Study of estimation accuracy of fast SAR measurement systems

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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

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

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 1g/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 all the concerned measurement systems are simulated without considering the uncertainty of the true instruments, 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

[1] J. Wiart, *Radio-Frequency Human Exposure Assessment: From Deterministic to Stochastic Methods.* John Wiley & Sons, 2016.

[2] *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz).* International Electrotechnical Commission (IEC), 2016.

[3] *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 3: Vector measurement-based systems (Frequency range of 600 MHz to 6 GHz).* International Electrotechnical Commission (IEC), 2019.