# Calculation of Coupling Factor of Prolate Spheroid Exposed to Low-Frequency Magnetic Field

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## 1. Introduction

When human body is exposed to low-frequency magnetic field, the induced current or electric field inside human body can lead to adverse health effects such as stimulation of nerve or muscle tissues. Since induced current density inside human body is difficult to measure, alternative methods have been proposed to assess magnetic field exposure at low-frequency. One of such methods is coupling factor approach that is defined in IEC standards. In IEC 62226-2-1 standard, coupling factor $K$ is defined as [1]:

$$K = \frac{J_{\text{nonuniform}}}{J_{\text{uniform}}} \quad (1)$$

where $J_{\text{nonuniform}}$ is the current density induced by nonuniform magnetic field, and $J_{\text{uniform}}$ is the current density induced by uniform magnetic field. In IEC 62226-2-1 standard, 2D circular disc model is used as an equivalent human model. In this paper, 3D prolate spheroid is used as an equivalent human model, and coupling factors are calculated for exposure to low-frequency magnetic field from circular coils.

## 2. Exposure Scenario by Circular Coil

Fig. 1 shows simplified exposure scenario when human body is located near circular coil. The human body is approximated by simple prolate spheroid, which has conductivity value of 0.2 [S/m], height of 0.8 [m], and width of 0.4 [m]. The frequency of current source is 50 [Hz], and the magnitude of the current is set to make magnetic field of 1.25 [μT] at the closest point on the spheroid as shown in Fig. 1. COMSOL Multiphysics software was used for induced current density calculation, and various values of coil radius $r$ and distance $d$ between coil and spheroid are investigated.

To alleviate the errors from element division of numerical analysis, 99 percentile values of induced current density is used for calculation of $J_{\text{nonuniform}}$ instead of maximum values. The 99 percentile values are extracted from 5 [mm] grid inside the spheroid.

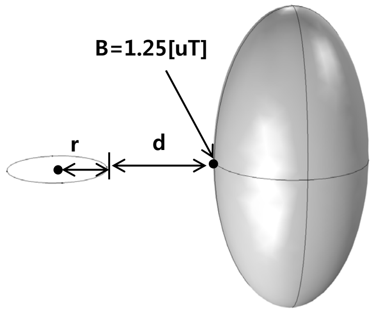


**Fig. 1.** Prolate spheroid model and circular coil.

## 3. Calculation Results

Fig. 2 shows calculated values of coupling factor $K$ according to the distance $d$ and radius $r$ of the coil. In general, $K$ value is increased as radius $r$ of coil and distance $d$ between coil and spheroid is increased. This is due to the fact that the characteristics of the magnetic field at the spheroid follow those of the uniform field as $r$ and $d$ are increased. Within 30 [cm] distance, maximum value of $K$ was less than 0.56, which means that less than 56 % of induced current is generated compared to uniform field exposure. The calculated $K$ values were slightly less than those obtained by 2D disc model in IEC 62226-2-1 standard [1].

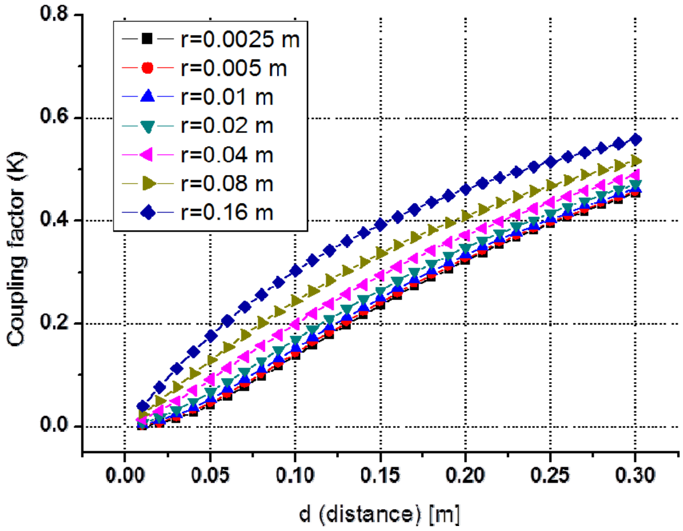


**Fig. 2.** Coupling factor $K$ of prolate spheroid according to radius $r$ and distance $d$.

## 3. Acknowledgment


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## 4. Reference


[1] *Exposure to electric or magnetic fields in the low and intermediate frequency range – Part 2-1: Exposure to magnetic fields – 2D models*, IEC Standard 62226-2-1, 2004.