Human Body Influence on Exposure Measurements

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Abstract

PEM's are typically used for epidemiological studies. It is known that these devices cause a perturbation of EMF exposure levels due to the presence of a human body. This paper analyses the BSE in motion conditions, in indoor enclosures at the 2.4 GHz Wi-Fi frequency. The simulation techniques based on ray-tracing have been carried out and verified experimentally. The cumulative distribution functions show that the E-field levels in indoor conditions follow a log-normal distribution with and without BSE. Thus, the perturbation caused by BSE in PEMs readings cannot be compensated for by correction factors. The mean value is well adjusted, BSE cause changes in the distribution function that would require improvements in measurement protocols and in the design of measuring devices to avoid systematic errors.

Acronyms: Personal Exposure Meters (PEMs), Body Shadowing Effect (BSE), Electromagnetic Fields (EMFs),non-line-of-sight (NLOS), angle of arrival (AoA)

1 Background

PEMs do not allow for the identification of the specific source of radiation within the same band (is this relevant or necessary?). AKA PEMs do not differentiate between exposure from different devices. The intensity of the measured EMF levels depends on: the output power of the device, the transmitted data rate, the number of receivers, the quality of service requirements etc. This study quantifies the presence of the body in indoor and outdoor environments. The influence of the human body is greater in open spaces than in indoor enclosures but is not negligible in indoor environments. It aims to simulate shadowing effect in indoor enclosures, and for movement conditions, by the attenuation of the incident rays on the body that belong to a predefined azimuth angle.

2 Experimental Methods

Theoretical reflections in an enclosed environment were estimated, although real world environments would be far more complex. Furthermore, the body adds complications to the estimates as the rays can be blocker, reflected and absorbed by the body. As well, even if the ray is not blocked by the user, a part of energy can be stopped if the ray is close to the body, although it is theorised that the interaction is localized in proximity to the body, and therefore the waveform recovers after leaving the body. The used PEM's have a noise floor of 0.05 V/m so this value is the lowest measured. The percentage of non-detects was always lower than 25% in the Wi-Fi band. Which is lower than the 60% that would allow for a substitution. Measurements taken and correction factors applied.

3 Conclusions

The measurements of the PEM with the BSE and the simulations in the absence of the body were compared, and the correction factor was approximately 9.3 dB. Solutions offered for mitigating the necessity of the correction factor by using multiple PEMs or using the PEM in the direction of the radiation source. initial experimentation measurements show that the BSE introduces an underestimation in the E-field levels of 2.8 (9 dB) in worst case scenario for PEM in NLOS via the body. Attenuation depends on AoA of the rays that impact the human body. A simulation technique has been proposed for the identification and quantification of the range of rays that are affected by BSE. A shadow angle was introduced as a model parameter to determine if a ray is attenuated or not. This technique shows a acceptable compatibility with the PEM measurements. For indoor environments the shadow angle computation depends on the dimensions of the area being tested. The BSE is more significant in spacious enclosures. In smaller areas the rays scattered by the body arrive at the PEM after reflecting of the nearest walls without much attenuation. This study demonstrates that ignoring the BSE is a systematic error that underestimates the real exposure of humans to non-ionizing radiation in indoor environments.

References

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