# COMMUTATION-MODULATION METHOD AND MEANS OF DETERMINING ACUPUNCTURE POINTS

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**Abstract**

*The authors developed an algorithm for measuring noise signals to determine acupuncture points using switching-modulation conversion of information signals. The functional scheme of means (device) concerning realization of the developed algorithm is offered. A characteristic feature of the developed method and the proposed device is the use of the patient's own electrical noise signals, which allows to conduct research without the influence of external electrical signals on the human body. The original algorithm of the device provides high sensitivity and eliminates the influence of temperature and instability of the parameters of the circuit elements on the measurement result, which increases the accuracy of determining the acupuncture points. The original algorithm of the device provides high sensitivity and eliminates the influence of temperature and instability of the parameters of its elements on the measurement result, which increases the accuracy of determining the acupuncture points.*

**Keywords:** commutation-modulation transformation, electropuncture diagnostics, acupuncture points, electrical resistance, thermal noise.

## INTRODUCTION

When conducting microwave, laser, thermal and other types of diagnostic and therapeutic procedures, methods are increasingly used that involve interaction with points of human acupuncture (electropuncture diagnostics, electropuncture therapy, reflexology, etc.) [1, 2] In some cases, electropuncture diagnostics ) provides a fairly high reliability of the results and can be used along with thermographic and ultrasound examinations of patients [3]. One of the problems that arises during ED is to correctly determine the position of acupuncture points (AP) on the human skin. The simplest method of finding AP is to measure the electrical resistance of the skin surface. Electrical measurements in AP confirm the minimum value of electrical resistance in relation to other areas of the skin [4]. At the same time, traditional methods of measuring the electrical resistance of the skin require the passage of electric current through the AP, which can change its parameters, as well as affect the

patient's condition. This is especially true for people who use pacemakers. In addition, the measurement result significantly depends on the temperature and humidity of the skin surface, as well as the amount of current used in the measurements. Therefore, an important task is to develop more accurate and safer for humans methods and means of determining AP. Such methods include radiometric thermometry and switching-modulation conversion of information signals, which in combination provide high sensitivity and accuracy of measuring information signals, and have virtually no effect on the object of measurement [5, 6].

## PHYSICAL FUNDAMENTALS OF THE MEASUREMENT METHOD

Physical and biological bodies (dielectric or quasi-dielectric), including the human body, emit weak noise signals. The power of such radiation is determined by Nyquist's theorem, according to which the mean square (dispersion) of thermal noise voltage is

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proportional to the temperature and resistance of the studied part of the body, on the area of which thermal noise is measured [7]:

$$\overline{U}^2 = 4kT\Delta fR, \qquad (1)$$

where is the Boltzmann constant; - thermodynamic temperature; - frequency band in which thermal noise is measured; - electrical resistance.

At a body temperature of 36° C, the level of human own radiation is very small and comparable to the level of own noise of the receiving equipment. Therefore, it is difficult to receive and analyze such signals. The implementation of such measurement is carried out by two-input (differential) radiometers based on the compensation, correlation, and most often the modulation method [5, 6].

In [8, 9, 10] variants of two-electrode measuring devices are considered, which allow to obtain a voltage value proportional to the square of thermal noise and, accordingly, electrical resistance. The measurements use base and measuring electrodes, which are placed at symmetrical points of the object of study or acupuncture points. A significant limitation in the use of such a device is that you need to know in advance the location of the AP. In addition, the measurement result depends on the temperature of the skin, because by formula (1) the resistance and temperature affect the voltage level of thermal noise equally, and the signal level. removed by the electrodes is very small and comparable to the own noise of the electronic elements of the measuring circuit of the device. As a result, even minor changes in the parameters of the elements of the conversion channel caused by time or temperature instability cause significant errors.

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The authors of this work have developed a functional scheme and proposed an algorithm for its operation, which provides a measurement result independent of changes in the temperature of the studied area of human skin and the instability of the parameters of the electronic elements of the measuring device.

Figure 1 shows the functional scheme of the tool proposed by the authors to determine the points of acupuncture.
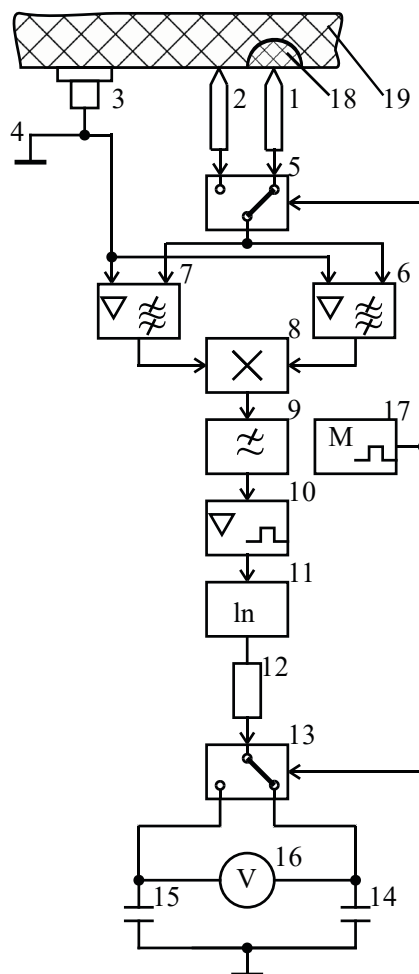


**Fig. 1**. *Functional diagram of the device for finding acupuncture points.*

The device contains the following functional elements: 1, 2 - measuring electrodes; 3 - support electrode; 4 - common ground bus; 5, 13 - controlled switches; 6,7 - band high-frequency amplifiers; 8 - multiplier, 9 - low-pass filter; 10 - video pulse amplifier; 11 - logarithmic converter; 12 - smoothing resistor; 14, 15 - storage capacitors; 16 - voltmeter; 17 - multivibrator. Position 18 in the drawing indicates the area of the acupuncture point, and position 19 - the human skin.

Determining the position of the acupuncture point is as follows. A measuring electrode 1 is placed on the skin of the examined person in the area of the desired acupuncture point. A second measuring electrode 2 is placed outside the AP zone.

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Due to the presence of thermal fluctuations of the elementary charge carriers between the measuring electrode 1 and the reference electrode 3 there is an electrical noise voltage. The greatest contribution to the noise voltage is made by the high-impedance section of the electrical circuit, which is the epidermis.

If we ignore the resistance of the subcutaneous tissues and the resistance of the skin in contact with the support electrode, the mean square of the voltage (dispersion) of thermal noise in this case is determined by the Nyquist formula:

$$\overline{U}_1^2 = 4kT_1\Delta f R_1, \qquad (2)$$

where - the temperature in the area of AP; - electrodermal resistance between electrodes 1 and 3.

By analogy between the measuring electrode 2 and the reference electrode 3 there is an electrical noise voltage:

$$\overline{U}_2^2 = 4kT_2\Delta f R_2, \qquad (3)$$

where - temperature outside the zone AP; - electrodermal resistance between electrodes 2 and 3.

Noise voltages (2) and (3) through the controlled switch 5 are sequentially applied to the potential inputs of the band high-frequency amplifiers 6 and 7. The switching frequency of the controlled switch 5 is set by the multivibrator 17 and selected within 1 kHz. The bandwidth of the amplifiers is chosen in the region of high-frequency thermal fluctuations (0.5…1 MHz). This choice of parameters of the measuring device avoids the influence of signals of man-made origin and low-frequency flicker noise.

Electric noise voltages after amplification are multiplied, and their value, proportional to the product of voltages is averaged by the filter 9 lower frequencies. At the output of the filter, a constant voltage component is formed, the value of which is proportional to the value of the mean square of the measured noise voltage.

At the output of the low-pass filter 9 at different positions of the switch 5 is formed two values of DC voltage:

$$U_3 = K_1^2 S_1 K_2 \overline{U}_1^2, \qquad (4)$$

$$U_4 = K_1^2 S_1 K_2 \overline{U}_2^2, \qquad (5)$$

where is the gain of the band high-frequency amplifiers 6 and 7; - the steepness of the multiplication transformation; - the transfer factor of the filter 9 low frequencies.

By multiplying the output signals of amplifiers 6 and 7, their own noise components are compensated. This is because their own noises are uncorrelated. Therefore, the product of uncorrelated noise signals when averaging is close to zero. That is why in formula (4) and (5) there are no components that are due to the own noise of the amplifiers.

Thus, during the periodic operation of the switch 5, controlled by the pulses of the multivibrator 17, the output of the filter 9 forms a sequence of rectangular video pulses, the value of the amplitude of which is determined by formula (4) and (5). The output signal of the filter after amplification is subjected to logarithmic transformation. As a result, the output of the logarithmic converter 11 at different positions of the switch 5 signals are formed:

$$U_5 = S_2 \ln K_3 U_3, \qquad (6)$$

$$U_6 = S_2 \ln K_3 U_4, \qquad (7)$$

where is the steepness of the logarithmic converter 11, is the gain of the video pulse amplifier 10.

Signals (6) and (7) through the smoothing resistor 12 are fed to the input of the second controlled switch 13. It, like switch 5, is controlled by signals of the multivibrator 17. As a result, during periodic synchronous operation of switches 5 and 13 pulses with amplitude (6) the storage capacitor 14, and the pulses with amplitude (7) - on the storage capacitor 15. There is a separate accumulation of charges by the capacitors 14 and 15.

The smoothing resistor 12 forms with the storage capacitors 14 and 15 integrating circuits, which from the sequence of pulses (6) and (7) emit constant voltage components:

$$U_7 = K_4 U_5 = K_4 S_2 \ln K_3 U_3, \qquad (8)$$

$$U_8 = K_4 U_6 = K_4 S_2 \ln K_3 U_4, \qquad (9)$$

where is the transmission (averaging) of the integrating circuits.

The difference between the DC voltage components (8) and (9) is measured by a voltmeter 16

$$U_9 = U_8 - U_7 = K_4 S_2 \left( \ln K_3 U_4 - \ln K_3 U_3 \right). \ (10)$$

Given that the difference of logarithms is equal to the logarithm of the relation, the formula (10) takes the form

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$$U_9 = K_4 S_2 \ln \frac{U_4}{U_3}. \qquad (11)$$

After substituting in (11) the values of voltage and c (5) and (4), as well as the values of dispersion from (3) and (2), we finally obtain

$$U_{10} = K_4 S_2 \ln \frac{T_2 R_2}{T_1 R_1}. \qquad (12)$$

Since the temperature in the zone AP and the temperature near this zone are almost the same, so we can assume. Then the measured voltage is determined by the formula

$$U_{10} = K_4 S_2 \ln \frac{R_2}{R_1}. \qquad (13)$$

From formula (13) it follows that the measured electric noise voltage is proportional to the logarithm of the ratio of resistances outside the zone AP and in the zone AP.

To determine the position of the AP, you need to move the measuring electrode 1 in the area of the AP at a fixed position of the measuring electrode 2.

The maximum readings of the voltmeter indicate that the measuring electrode 1 is at the point of acupuncture.

## CONCLUSION

1. The commutation - modulation method and means of determining acupuncture points proposed by the authors is based on the use of anomalous values of electrical resistance of the human skin surface in the areas of AP.

2. Internal information fluctuations of electric charges which intensity is proportional to resistance and temperature of the investigated site of a skin of the person are used as information signals.

3. The algorithm for measuring noise signals and their conversion is based on the comparison of signals at the acupuncture point with the adjacent part of the human body and the reference point.

4. The use of the proposed method and means of determining the points of acupuncture provides complete safety when performing diagnostic procedures.

5. The result of determining the location of the AP is not affected by the temperature of the studied area of the skin, the variability of the gain of the measuring channel of the device and the change of the conversion factors of the passive elements.

6. These advantages provide an increase in the accuracy of determining the points of acupuncture and, accordingly, increase the effectiveness of treatment.

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