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Numerical modeling of SAR in the user's head of protecting wearable IoT device equipped with Bluetooth and Wi- Fi radio module

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Extended Abstract
Internet of Things (IoT) is often used as a concept of a control and measurement network that connects, by wire or wirelessly, devices characterized by an autonomous (not requiring human involvement) operation in the field of obtaining, sharing, processing data or interacting with the environment under the influence of these data, practically in every area of life, economy or science. Example of IoT application is a system warning against approaching vehicles, dedicated for workers using hearing protectors for reducing direct acoustic hazards in the work environment [1]. Such system consist of a specific type of wearable devices that is able to perform Wi-Fi and/or Bluetooth connections. Wearable IoT devices are used in such systems in close proximity to the human body (for example on the headband or attached to the helmet). In such cases, in accordance with international safety guidelines, a SAR compliance assessment is required, even when the incidental electromagnetic field has already been evaluated.

Investigations are covering exposure scenarios modelled with various complexity levels of wearable IoT device (including only a radio module (i) or a radio module and the battery that powers it (ii)). The SAR values were calculated in a multi-layer ellipsoidal model of the human head (involving skin, fat, skull bones and brain layers) [1].

The numerical model of the radio module antenna was validated by laboratory tests of the undisturbed (in free space) reflection coefficient S11 parameter. The results of an experimental validation showed sufficient agreement of the RF module matching frequency (i.e. a centre, resonance, frequency) - with difference of 1.3% between the measurement and simulation results.
In the results of numerical simulations, it was observed that antenna performance drops dramatically when it is located very close to tissues (exposure scenario (i) only 6.1 mW EIRP @ 100 mW of input power to antenna at distance of 2 mm, compared to 95 mW when used at distance of 7 mm). Additionally, SAR10g values obtained for the radio module antenna plane at a distance of 2 mm from the model of the head were twice higher than values obtained at distance of 7 mm.

At a distance of 7 mm between the model of the head and the numerical model of the wearable device with the radio module antenna plane, obtained results for mentioned exposure scenarios (i) and (ii) showed insignificant differences between the obtained maximum SAR10g values (0.2%, higher value at (ii) exposure scenario) and the SAR evaluated as averaged over the entire exposed head values (1%, higher value at (i) exposure scenario).
For an input power to the antenna over 100 mW (95 or 93 mW EIRP in exposure scenario (i) and (ii) respectively), SAR10g values may exceed the limits for the general public (2W/kg), while for an input power to the antenna over 500 mW (475 or 465 mW EIRP in exposure scenario (i) and (ii) respectively), SAR10g values may also exceed the limits for occupational exposure (10W/kg).

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References

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