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# Visualisation of Space-Temporal Configuration of Low Frequency Magnetic Signals

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## Introduction

One new method for magneto-therapy by movement of magnetic wave is used during the last time in medicine. This kind of magneto-therapy can be provided by several pairs of coils, situated on the bed for therapy. Some additional coils situated up the human body can be used, also (Fig. 1) [1–6].

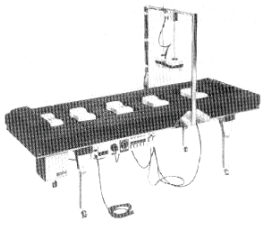


**Fig. 1**. Bed for magnetotherapy

All coils are connected with the outputs of apparatus for magnetotherapy, which can be situated under the bed for magnetotherapy. The movement of magnetic wave can be provided by electronic swiching of different coils. Usually there is a microprocessor is upgrated in the apparatus for magnetotherapy.The swiching of coils can be provided using appropriate software for the microprocessor. It‘s very friendly to be changed parameters of mafnetic fields of different coils by the same software, also. It’s well known[2–6] that for each point around one coil ,the vector of magnetic intensity $\vec{H}$ can be calculated according to Fig. 2 and equations (1) and (2):

$$B_\rho = \frac{\mu_0 i}{2\pi} \frac{z}{\rho\sqrt{(R+\rho)^2+z^2}}\left[\frac{R^2+\rho^2+z^2}{(R-\rho)^2+z^2}L - K\right], \quad (1)$$

$$B_z = \frac{\mu_0 i}{2\pi} \frac{1}{\sqrt{(R+\rho)^2+z^2}}\left[\frac{R^2-\rho^2-z^2}{(R-\rho)^2+z^2}L + K\right], \quad (2)$$

where $B_\rho$ and $B_z$ are the components of magnetic induction; $\mu_0$ is magnetic permeability; $i$ is the electrical current in the coil; $\alpha = \pi + 2\beta$ is a substitution; $K = \int_0^{\pi/2} \frac{d\beta}{\sqrt{1-k^2\sin^2\beta}}$ is an eliptical integral; $L = \int_0^{\pi/2} \sqrt{1-k^2\sin^2\beta}\,.\,d\beta$ is an eliptical integral; $k^2 = \frac{4\rho R}{(R+\rho)^2+z^2}$ is a substitution.

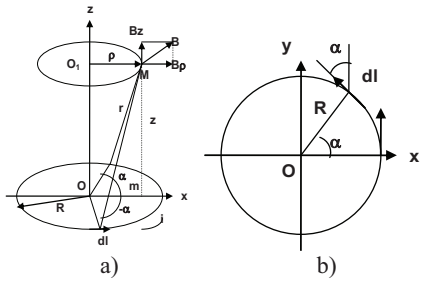


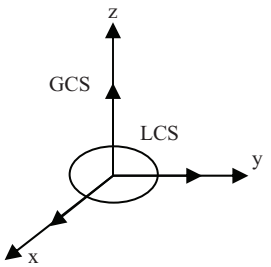

**Fig. 2.** Determination of magnetic induction of magnetic field, created by coil

## Calculation of total magnetic field of two coils in linear environment

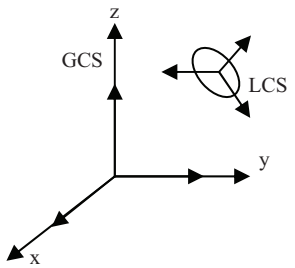
In practice, often using several coils excite a total magnetic field as a result of superposition in a linear environment. Centers and axes of the individual coils do not coincide in general. Therefore each loop (coil) has its own local coordinate system (LCS) (Fig. 3a).

At the time of the creation of contour its local coordinate system is starting, coinciding with the center of the contour and its orientation matches the orientation of the global coordinate system(GCS) (Fig. 3, b). The magnetic induction of magnetic field generated by each electric circuit is calculated in the local coordinate system

of the outline for a set of points which are calculated at the time (on fly) and form a hemisphere. As first step it's necessary to be done transformations of 3D coordinates of every point (for instance point P) from global coordinate system (GCS) to local coordinate systems(LCS) of different coils. In result the coordinates of the same point P will be different (specific) for every local coordinate systems(LCS) or for every coil. For calculation of the value of partial magnetic induction created by every coil in point P can be used equations (1) and (2), taking in account respective local coordinates of point P. The vector of total magnetic induction in point P can be calculated as sum of vectors of partial magnetic induction created by different coils.




a)



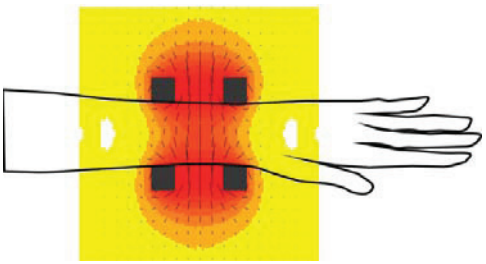

b)

**Fig. 3.** Local and Global coordinate system

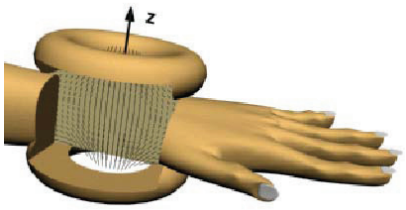
## Experimental results

Some computer simulation of space configuration of magnetic field several coils were obtained during the investigations. The space configuration of total magnetic induction of two coils, which have one axis in the case of magneto-therapy of hand can be seen on Fig. 4 a) and b)

The space configuration of total magnetic induction of two coils, which have different axis in the case of magneto-therapy of knee, can be seen on Fig. 5.



a)




b)

**Fig. 4.** Space configuration of total magnetic induction of two coils, which have one axis in the case of magneto-therapy of hand

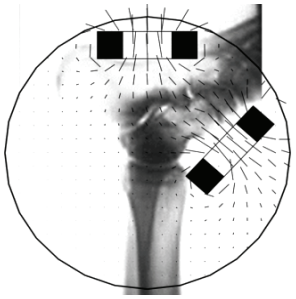


**Fig. 5.** Space configuration of total magnetic induction of two coils, which have different axis in the case of magneto therapy of knee

## Calculation of total magnetic field of several coils in linear environment

The practical application of the above suggested methods for calculation and visualization of spatial configuration of low-frequency magnetic field excited by pairs air coils with one axis and with different axis can be used in the case of investigation of magnetic field of several pair of coils, located on one plane (Fig. 1). Above these coils is located mobile coil that moves so that its center moves in a straight line, which is parallel of line upon which lie the centers of other stationary coils.

Usually excites only one of the fixed coils - one that is closest to the moving coil. Investigations could be pooled and thus obtain as the spatial distribution of magnetic induction module in mode of "movement" magnetic wave, which is ensured by the consistent movement of the movable coil. In this case often there ia a movement of magnetic field in the process of therapy. Usually the movement of mobile coil is discret „step by step". Therefore for the part of positions of mobile coil the axis of this coil is the same as the axis of respective coil which is down on the bed. For the rest position of mobile up situated coil it's axis is not the same as the axis of respective coil which is down on the bed, but the axises of respective pair of coil are at least parallel. On Fig. 6 can be seen images of the spatial distribution of the module of magnetic induction in a plane, which is perpendicular to the plane in which lie the coils and goes through line on which their centers lie.

On Fig. 7 can be seen the location of power lines of low frequency magnetic field to the patient's body in the same perpendicular plane through the axis of the bed.

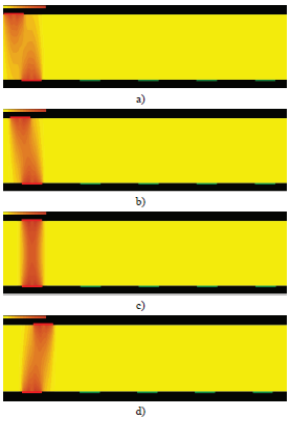


**Fig. 6.** Spatial distribution of module of magnetic induction in a plane, which is perpendicular to the plane in which lie the coils and goes through line on which their centers lie (a–d)

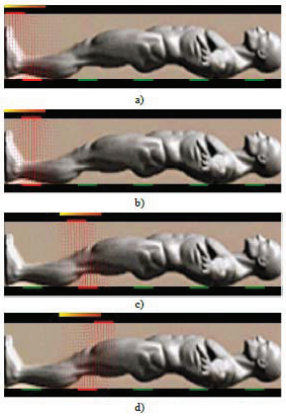


**Fig. 7.** Location of power lines of low frequency magnetic field to the patient's body in the same perpendicular plane through the axis of the bed

## Conclusions

A method for computer visualization of movement of low frequency magnetic field is described in the paper. The visualization is obtained on the base of investigation of space temporal configuration of magnetic field of several pair of coils. The obtained results in the paper can be used in the process of medical therapy.

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**D. Dimitrov, A. Dimitrov. Visualisation of Space-Temporal Configuration of Low Frequency Magnetic Signals // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 3(109). – P. 46–48.**

Some methods for calculation and computer visualization of space configuration of low frequency magnetic field, used in magneto-therapy is described in the paper. The subject of present paper is connected especially with moved magnetic wave. A mathematical method for calculation of magnetic induction in different points in the case of application of several pairs of air coils is done. Some results obtained by computer visualization of space configurations in the cases of one pair of coil and several pairs of coils are done. A computer visualization of space configuration of moved low frequency magnetic field in the case of medical therapy is done on the base of suggested method for investigation. Ill. 7, bibl. 6 (in English; abstracts in English and Lithuanian).

**D. Dimitrov, A. Dimitrov. Žemojo dažnio magnetinių signalų taikymas erdvėje esantiems kūnams vizualizuoti // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 3(109). – P. 46–48.**

Aprašomas žemojo dažnio magnetinių signalų taikymas erdvėje esantiems kūnams vizualizuoti. Analizuojamas magnetinės bangos poslinkis. Pateiktas magnetinės indukcijos keliose erdvės taškų porose apskaičiavimo principas. Kai kurie rezultatai gauti taikant kompiuterinę vizualizaciją su viena ar keliomis ričių poromis. Toks metodas gali būti taikomas medicinoje. Il. 7, bibl. 6 (anglų kalba; santraukos anglų ir lietuvių k.).