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SAR investigation for the cardiac implanted antennas in MedRadio

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Extended Abstract

Nowadays wireless implanted medical devices (WIMDs) are playing a vital role in healthcare applications. They provide substantial improvement in managing disease, improving patients' quality of life, and helping sustain their lives. The Medical Device Radiocommunications Service (MedRadio) (previous specification named as the Medical Implant Communication Service (MICS)) is in the 400 MHz frequency band for the communication needs of diagnostic and therapeutic medical implants and body-worn medical devices [1]. A maximum transmit power of the medical implants EIRP=25 microwatt is designated in order to reduce the risk of interfering with other users of the same band. Devices operating on MedRadio include cardiac pacemakers, defibrillators, neuromuscular stimulators, and drug delivery systems. Since the human body tissues may have a high energy absorption in MedRadio frequency band, it is necessary to comply with the safety guideline of specific absorption rate (SAR) to insure the human safety. Because the implanted MedRadio device has a very small size, the induced SAR would be highly localized so that the local peak SAR will be of most interest. According to the ICNIRP guideline [2], a localized SAR as averaged over any ten-gram tissue should never exceed 2 W/kg for public exposure in the frequency range of 10MHz to 10GHz.

At the cardiac region, the relatively high water-content property of the heart tissues (blood and myocardium) makes its SAR a bit higher compared with the general muscle tissue. In fact, the dielectric permittivity and conductivity values of the overall heart are higher than that of the muscle in the microwave band. Based on our previously developed helix antenna design [3], a compact helix antenna in MedRadio band around 400MHz can be realized inside the cardiac region. SAR values are compared between coated and uncoated helix antenna as well as helix antenna pairs (with spacing distance 5cm). Coated/uncoated half-wave dipole and dipole pairs (with spacing distance 3cm) are also referred to investigate the resulting peak SAR in the heart. Figure 1 and Table 1 show the calculated 10g averaged SAR and its peak. Coating layer lowers the SAR. Uncoated dipole and helix tend to be easily matched since they will act more as kind of lossy-waveguide type of radiator. However, in practice a coating/insulating layer is employed otherwise the current decay on an uncoated metal wire inside human tissue is very rapid. It will result in a low transmission/radiation efficiency in the context of medical communications. Therefore a high reliability communication performance cannot be expected. The SAR value of two very nearby dipoles will be influenced and enhanced compared to the single dipole. This influence will become insignificant with increasing spacing distance between two antennas. It can also be observed from the similar SARs of uncoated single helix and helix pair with spacing 5cm. In a word, compared with the local SAR safety guideline, the human body can be secured with the cardiac implanted antenna. The threshold transmit power can also be estimated corresponding to the 2 W/kg localized averaged SAR limit in MedRadio cardiac implanted device.

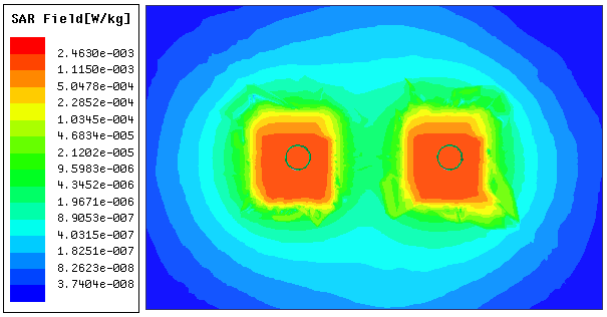

Figure 1. 10g SAR contribution of uncoated helix pair in heart

Table 1. Peak 10g SAR values for the antennas

Antenna	Peak 10g SAR
dipole (coated)	0.22mW/kg
dipole (uncoated)	0.56mW/kg
2 dipole (coated)	0.23mW/kg
2 dipole (uncoated)	1.29mW/kg
helix (uncoated)	2.45mW/kg
2 helix (uncoated)	2.46mW/kg

References

1. https://www.fcc.gov/general/medical-device-radiocommunications-service-medradio.
2. ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)," Health Physics, Vo1.74, pp.494-522, 1998.
3. Q. Wang, D. Plettemeier, C. Andreu, C. García-Pardo, N. Cardona., "Characteristics Comparison of Three Different WCE Implanted Antennas in UWB Low Band," 11th International Conference on Body Area Networks, Turin, Italy, December 2016.