Novel Approach for Compliance Testing of Wireless Power Transfer Systems with Human Exposure Limits

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The expansion of WPT technology in daily use has raised concerns about the possible health effects of exposure to WPT devices. Indeed, the magnetic fields (MF) generated by powerful wireless power transfer (WPT) systems generally exceed the reference levels (RL) of incident fields in the closest vicinity of the coils and might also violate the basic restrictions (BR) for induced fields. The demonstration of compliance with the BR of WPT systems is so far possible only by numerical methods, which require demanding computational input; however, testing of compliance against RLs leads to large overestimations due to strong field gradients in the vicinity of the sources. This means that more restrictions could be imposed on the performance of WPT devices in terms of emitted power. Within the standardization activities of IEC TC106 WG9, dealing with "Addressing methods for assessment of Wireless Power Transfer (WPT) related to human exposures to electric, magnetic and electromagnetic fields", we have proposed an innovative method for assessing compliance with BRs of WPT generated gradient MFs at frequencies of 3 kHz – 10 MHz. This solution, which reduces the computational cost required to study real localized exposure scenarios and permits conservative estimation of the exposure of any WPT system, consists of translating the measured MF and gradient (G_n) in induced metrics (electric field, current density, specific absorption rate) through suitable coupling transformation functions ($k_{GGSM}(G_n,f)$). In detail, the WPT source is modeled by a generic gradient source model (GGSM) with MF and G_n of equivalent amplitude (in our case, the equivalent source is a 2-line model). The WPT generated gradient MF is mimicked over the whole-body by coupling the GGSM to specific body profiles (frontal, back, lateral, top) with the maximum MF and G_n measured on the body surface, and the MF decay within the body according to the 2-line model. Worst-case exposure scenarios have been found by numerical simulations of different human body models, and coupling transformation functions have been estimated for each induced metric defined in the current guidelines (ICNIRP 1998, 2010, IEEE C95.1 2005, HC Code 6, FCC). The procedure of compliance testing with BR consists of measuring the spatial peak MF amplitude (B_{meas}) and gradient ($G_{n,meas}$) generated by real WPT systems at the closest accessible location. The induced metrics are then estimated analytically for a specific frequency according to formulas, e.g., $E_{peak} = k_{GGSM,E}(G_{ni,meas},f_i)*B_{meas}$. The GGSM approach has been validated by comparison to real WPT systems placed at specific body locations. Our method generally overestimates real exposure >3 dB, but also mitigates overestimation by incident MF assessment in strong field gradients close to WPT systems. Indeed, assessing compliance with BR through the GGSM results in a gain of up to 30 dB in WPT coil currents compared to compliance testing against RL.