INVESTIGATION ON INFLUENCE OF LOW FREQUENCY INTEREFERENCE ELECTRICAL SIGNALS WITH FREQUENCY MODULATION ON CHARGED PARTICLES

Dimiter Tz. Dimitrov*, Petja Petrova, Borislav Tonev*****

Technical University of Sofia, Bulgaria
**Faculty of Communication Technique and Technologies of Technical University-Sofia, ,Kl.Ohridsky 8, 1000 Sofia,Bulgaria*
***Faculty of Computer Sciences of Technical University-Sofia, ,Kl.Ohridsky 8, 1000, Sofia, Bulgaria*
****Medical University of Sofia, Departmet of Physiotherapy, Praga str.40*

Abstract

There are some results about investigations of low frequency electrical currents on the human body. An description of influence and space configuration of two independent low frequency currents on the human body is done in the paper. The main results of investigation are connected with the case when one of the electrical signals is frequency modulated.

1. Introduction

It's well known that the in the case of low frequency electromagnetic field it's possible to investigate the electrical and magnetic field separately [1,2,3]. In this case the vector of current density $\vec{\delta}$ is connected with intensity of electrical field $\vec{E}$ by the electrical conductance of live tissues γ.

$$\vec{\delta}(t) = \gamma \vec{E}(t) \qquad (1)$$

Usually in the live tissues:

$$\gamma(x, y, z, t) \approx const \qquad (2)$$

In this case the space configuration of the current density $\vec{\delta}$ is the same as the space configuration of intensity of electrical field $\vec{E}$ [4,5]. So, it's possible to use the results on investigation of space configuration of intensity of electrical field $\vec{E}$ for investigation of space configuration of of the current density $\vec{\delta}$.

2. Mathematical description

The space disposition of two pairs of patient's conductors can be seen on the fig.1. The two pairs of patient's conductors are connected to two independent low frequency generators of sinusoidal signals with different frequencies ω_1 and ω_2, where:

$$\begin{aligned} &\omega_1(t) = const \wedge \omega_2(t) \neq const \wedge \\ &\wedge \omega_1(t) \neq \omega_2(t) \wedge \omega_1(t) \approx \omega_2(t) \end{aligned} \qquad (3)$$

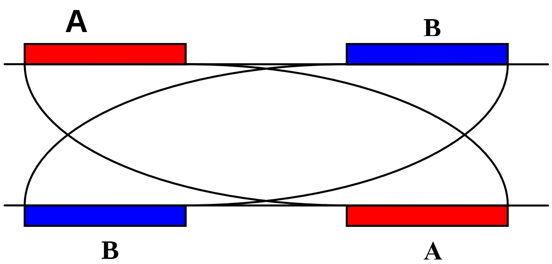

Fig. 1

The conductors A-A are connected with the first generator with the output tension $U_1(t)$ and the conductors B-B are connected with the second generator with output tension $U_2(t)$, where:

$$U_1(t) = U_{1m} \cos \omega_1 t \qquad (4)$$

$$U_2(t) = U_{2m} \cos \omega_2(t) t \qquad (5)$$

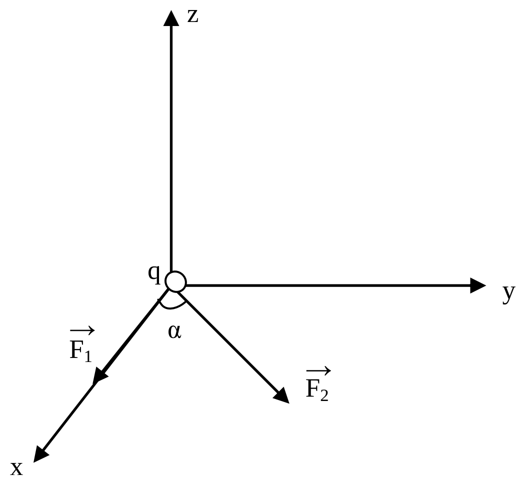

Fig. 2

In every moment and in every point in the space between two pairs of patient's conductors A-A and B-B there is an influence of two independent electrical forces $\vec{F}_1$ and $\vec{F}_2$ on every particle (ion) with mass m and electrical charge q. It would be easy for the next calculation if the ion is in the centre of coordinate system X,Y,Z (fig.2) and one of the forces $\vec{F}_1$ is on the axis X. The angle between two forces is α . It's clear that:

$$\overrightarrow{F_1}(t) = q\vec{E}_1 \cos \omega_1 t \qquad (6)$$

$$\vec{F}_2(t) = q\vec{E}_2 \cos \omega_2 t \qquad (7)$$

According to the main equation of the dynamic and fig.2:

$$\left| \begin{aligned} m\ddot{x} &= \overrightarrow{F_1}(t) + \overrightarrow{F_2}(t)\cos\alpha \\ m\ddot{y} &= \overrightarrow{F_2}(t)\sin\alpha \end{aligned} \right. \qquad (8)$$

The components of velocity of ions on the two axis X and Y are:

$$\left| \begin{aligned} \dot{x} &= \frac{1}{m}\int_0^t (\vec{F}_1(t) + \vec{F}_2(t)\cos\alpha)dt \\ \dot{y} &= \frac{1}{m}\int_0^t \vec{F}_2(t)\sin\alpha dt \end{aligned} \right. \qquad (9)$$

The components of movement of ions on the two axis X and Y are:

$$\left| \begin{aligned} x(t) &= \frac{1}{m}\int_0^t\int_0^t (\left|\vec{F}_1(t)\right| + \left|\vec{F}_2(t)\right|\cos\alpha)dtdt \\ y(t) &= \frac{1}{m}\int_0^t\int_0^t \left|\vec{F}_2(t)\right|\sin\alpha dtdt \end{aligned} \right. \qquad (10)$$

Usually the electrical field between the two pairs of patient's conductors is homogeneity.

$$\vec{E}_1(h,y,z) = const \wedge \vec{E}_2(x,y,z) = const \qquad (11)$$

Therefore in every point in the space between the patient's conductors:

$$E_1(t) = \frac{U_1}{l_1} \wedge E_2(t) = \frac{U_2}{l_2} \qquad (12)$$

where: l_1, l_2 are the respective distance between conductors A-A and B-B (fig.1).

Equations (12) can be put in the equations (6) and (7). Then the equations (6) and (7) can be put in the equations (8):

$$\left| \begin{aligned} \frac{d^2x}{dt^2} &= \frac{q}{m}(\frac{U_1}{l_1}\cos 2\pi f_1 t + \\ &+ \frac{U_2}{l_2}\cos\alpha\cos 2\pi f_2 t) \\ \frac{d^2y}{dt^2} &= \frac{qU_2}{ml_2}\sin\alpha\cos 2\pi f_2 t \end{aligned} \right. \qquad (13)$$

It's clear that an optimization of the components of velocity and movement of ions on the two axis X and Y is possible by optimization of the value of angle α and values of output tensions $U_1(t)$ and $U_2(t)$ of two generators. These components depend to the mass m and electrical charge of ions, according to the equation (9) and (10), also. The ion's current on the axis X and Y can be calculated by equations (14) and (15):

$$i_x(t) = \frac{q^2 s_x}{m}\left(\frac{U_1}{2\pi f_1 l_1}\sin 2\pi f_1 t + \frac{U_2 \cos\alpha}{2\pi f_2 l_2}\sin 2\pi f_2 t\right) \quad (14)$$

$$i_y(t) = \frac{q^2 s_y U_2 \sin\alpha}{2\pi f_2 m l_2}\sin 2\pi f_2 t \quad (15)$$

Where:

f_1 and f_2 are the frequencies of two generators;

s_x and s_y are the sections of ion's flows on the axis X and Y.

The ions of Na^+ and Cl^- are the main kind of ions in the human body. For example the trajectory of ions of Cl^- can.

be seen on fig.3 in the case of following parameters:

$$U_{1m} = 15V, U_{2m} = 30V, \alpha = 45^\circ,$$
$$f_1 = 4000[Hz],\ f_2 = 4000 - 4100[Hz]$$
$$l_1 = l_2 = 0{,}08[m]$$

The output signal of the second generator is frequency modulated and the deviation is: $\Delta f = 100[Hz]$. The dimensions on the axis X and Y are $[m.10^{-2}]$.

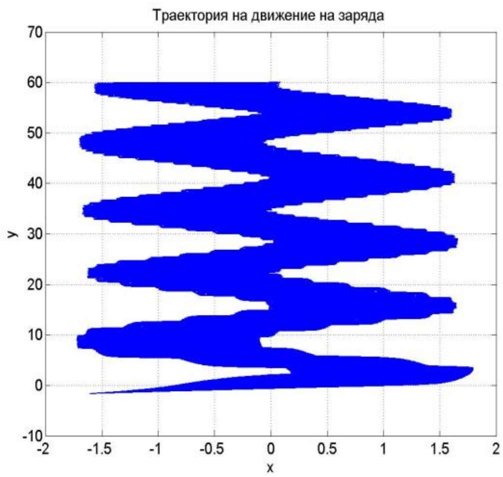

Fig. 3

The moment trajectory of the ions can be seen on fig. 4.

Usually these kind of therapy is used in medicine in physiotherapy for reducing

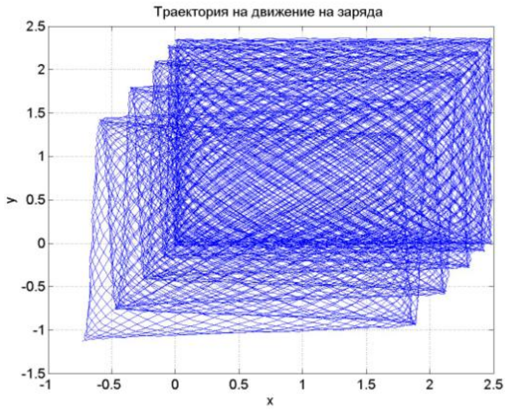

Fig. 4

of pain. An application of this method in the case where the pain is in the foot can be seen on fig.5.

Fig. 5

Conclusion

A mathematical description and computer visualization of movement of ions in the live tissues is described in the paper.

The results of investigations can be used for obtaining of more good effect in the process of therapy with interferent currents.

References

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