “one-way injector” located at the end of transmission line. Its advantage is that the reflected voltage can be directly obtained, and it is closer to realistic scenarios for array antennas that each element is excited by a power amplifier.

Previous study has evaluated the dependences of power absorption and temperature rise in body model on the incidence angle of the radiation beam of array antenna at 28 GHz [2]. In that study, the model was place tens of millimeters from the sources to let the beam form. In such cases, the differences between the feed models in the assessment is marginal because the reflection from the biological medium upon the one-voxel feed gap is trivial. However, when the medium is in the reactive near-field region of an antenna, feed modelling may cause deviations in the results, as the rather strong reflection would affect the port impedance as well as the mutual coupling between array elements.



(a) (b)

Figure 1. Two types of the feed models: a) voltage source, b) transmission line.

This study aims at quantifying the effect of feed models on the exposure assessment of the 5G array antenna working at 30 GHz when human body is placed in its reactive near-field region. A 4 × 1 half-wave dipole array antenna was adopted as the source in the simulation. A three-layer human body model consists of skin, fat, and muscle, was placed 2 mm from the antenna center. Two types of feed models, hard voltage feed and transmission line feed, were employed. Different beam angles, i.e., 0°, 15°, 30°, 45° achieved by adjusting the phase shift between adjacent array elements, were considered. The absorbed power density in tissues was first calculated, then the temperature rise was calculated using in-house program solving the stead-state bioheat equation by finite-difference method. Finally, comparisons of the dosimetry results between the two feed models were conducted.

References

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