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Comparisons of Absorbed power density and Incident Power Density for EMF exposure in the near-field at 10–90 GHz

*Ming Yao**[(1)], *Kun Li*[(2)], *and Shuai Zhang*[(1)]
(1) The Propagation and Millimeter-Wave Systems Section, Department of Electronic Systems, Aalborg University, 9220 Aalborg, Denmark (e-mail: sz@es.aau.dk)
(2) The Faculty of Engineering and Design, Kagawa University, Takamatsu 761-0396, Japan

Summary

This paper compares the limits of absorbed power density and incident power density, and reveals that incident power density cannot be used for electromagnetic fields exposure assessment in the electromagnetic fields ranging from reactive near-field to radiating near-field.

1 Abstract

The electromagnetic fields (EMF) exposure from user equipment (UE) has attracted much attention as the wireless communication technologies have been developing. Some guidelines, have been published to define the limits of the EMFs from UE to protect human health. The most widely used guidelines, covering the range 100 kHz to 300 GHz, were published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [1]. In ICNIRP guidelines, the metrics for EMF limits named basic restrictions, derived from the associated heating effects with great safety margins, are established to against the associated heating effects on whole-body and localized exposure separately. The basic restrictions for localized exposure are defined in terms of specific absorption rate (SAR) averaged over a mass of 10 g of human tissue below 6 GHz. Above 6 GHz, the absorbed power density (APD) is used as the basic restrictions. Another metrics for EMF limits are named reference level, which is derived from basic restrictions based on the plane-wave scenario.

The reference level above 6 GHz is defined in terms of incident power density (IPD) in free space [1]. To correlate to the associated heating on the human skin surface, APD and IPD should be averaged over an square area of 4 cm^2 for frequencies from 6 to 300 GHz and also averaged over an area of 1 cm^2 for frequencies ranging from 30 to 300 GHz. The limit values of APD and IPD for averaging area of 4 cm^2 are 20 W/m^2 and $55f^{-0.177}$ W/m^2 (f is the frequency in GHz), respectively [1, 2]. while for averaging area of 1 cm^2, the limits of IPD and APD should not exceed twice of the corresponding limits for averaging area of 4 cm^2 neither [1].

Recently, IPD has attracted more interest because it is easier to evaluate than APD within the human tissue. However, as mentioned before, IPD must be used in the reactive near-field because it is derived based on plane-wave scenario. Thus, it is required to study whether IPD can be used for EMF assessment in the near-field. Currently, there are two widely used definitions of IPD, one is the component of IPD vectors that normal to the averaging area, the other definition is the magnitude of IPD vectors. some recent studies provide comparisons of correlation of different IPD expressions with tissue temperature rise when the evaluation distances are close to the antennas, e.g., Some recent studies provide comparisons of correlation of different IPD definitions with tissue temperature rise, e.g., [3–7]. However, the limit values are also important factors that should not be ignored. Thus, in this paper, the exposure ratio (ER), defined as the ratio of peak value to the corresponding limits, are studied for APD and IPD at a close distance from antenna or antenna array for operating frequency at 10, 30 and 90 GHz. The results show that the ER of APD could be larger than IPD, and APD must be used for EMF assessment in the EMF region from reactive near-field to radiating near-field, which is in line with the international EMF exposure guidelines.

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