On the performance of low-profile antennas for wearable UHF-RFID tags

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Main challenges while designing wearable antennas are related to the fact that the antenna platform, i.e. the human body, is a lossy non-homogeneous material. Also, input impedance, resonant frequency and radiation efficiency of the antenna are very sensitive to the distance of the antenna from the body surface, and such a distance changes randomly during natural body movements. At frequencies larger than a few GHz, it is possible to significantly reduce above coupling effects by using an antenna layout with a metallic ground plane that is large enough in terms of free-space wavelength, yet ensuring the wearer's comfort.

Wearable tag antennas for UHF-RFID (radio frequency identification) systems operating at the 860-960MHz band cannot include a large effective metallic reflector, since it cannot be larger than one free-space wavelength, if the wearable antenna must be unobtrusive and comfortable. To get tag antenna gains larger than 2-4 dB, the most promising solutions (patches, slots, planar inverted-F antennas) exhibit a radiating element whose size is between a quarter of wavelength and a half-wavelength, with a ground plane that is only slightly larger than the radiator itself. It is worth to mention that the RFID tag antenna input impedance has to be conjugate matched to the IC input impedance (different from 50Ω) to ensure an adequate power transfer to the tag microchip, which exhibits an ohmic-capacitive impedance. Since those antennas are not electrically small, they exhibit one or more regions where a maximum of the electric and magnetic energy densities is present. The latter phenomenon does not occur in wearable antennas operating at frequencies lower than a few hundred MHz (which inherently are electrically small antennas), as in the region close to the body (antenna near field region) usually only one of the two energy densities dominates (e.g., magnetic energy density for the loop antenna case).

Since the human tissues are nonmagnetic materials, it is expected that the best performance in terms of the robustness with respect to the antenna-body coupling is exhibited by a class of antennas where the regions with a maximum of the electric energy density are in the central part of the antenna (between the radiating element and the ground plane), while the regions with a maximum of the magnetic energy density are close to the antenna borders. In this paper, the robustness to the body proximity of UHF-RFID wearable antennas is numerically investigated, and then discussed on the basis of the corresponding distributions of electric and magnetic energy densities.

In the past years, several papers have been devoted to the analysis of the general energyabsorption mechanism in the human tissue, for different applications (e.g. tactical military communications at VHF band and personal mobile communications at UHF band). However, they often referred to simple dipole antennas, or just presented numerical results about field distributions and SAR values, without explicitly motivating the robustness of the antenna they proposed with respect the body vicinity. The goal of this paper is to define a systematic approach for the comparison of different antenna layouts, as well as to explain why some configurations perform better than others in terms of body-coupling effect reduction, when above issues are faced through the numerical analysis of the electric and magnetic energy densities around the antenna borders.