Study of estimation accuracy of fast SAR measurement systems

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Keywords: Human exposure, specific absorption rate, traditional SAR measurement system, fast SAR measurement system, estimation accuracy, field reconstruction

Abstract:
With wireless devices, the specific absorption rate (SAR), which quantifies the human exposure by electromagnetic waves, is usually measured by a traditional measurement system where a probe measuring amplitude is intensively moved inside the phantom so that the peak spatial-averaged SAR is accurately estimated. However, such measurement process is time consuming considering varied configurations (device position, working mode, etc.) for the full-compliance test and massive production (e.g., mobile phones). Types of fast measurement systems have been developed to overcome this difficulty but estimation discrepancies are observed for different systems. Investigations are made on the estimation discrepancies by simulating the fast measurement system based on techniques of field reconstruction and comparing results from the traditional measurement system and the fast ones.

The electromagnetic exposure draws much public attention due to the wide usage of wireless devices in telecommunication systems. Specific absorption rate (SAR) [1] defined by

$$\mathrm{SAR} = \frac{1}{V}\int_{\mathbb{V}} \frac{|\mathbf{E}(\mathbf{r})|^2\sigma(\mathbf{r})}{\rho(\mathbf{r})} d\mathbf{r}, \tag{1}$$

is used to quantify the spatial-averaged power absorbed by the whole body or tissues. In (1), V is defined as the volume of region $\mathbb{V}$, $|\mathbf{E}(\mathbf{r})|^2$ the root-mean-square of electric field at the position $\mathbf{r}$, and σ, ρ conductivity and density, respectively. While the density is set as $1\mathrm{g/cm}^3$ [2] and the conductivity is obtained from the database [2] in literature, $|\mathbf{E}(\mathbf{r})|$ is measured by a probe, the position of which is controlled by a robot arm. The integral of (1) is computed with numerical methods based on sampled measurements by moving the probe. To reach a certain accuracy, high-density sampling is required and the measurement process becomes time consuming considering tests with different device positions and working modes.

Fast measurement systems have been developed and as an representative, the estimation of SAR based on techniques of field reconstruction is concerned here. Measuring the electric field (amplitude and phase) by vector probes on a plane surface inside the phantom, the electric field at other interested regions is obtained by a field-reconstruction algorithm [3]. Then, (1) is solved based on the reconstructed fields. Benefiting from the high efficiency of the reconstruction algorithm, the measurement speed can have a significant improvement.

Discrepancies are observed on the estimation by different fast measurement systems. However, no literature exists to investigate the reasons. Our contributions lies in simulating different fast measurement systems by applying two field-reconstruction algorithms and investigating the estimation accuracy with analytical functions (thus available reference value). In addition, comparisons between the traditional measurement system and fast ones are presented trying to conclude which measurement methodology is superior. Remark that the study is performed through simulating the concerned measurement systems based on analytical functions which generate the electric field inside the phantom. The uncertainty of the true instruments will not be considered, since no means to get the related parameters due to the security protection and the high complexity of the analysis of the whole system due to many uncertain variables.

References

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