SOME BASIC CHALLENGES FOR COURSES ON MEDICAL SYSTEMS FOR THERAPY IN BIOMEDICAL ENGINEERING CURRICULUM IN THE PROCESS OF LIFELONG LEARNING

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Abstract

It's well known that the engineering education on health issues (bioengineering) is one interdisciplinary education. Principally the challenges for medical systems for therapy are a big part of challenges for engineering education on these systems, also. As result, a new methodology for presentation of courses on medical systems for therapy can be created and implemented in bioengineering education in the process of lifelong learning. The courses on medical systems for therapy can include new modules as: computer simulation and investigation of movements of ions in live tissues under influence of external electromagnetic fields in a long frequency band; computer visualization of these movements of ions in 3D; investigation on "internal" electromagnetic signals in live tissues as "reply" of influence of external electromagnetic signals; new interpretation of connection between parameters of movement of ions in live tissues and parameters of "internal" electromagnetic signals; formalization of live tissues as system in theoretical investigations; new explication of some reasons for result of therapy in connection with "internal" electromagnetic signals, etc. On the base of above mentioned investigations, some recommendations for the processes of actualization of bioengineering's curriculums and especially actualization of courses on medical systems for therapy, including new methodology are done at the end of paper.

1. INTRODUCTION

Exposure to electromagnetic fields is not a new phenomenon. However, during the 20th century, environmental exposure to man-made electromagnetic fields has been steadily increasing as growing electricity demand, ever-advancing technologies and changes in social behaviour have created more and more artificial sources. Everyone is exposed to a complex mix of weak electric and magnetic fields, both at home and at work, from the generation and transmission of electricity, domestic appliances and industrial equipment, to telecommunications and broadcasting. Tiny electrical currents exist in the human body due to the chemical reactions that occur as part of the normal bodily functions, even in the absence of external electric fields. For example, nerves relay signals by transmitting electric impulses. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles. Even the heart is electrically active - an activity that your doctor can trace with the help of an electrocardiogram.

2. BASIC CHALLENGES FOR COURSES ON MEDICAL SYSTEMS FOR THERAPY IN BIOMEDICAL ENGINEERING CURRICULUM

Most often systems for low frequency electrical field and systems for low frequency magnetic field are used in physiotherapy. Usually the application of these systems is user friendly and allow to be obtained good effect of therapy. Therefore there is not only permanent engineering development of systems for medical therapy by using of electromagnetic field, but development of medical methods for application of these systems in the cases of more and more disease. Because of that the courses "Medical Systems for Therapy" in biomedical engineering curriculum are one of the basic courses. These courses are very important in the process of lifelong learning also because of permanent development of these systems.

Usually there is only one macro description of phenomena of influence of electromagnetic field on live tissues in the engineering courses on medical systems for therapy by using of electromagnetic field. Often there is not description of connection between parameters of external electromagnetic field and biological phenomena in live tissues under influence of electromagnetic field. Only final effect of therapy is mentioned as result of this influence.

The presentations of lectures are only on the base of engineering skills of students, but not connected with preliminary skills on biology. It's a big disadvantage because these courses are on one interdisciplinary scientific area. In result students have not enough knowledge on connection between parameters of external electromagnetic field, biological phenomena in live tissues and final effect of therapy. This is one restriction when future engineers go to the design and optimization of systems for medical therapy. Often the descriptions of influences of low frequency electrical and magnetic field on the human body in the courses on systems for medical therapy are the next [1,2]: "Low-frequency electric fields influence the human body just as they influence any other material made up of charged particles. When electric fields act on conductive materials, they influence the distribution of electric charges at their surface. They cause current to flow through the body to the ground". Or "Low-frequency magnetic fields induce circulating currents within the human body. The strength of these currents depends on the intensity of the outside magnetic field. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes".

Or"Biological effects are measurable responses to a stimulus or to a change in the environment"t.[3]Or "It is not disputed that electromagnetic fields above certain levels can trigger biological effects. and influence people's well being"[4]. Some members of the public have attributed a diffuse collection of symptoms to low levels of exposure to electromagnetic fields at home. Reported symptoms include headaches, anxiety, suicide and depression, nausea, fatigue and loss of libido. To date, scientific evidence does not support a link between these symptoms and exposure to electromagnetic fields. Finally some keypoints[5] are determined in the courses on medical systems for therapy using electromagnetic field:

- A wide range of environmental influences causes biological effects.
- At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects.
- The main effect of radiofrequency electromagnetic fields is heating of body tissues.
- Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.

It's clear that in the courses on medical systems for therapy it's necessary to be used new methodology. It would be on the description of some processes in live tissues as result of influence of external electromagnetic field. It should be engineering presentation, but it should be on the base of structure and properties of live tissues. In other site this engineering course should be the base for future investigation and design of real medical systems for therapy. Therefore the above mentioned description of processes in live tissues under influence of external electromagnetic field is not appropriate for engineering education. This description is are too yeasty. The described phenomena are not presented as result of movement of ions in live tissues under influence of external electromagnetic field. There is not any mathematical description of processes, which is compulsory for one engineering course.

3. AN ACTUAL PRESENTATION FOR THE COURSES OF BIOENGINEERING ON PROCESSES IN LIVE TISSUES IN THE CASE OF INFLUENCE OF EXTERNAL LOW FREQUENCY ELECTROMAGNETIC FIELD

Often encounter cases where low-frequency electromagnetic field affects the ions in various linear environments including living tissue, also. Always there is a movement of ions because of influence of electromagnetic field. In other site the motion of charged particles (ions) in the volume of research can be seen as electromagnetic signals with a determined space-time configuration in the system. These signals can be seen, also as a reaction of the system. In this sense, the low frequency electric and/or magnetic signals that trigger these movements of charged particles can be considered respectively as formal influence of electric and/or magnetic signals on the system. This part of the physical environment in which there is a a movement of charged particles under the influence of external electric and/or magnetic signals can be viewed as a system. Generally in this case there is a spatial and temporal effects of low frequency electric and/or magnetic signals on the system (especially living tissue).

It's possible to speak about a process of space-time processing of low frequency electric and / or magnetic signals as far as the external impacts on the system cause the system's reaction and the space-time configuration of the "external" low-frequency electric and / or magnetic signals do not coincide with the space-time configuration of the signals considered as system response.. The equations (1), (2) and (3) are known in the references [6,7,8] for the case of disposition of electrical charges $Q(t)$ with linear distribution $q(x)$ on axis X, trajectory of movement $X(t)$ and velocity $V(t)$ of electrical charges. It's possible to be used these equations for obtaining of parameters of system's reaction, respectively, current density $\left|\vec{\delta}(t)\right|$ and current $i(t)$ through surface s in alive tissues and spectral function $\dot{S}_i(\omega)$ of this current.

$$\left|\vec{\delta}(t)\right| = \frac{dQ(t)}{dt} = \frac{d}{dt}\int_0^{X(t)} qdx = q\frac{dX(t)}{dt} = qV(t) \qquad (1)$$

$$i(t) = \int_{(s)} \vec{\delta}(t)d\vec{s} \qquad (2)$$

$$\dot{S}_i(\omega) = qs\int_0^{\infty} \frac{dX(t)}{dt} e^{-j\omega t} dt \qquad (3)$$

Therefore, the determining of components of the velocity $\vec{V}$ of the movement of ions on the three axes X, Y, Z is the first step in the process of determining the response of the system, i.e. determining of the parameters of the "internal" signals. Because of that, the determination of the components of velocity $\vec{V}$ of the movement of ions on the three axes X, Y, Z is an important result in the paper as one result of method for visualization of movement of ions by the action of external low frequency electromagnetic signals. This method and the obtained results would be important for medical therapy.

3.1. Presentation of mathematical model as base of the lecture

The mutual disposition of both independent vectors of electrical intensity $\vec{E}(x,y,z,t)$ and magnetic induction $\vec{B}(x,y,z,t)$ in the case of simultaneously influence of low frequency electrical and magnetic field on the ions can be seen on Fig. 1.

It's assumed that the origin of coordinate system is at the point in which is situated the charged particle. This point can be any point in space, in which act both signals. Below without reducing community of investigations is assumed that the location of the axes of the three dimensional coordinate system is chosen so, that the vector of the magnetic induction $\vec{B}(x,y,z,t)$ coincides with the axis Z. The components of vector of electrical intensity $\vec{E}(x,y,z,t)$ on the axis X, Y, Z of coordinate system are E_x, E_y, E_z. The vector differential equation (4) of movement of ion can be done taking in account Fig. 1.

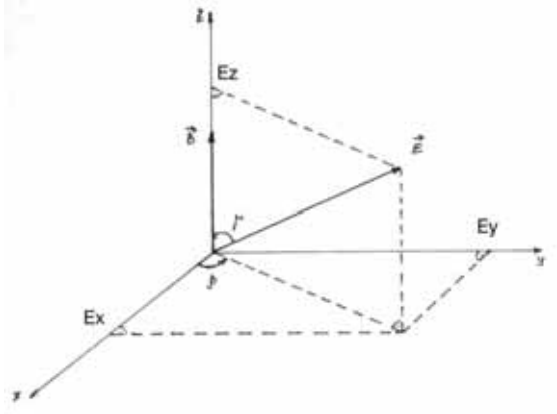


Fig. 1. The mutual disposition of both independent vectors of electrical intensity $\vec{E}(x,y,z,t)$ and magnetic induction $\vec{B}(x,y,z,t)$

$$m\frac{d^2\vec{r}(t)}{dt^2} = q\vec{E}(x,y,z,t) + q[\frac{d\vec{r}(t)}{dt} x\vec{B}(x,y,z,t)] \qquad (4)$$

Where:

m is the masse of ion?
q is the electrical charge of ion;
$\vec{r}$ is tangential trajectory's vector of ion's movement;

3.2. Presentation of Experimental Investigations and Discussion at the end of lecture

It is known that sodium ions Na^+ have a considerable percentage of the composition of living tissue. Therefore the further results are on investigations on movement of sodium ions Na^+ because the effect of different low frequency "external" signals on ions. Therefore, the movements of sodium ions Na^+ under influence of "external" signals with certain parameters are described in the article as examples. Some results of visualization of movement of ions, which have been obtained by computer's methods for solution of differential equation (4) using MATLAB for instance. As example can be presented a simple phenomena in the case of sim-

ultaneously influence on the ions of both simple sinusoidal magnetic signal and permanent electrical field (very often used process of magneto-therapy with ionoforesis) The terms of the influence of "external" signals on magnetic ions are defined by the expression (5).

$$\vec{E}(x,u,z,t) = const \wedge \vec{B}(t) = \vec{B}_m \cos\omega_3 t \wedge \\ \wedge \vec{B}(x,y,z) = const \wedge \omega_3 = const \wedge \beta = 45^\circ \wedge \gamma = 45^\circ \quad (5)$$

Where:

B_m is the amplitude of magnetic induction in any points of homogenous sinusoidal magnetic field;

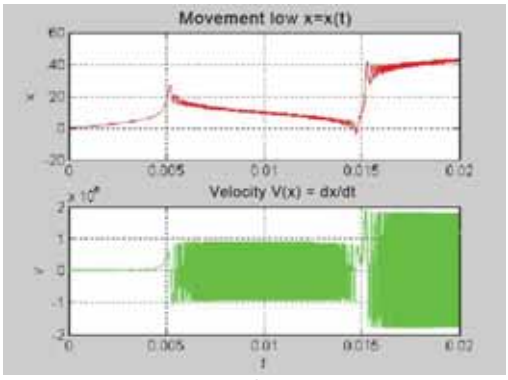
ω_3 is the frequency of the simple magnetic signal

Below the system of differential equations (6) is a modification of differential equation (4) taking in account expression (5).The solutions of system differential equations (6) can be seen on Fig.3. The dimensions for the trajectory of movement of ions are $[m.10^{-1}]$ and the dimension for the velocity of ions is $[m.s^{-1}]$.

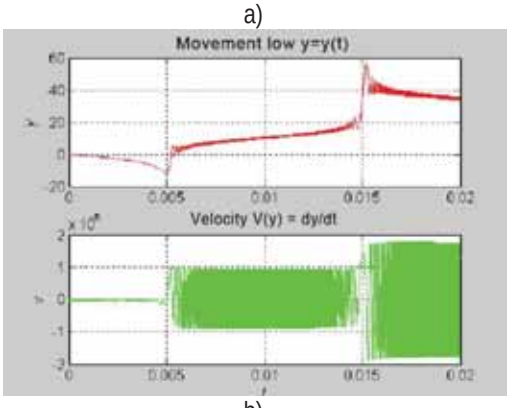
$$m\frac{d^2x(t)}{dt^2} = q[E\sin\gamma\cos\beta + \frac{dy(t)}{dt}B_m\cos\omega_3 t]$$

$$m\frac{d^2y(t)}{dt^2} = q[E\sin\gamma\sin\beta + \frac{dx(t)}{dt}B_m\cos\omega_3 t] \quad (6)$$

$$m\frac{d^2z(t)}{dt^2} = qE\cos\gamma$$



a)



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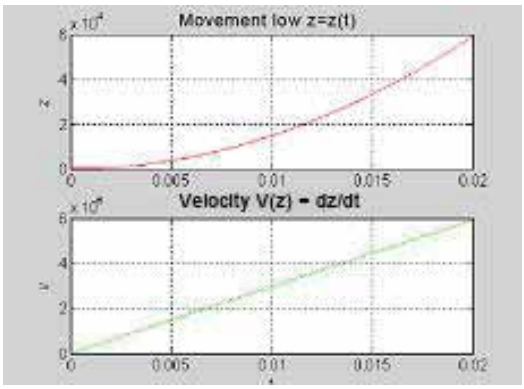
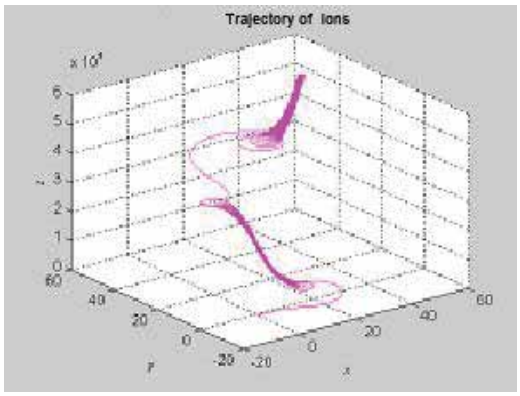


c)



d)

Fig. 2. The solutions of system differential equations (6)

The components of velocity and trajectory of movement of ions on the axis X, Y, Z can be seen on fig. 2a, 2b and 2c.

The second step of presentation of processes in live tissue can be on the base connection between velocities of ions on the axis X, Y, Z (fig. 3a, 3b and 3c) and current density $\left|\vec{\delta}(t)\right|$ and current $i(t)$ through surface s in alive tissues according to equations (1) and (2). It would be one basic and detailed description of the processes in live tissue.

The trajectory of movement of ions can be seen on fig. 3d. This visualisation of trajectory of ions in live tissue is very important because:

- it's connected with movement of determined kind of ions in the case of determined conditions according to equations (5) and (6);
- one optimisation of this trajectory can be obtained by optimisation of parameters of external electromagnetic field. It's important for physician for obtaining of more good and more fast effect of therapy. It's important also for engineer in the process of design of systems for therapy.

On the base of above discussion it would be easy to explain for students the process of magneto-therapy with ionoforesis (Fig. 3), as example for one engineering interpretation in the course on medical systems for therapy.

Fig. 3. Visualisation of process of magneto-therapy with ionoforesis

On the base of discussion and in relation to equations (1) and (2) can be obtained the next important conclusion. The forms of the components of the "internal" signals (reaction of the system) along the three axes X, Y and Z are the same as the shape of the components of the velocity of the ions along the respective axes.. Therefore, the solution of the differential equations (6) practically defines the reaction of system (living tissue).Thus, the description of the process of space-temporal processing of low frequency electric and magnetic signals in linear environments (especially in living tissue) can be obtained solving the system differential equations for the movement of ions.

4. CONCLUSION

A new engineering method for education in the process of lifelong learning about influence of external low frequency electromagnetic signals on alive tissues is described in the article. The external electromagnetic signals are described as influence on one linear system (alive tissues) and the reaction of this system is described through "internal" low frequency electromagnetic signals. According to the equations (1), (2), (3) the reaction("internal" low frequency electromagnetic signals) of system (alive tissues) depends to the velocity of movement of ions under influence of external low frequency electromagnetic field. It's the base for presentation and engineering explanation of process of therapy.

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