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AUTOMATED SYSTEM FOR IRRADIATION OF BIOLOGICALLY ACTIVE POINTS OF THE HUMAN BODY

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Summary. *The automated system for the control of the absorbed energy dose of laser irradiation in the frequency range of modulation is developed and proposed.The possibility of choosing radiation frequencies with the maximum absorption of irradiation of biologically active points, which undoubtedly increases the efficiency of the medical process is provided. The control over the level of optical irradiation absorption during the therapeutic procedure has been achieved, which makes it possible to assess the biological effect and predict irradiation response. The use of amplitude modulation at different absorption frequencies can vary considerably and resonance absorption is possible, and this is what makes the maximum effect of treatment possible.*

Key words*: optical radiation, optoelectronic system, bioobject, biologically active point, feedback, modulation of light flux, radiation source, light therapy device*.

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The statement of the problem. Application of optical signals in the practical medicine has been increased greatly, that is why new and advanced requirements as to the improvement of investigations of the irradiation effect on the human body arise, investigation of propagation of these signals in biologically active points (BAP) in particular. Unfortunately, modern devices and available engineering solutions do not always meet the requirements of the stated tasks, that is, possibility to apply in one device light sources spread in the frequency range; to control the radiation doze and light flux energy absorption, possibility to modulate the light flux by the human body biological rhythm frequencies; to control automatically the device operation regimes using microprocessor equipment and to combine the diagnosis and feedback possibilities, etc.

Analysis of the available investigations. Application of the light therapy (laser therapy) as low intensity laser radiation of different range waves – infrared, visible and ultraviolet in such branches of medicine as orthopaedy and traumatology, dermatology, urology, ophthalmology, stomatology is well known [1]. Light therapy is efficient enough for treatment of different ulcers, erosions and pain points. It is effective for irradiation of biologically active points or parts of human body, which are known as those possessing the conglomerate of very sensitive cells, which have special electrophysical and electromagnetic parameters and properties [2].

The choice of the irradiation signal intensity, radiation frequencies and light flux modulation frequencies is of great importance in the laser therapy technologies. Usually the frequency of the carrying signal is specified by the type of the source (laser) and the modulation frequency can vary considerably from hertz units till kilohertz units. Radiation intensity of low-energy laser radiations (LELR) applied in special laser devices, for the laser therapy of BAP in

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particular, “Ellada 7”, “Orion”, “Mustang”, etc. is according to [3] 1 – 30 mVt/cm^2.

At the same time therapy efficiency depends not on the radiation source intensity itself, but mostly on the adsorbed doze, which is in proportion to the biological effect appearance, but therapeutic devices, which provide measuring of the absorbed doze of the laser radiation, are not available. Usually the doze of the falling signal energy is measured to protect the patient from the harmful effect of the laser radiation (e.g. burns).

In the paper [4] the device, in which the control of the absorption intensity is performed taking the temperature of the patient’s part being irradiated, is described. Disadvantage of this device is, that direct assessment of the absorbed doze intensity and the assessment of the biological effect itself is not possible, as well as low accuracy of measuring due to the double transformation of the light flux intensity, warmth first and then voltage. Besides, the process of measuring is very slow.

The authors [5] propose the device, which makes possible to measure the absorption doze at the fixed modulation frequency, but selection accelerator of commutation frequency, as well as automation elements being not available, decrease greatly the device abilities for its application in the light therapy technologies.

Measuring the absorbed energy intensity is of great importance for modulation of the light flux with the frequencies of the human body biological rhythms (F_{mod} within till 200 hz) and irradiation of the biologically active points during reflexotherapy. The absorption can vary greatly under different frequencies, resonance absorption is possible and the maximum therapy effect is obtained under these frequencies, the modulation types being different, but the amplitude modulation is advantageous [6]. According to the results of experimental investigations the author states, that human body and animal biological active points (BAP) [7], being affected by the electromagnetic signals, demonstrate: biologically active band of the impulse modulation frequency is within 0.1 – 100 hz; maximum sensity for the brain tissues being 6 – 20 hz; low-frequency impulse modulation causes clear biological effects testified experimentally. Modulation provides the possibility of sufficient decrease of the electromagnetic signal level, the efficiency effect being provided.

That is why the introduction of impulse modulation and determination of the modulation frequencies with maximum absorption automatically is of paramount importance for the developers of therapeutic devices and will result in the improvement of the light therapy possibilities.

The Objective of the paper is the development and investigation of the automated system for the light therapy while affecting the biologically active points or parts of human body, in which the control of the absorbed energy doze itself of the laser radiation within the modulation frequency range, can be provided. Besides, the possibility to choose the irradiation frequencies is possible with the maximum absorption of the light flux flow by the biologically active skin part of the patient (BAP), which would contribute to the therapeutic efficiency.

Statement of the task. As it follows from the analysis carried out, it was found that no one of the available light therapy devices does not provide the necessary control of the obtained laser irradiation doze. At the same time the difficulty of providing automation system for irradiating biologically active points of the human body is that unsufficient application of photomedical technologies. That is why there arises the problem of application of new engineering solutions, transformation algorithms and electronic elements. That is why the development of automation system, provided with the possibility to perform low-frequency modulation of the light irradiation flow with simultaneous measuring of the absorbed energy doze, is the urgent task, solution of which is presented in the paper by authors.

The authors have proposed the automated system for irradiating biologically active points or parts of human body taking advantage of the radar irradiation regime, in which the source of light energy is modulated. In the calibration and diagnose regime the measuring of the light flux power is performed, and the measuring detector of the irradiation doze with the commutation-modulation transformation of signals provides precise measuring and the BAP response for the laser irradiation.

Future processing of the results of two-stage measuring and plotting of graphs for BAP absorption depending on the modulation frequency, is performed taking advantage of microcontroller software and PC.

In graph (Fig. 1) operating structural scheme of the automated system for irradiating biologically active points of human body has been presented.

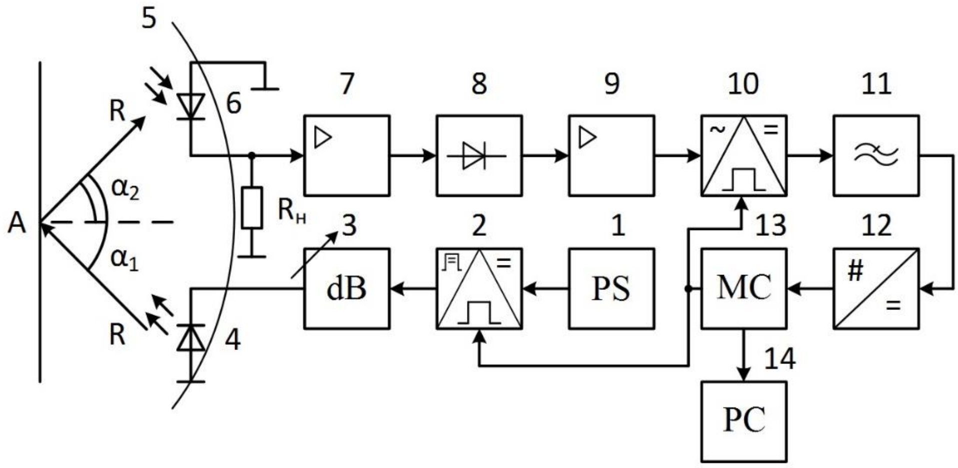

Figure 1. Strucural scheme of the automated system for irridiating BAP

The system includes self-contained supply unit 1, connected in series with modulator 2, attenuator 3 and laser radiator 4, mounted in the reflector 5 at the angle α_1. Irradiation doze receiver contains photodiode 6, mounted at the angle α_2, here $\alpha_1 = \alpha_2$. The photodiode output is connected to the input in series with the connecting amplifier 7 of the quadratic detector 8, modulation frequency amplifier 9, synchronous detector 10 and lower frequency filter 11. LPF exit through ADC 12 in connected with the microcontroller input 13. Controlling output of the microcontroller 13 is connected with the controlling inputs of the modulator 2 and synchronous detector 10, microcontroller output 13 is connected to the PC input 14, and modulation frequency amplifier 9 is of wide-band type.

The proposed system for the light therapy operates in some stages as follows. At first, during the first stage the calibration of the device is performed. With this purpose the mirror, which is ideal reflector, is placed in point A (reflector focus), the distance being chosen in accordance with the irradiation scheme of the chosen BAP. Scanning of the modulation frequency (F) from 0 to 200 Hz is performed with the chosen step from the microcontroller 13 in the “calibration” regime, e.g. ΔF =10 hz. Impulse voltage is transformed from the microcontroller 13 to the modulator 2, which provides periodical modulation of the supply voltage of the laser radiator 4. Reflected light flux from the mirror in the “calibration” regime or from BAP in the “diagnose” regime is received by the photodiode 6 and transformed in the measuring channel of the receiver.

As the result of the commutation-modulation transformation at the output filter of low frequencies 11 of the receiver, in the “calibration” regime for one of frequencies, for example, the voltage is obtained:

$$U_k = S_0 \frac{I_{F1}}{2} R_H \equiv N_{F1}, \qquad (1)$$

where I_{F1} – photocurrent in the loading chain R_H being calibrated at frequency *F1*; S_0 – total conversion ratio of the receiver measuring channel.

At the same time voltage U_k is proportional to the code N_{F1} at the ADC 12 output. At the receiver output for every step of the modulation frequency range constant voltage, which is in proportion to the falling power of laser 4, which is transformed by ADC 12 into the N_i code and registered by PC 14, is obtained.

Natural noises are compensated thanks to the application of the commutation-modulation transformation.

The voltage values for all points (for some chosen value, e.g. 20 measurements) are transformed into codes and registered in the computer 14 as a graph of the signal reflection in the “calibration” regime.

At the second stage the measuring of the absorption doze while irradiating the patient in the microcontroller “diagnose” regime is performed, the skin area (or BAP) here being located in the reflector 5 focus in the distance of the mirror placement.

The measuring of voltage of the reflected signal in the “diagnose” regime for the frequency *F1* and some frequencies is performed similarly

$$U_d = S_0 \frac{I'_{F1}}{2} R_H \equiv N'_{F1}. \qquad (2)$$

With the help of the computer 14 software the measuring of BAP absorption is performed for every step of frequency range, which is determined as the difference of equations (1) and (2), and for the frequency *F1* we obtain:

$$U_{BAP\,\mathrm{Absorption}} = U_k - U_d = \frac{1}{2} S_0 R_н (I_{F1} - I'_{F1}). \qquad (3)$$

From the equation (3) the level of BAP absorption is determined by the difference of the signal intensities in the “calibration” and “diagnose” regime. The equation (3) can be written as the difference od codes, e.g. for frequency *F1*

$$N_{BAP\,\mathrm{Absorption}} = N_{F1} - N'_{F1}. \qquad (4)$$

As a result summarized graph of the BAP absorption ability in the frequency range of the human body biological rhythms is presented on the computer screen or on the paper carrier.

In Fig. 2 one of the options of the output voltage distribution (illustration) of the automatic system during the preparing procedure for treatment, is presented.

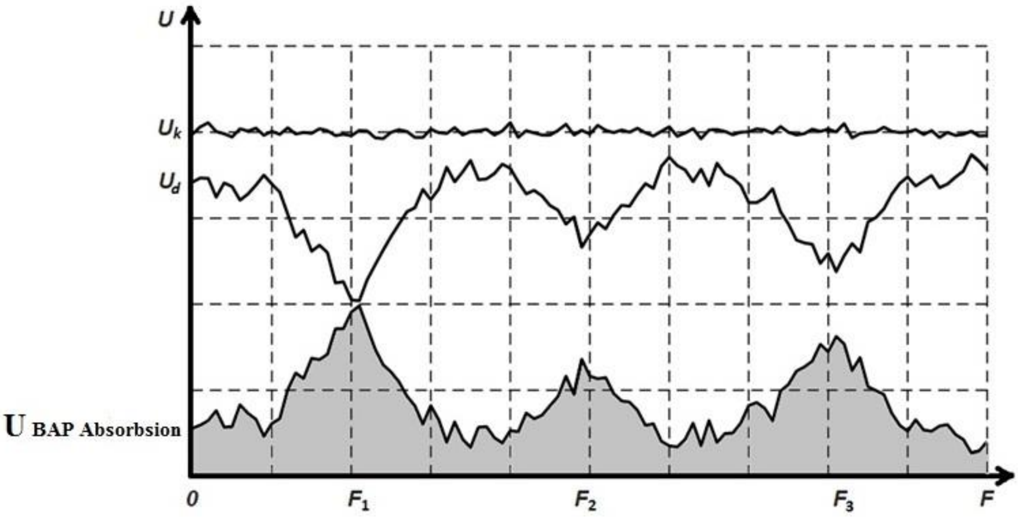

Figure 2. Option of the output voltage distribution of the system during calibration and diagnose depending on the modulation frequency

The upper line specifies the voltage distribution of the calibration U_k at the modulation frequency change, usually within 0-200 hz. This range can be changed (decreased or increased), as well as spread, for example, within the heart rhythm, etc.

The voltage obtained under reflection from the mirror is maximal and is uniformly distributed. The medium line describes the distribution of the output voltage U_d in the diagnose regime. The values of this voltage is a little bit less, than under calibration due to the absorption in the chosen range of the modulation frequencies. But this absorption is not uniform, at frequencies F_1, F_2 and F_3 sharp decrease of the reflectted signal is seen, which is the characteristic of the resonance absorption. Distribution of the absorption voltage $U_{BAP\ abs}$, as the difference $U_k - U_d$, is presented by the lower line and dashed area.

The absorption at all range of moduling frequencies is noticed, but at the resonance frequencies it is increased sufficiently and in the case of question the irradiation prevails at first at frequency F_1, then at F_3, and at last at frequency F_2. It should be noted, that distribution diagrams for every case of treatment and for the chosen point (irradiation area) are original and valid for each patient and chosen BAP.

Frequencies with the maximum absorption of the light flux energy prevail, because biological effect is proportional to the absorbed doze and contribute to the efficiency of the light therapy. Besides, information about the results of measuring of the determined BAP are stored in the computer and can be used for the treatment of a patient during further periods of the light therapy without any additional checking up. The change of the BAP absorption ability data can be treated as the statistic diagnostic parameters under the functional changes in the body of ill people.

Results of the invastigations. Automatic system for the light therapy, proposed by the authors, provides immediate control of the absorption energy doze of the light flux within the modulation frequency range and possibility to choose the modulation frequencies with the maximum (resonance) absorption at the irradiation of the biologically active points, which is sure to raise the efficincy of the treatment procedure. Besised, control over the level of the optical irradiation absorption during the therapeutic procedure makes possible to assess the biological effect and to predict the patient’s response to the irradiation.

Conclusions. Proposed automated system for the light therapy makes easier the process of finding therapeutic parameters, raises its precision and provides the possibility to determine the correlation dependencies between the level of absorption and the light therapy efficiency. Taking advantage of this system the possibility to use dissipated within the range light sources frequencies in one device is provided. The control over the irradiation doze and the light flux energy absorption makes possible to optimise the light source as well.

Modulation of the light flux by the frequencies of the human body biological rhythms due to the automated control of the device operation regimes, using microprocessors equipment together with the diagnose possibilities, can be efficient enough element of the feedback of the therapeutic device and the patient.

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УДК 331.435

АВТОМАТИЗОВАНА СИСТЕМА ДЛЯ ОПРОМІНЕННЯ БІОЛОГІЧНО АКТИВНИХ ТОЧОК ЛЮДСЬКОГО ОРГАНІЗМУ

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Резюме. *Розроблено та запропоновано автоматизовану систему для забезпечення контролю дози поглинутої енергії лазерного опромінення в діапазоні частот модуляції. Забезпечено можливістю вибору частот випромінювання з максимальним поглинанням опромінення біологічно активних точок, що, безперечно, підвищує ефективність проведення лікувального процесу. Досягнено контроль за рівнем поглинання оптичного опромінювання в процесі терапевтичної процедури, що дає можливість для оцінювання біологічного ефекту та створення прогнозів реакції опромінення. Не менш важливим є те, що використання амплітудної модуляції на різних частотах поглинання може значно відрізнятися і можливе резонансне поглинання. Саме це й дозволяє досягти максимального ефекту від лікування.*

Ключові слова: *оптичне випромінювання, оптико-електронна система, біооб'єкт, біологічно активна точка, зворотний зв'язок, модуляція світлового потоку, джерело випромінювання, пристрій світлотерапії.*

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