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Imaging Tissue Conductivity via Contactless Measurements: A Feasibility Study

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Abstract: The feasibility of a new imaging system is investigated. This system will be used to image electrical conductivity distribution of biological tissues via contactless measurements. This will be achieved by introducing currents in the conductive medium using time-varying magnetic fields and measuring the magnetic fields of the induced currents. Consequently, the imaging system consists of transmitter and receiver coils placed nearby the conductive body. In this study, the basic features of the coplanar and coaxial coils are studied. The validity of the simplifying assumptions for the governing field equations is investigated. It is found that, for operating frequency of 100 kHz the displacement currents can be ignored, however, the propagation effects become effective for a representative distance of 20 cm. In order to estimate the induced current and the secondary field strengths, the half-space problem is solved for representative coil configurations. The validity of these solutions are also tested with a semi-analytical solution based on conductor-rings model of the half space. For coaxial coil configuration, the maximum induced current density, primary voltage and secondary voltage are obtained as 0.2\times 10^{-4} mA/cm^2, 468 mV and 8.7 μ V, respectively. These results are obtained for 1 turn transmitter coil excited by sinusoidal current having a peak value of 1 A at 50 Khz, and 10000-turn detection coil. Note that the calculated voltages are measureable while the maximum current density induced in the conductive body is much lower than the safety limits (1.6 mA/ cm^2) at that operating frequency. For coplanar coil configuration, the maximum current density increases to 4.9 \times 10^{-4} mA/ cm^2, since the transmitter coil is closer to half space surface. These results ultimately revealed that the signals are in the measurable range while the currents are below the safety limits.

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