MEASUREMENTS OF PRESSURE INFLUENCE USING PNEUMATIC MAPPING PROBE

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Received 28 April 2016; accepted 13 May 2016

1. Introduction

Human skin and the human body, in general, are areas for interesting research from physical, medical and electro-technical point of view. Physiological structures of skin determine the electrical skin behavior. Several authors have researched and described the certain specific parts of skin surface - active points of human and animal skin. It is possible to see them clearly by a measurement of voltage map. These parts on the skin's surface are called active points (acupuncture points, ACU-points) and they are known and have been used in acupuncture centuries ago. For many years a number of authors concentrated their efforts to measure them, to describe them and to learn about new properties of them [1]. They are used in different new diagnostic and therapeutic medical devices nowadays and in electro-acupuncture as well [2]. Physiologically the energy channels - meridians are discussed as the flow of electric charges through the extracellular space. Any disturbance or irregularity is guessed to cause deviation from the body's inner balance and appearing diseases. The active points of skin can be shown by the means of electrical measurement. There is significant reduced impedance recognizable in measuring process.

2. Measuring device construction and experimental measurements

The basic control construction element of the designed and realized measuring device is a processor ATmega16. The system uses one serial port, one 10-bit A/D converter and one serial peripheral interface. For the controlled connection of measuring electrodes multiplexers DG406 were used. The device also contains a modified version of a peak detector, the DDS AD9833, the communication with the PC covers the module DLP-USB-232M which serves as a converter of the USB interface to UART . See on Fig.1.

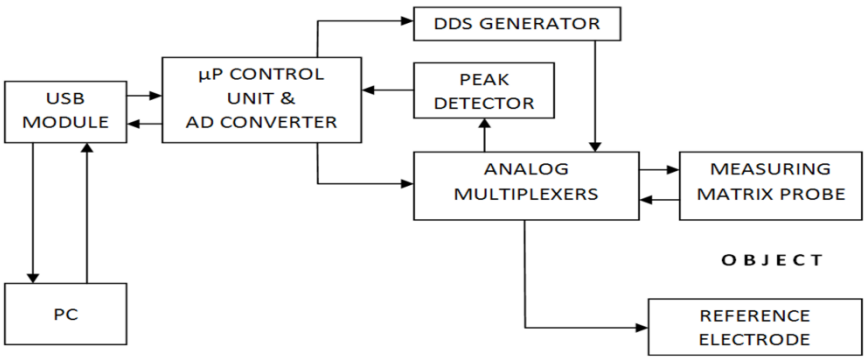

Fig.1. Functional block diagram of measuring device

The skin interaction and surface contact is provided by the electrodes of the measuring probe. All the electrodes measure the change of voltage with regard to a reference electrode [1] - a drop of potential on the skin induced by driving measuring electrical current from generator of the device, flowing through the unknown skin or body impedance. Our measuring device is allowed to apply maximally 5 V driving voltage. As the reference electrode is used an electrode with larger conductive contact area.

Pneumatic Sensing Electrode Probe Construction

There were designed, developed and realized several constructions of non-invasive sensing electrode probe, in our Research Laboratory of Biomechatronics. The whole probe consists of 64 electrodes placed into an 8x8 matrix on an isolative holding construction. Certain areas on human skin have complicated access and during the measurement the non-stable proper contact electrode-skin. Also the problem with skin irritation was remarkable in some complicated skin areas as fingers, ears and parts of face. The pneumatic sensing electrode probe uses pneumatic telescopic electrodes with the complex mechanism and device of pressed air pipe distribution, external controlled air compressor and pressure distributing driving elements [2]. In pneumatic probe are used electrodes with pistons inside and extended contact heads of 0.5 mm tip diameter. The complete look on the whole pneumatic-mechanic-electronic measuring system with pneumatic sensing probe, mechanical holding and driving system and measuring device connected to control computer can be seen on Fig. 2.

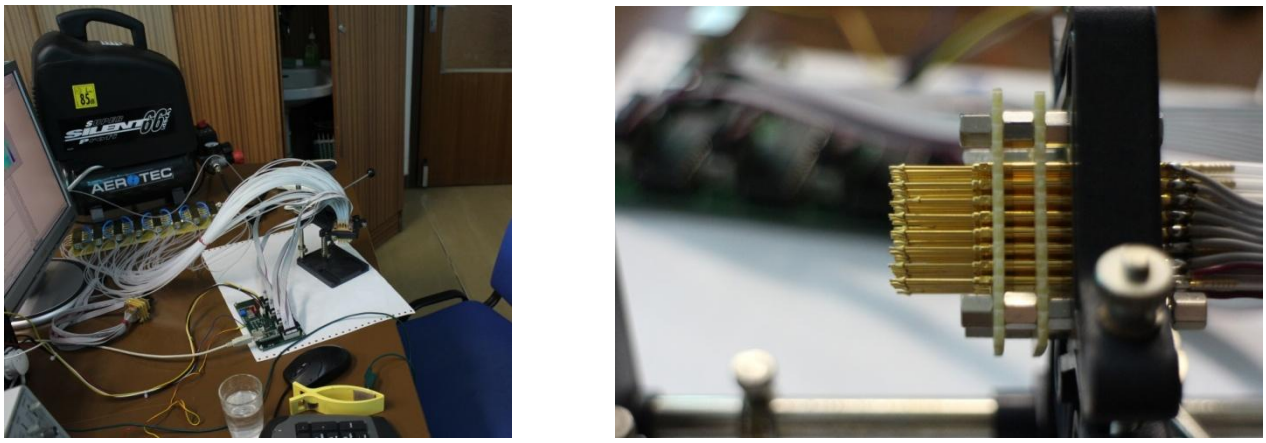

Fig.2. Measuring device with pneumatic sensing probe and its supporting devices (left) and the detail of measuring probe (right).

ACU-points are situated on (or under) flat and good accessible skin areas but specific ACU-points are in difficult accessible parts of human body. We consider a part of skin as difficult for our mapping measurement, when that part is smaller than the dimension of touching part of contact side of measuring probe. Problems are also caused by the uneven skin areas of certain parts on human body, e.g. lateral side of fingers on hand where important active points of several meridians are situated. Performing a mapping skin measurement on the

uneven lateral side of hand finger, the tips of all the electrodes have been pressing on skin by the same lower and comfortable force, because of the same appropriate constant air pressure in system. Air in system is pressing on pistons of all the electrodes and produces the same force pressing on the skin under the electrodes [3], therefore the skin irritation, perspiration and temporary change of quality of electrical contact for all measuring electrodes are the same.

A great number of experimental measurements were performed in our laboratory. There was chosen the representative set of measurements on position (see Fig. 3.), because of the final paper length limitation. A mapping skin measurement has been performed on the lateral side of hand finger.

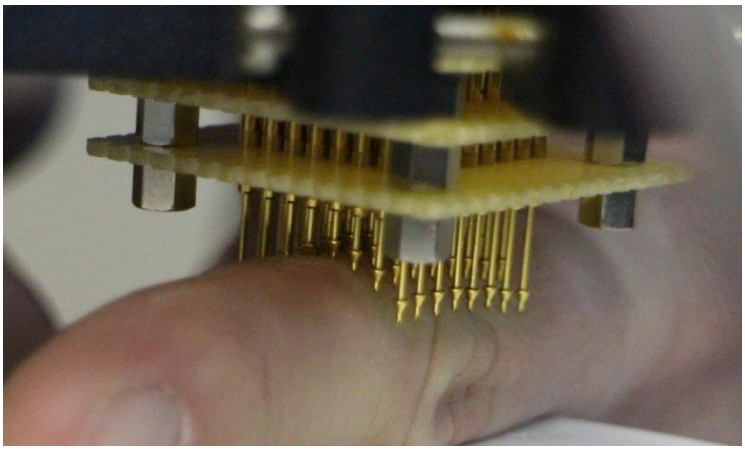

Fig. 3. Electrodes-skin detail of touching area of pneumatic probe

3. Results

Measured graphical results are displayed on voltage-impedance maps below. They contain the blue parts of map which are places on skin with lower measured voltage/impedance drop (ACU-points), yellow or red places are surroundings with higher measured voltage or impedance, the voltage scale bar is situated on the right side of single maps.

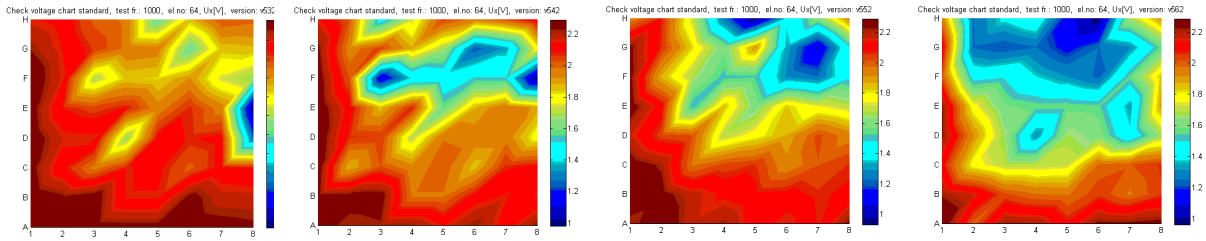

Fig. 4. Voltage map of skin on selected area, measured with driving pressure p_D = 350 kPa (first), p_D = 400 kPa (second), p_D = 450 kPa (third) and p_D = 500 kPa (fourth).

Measured results are stored in tabular and graphical form. Both forms contain values of voltage drops of measured voltage Ux induced by harmonic driving current (I = 1 μA, f = 1 kHz) flowing through the skin. Measured voltage drop is the measure of skin impedance under the measuring electrode. Measured maps of relatively uneven skin area in position of LI2 ACU-point obtained in four steps of driving pressure are shown on Fig. 4. Common consequence and shape relation of them all is apparent. Primarily the force of application the probe in measurement process has been considered. The driving pressure (p_D) of application was varied by choosing the pressure range between 350 kPa and 500 kPa in 50 kPa steps. According to technical point of view the air pressure 400 kPa and higher ejects all the pistons in measuring electrodes (Fig. 2, right and Fig. 3) in correct working position (because of mechanical construction some of them push out with higher driving pressure), then the higher pressure followes by the better transition contact and the lower transition impedance. According to measured human object, the lower pressure causes the higher comfort of measurement and also lower skin irritation. While the maximal voltage drop measured on skin for driving pressure $p_D = 350$ kPa was $Ux_{MAX} = 2.31$ V and $Ux_{MIN} = 1.21$ V, for $p_D = 400$ kPa it was $Ux_{MAX} = 2.29$ V and $Ux_{MIN} = 0.98$ V, for $p_D = 450$ kPa it was $Ux_{MAX} = 2.29$ V and $Ux_{MIN} = 0.93$ V and for the driving pressure $p_D = 500$ kPa it was $Ux_{MAX} = 1.36$ V and $Ux_{MIN} = 0.96$ V. Maximal dynamic range of measurement was obtained with $p_D = 450$ kPa and it was $(Ux_{MAX} - Ux_{MIN}) = (2.29 \text{ V} - 0.93 \text{ V}) = 1.36$ V. Considering all the influences and parameters the optimum pressure for recognition results appears 450 kPa, as the compromise value and because of the higher dynamic range of measurement.

4. Conclusion

The voltage mapping of the skin, unfolding the position and the shape of certain active points on the human skin surface, research and measure of their voltage/impedance maps has a tradition in our Research Laboratory of Biomechatronics at the Institute of Automotive Mechatronics FEI SUT in Bratislava for several years. There has been continuity in this paper with our previous research of various parameters and conditions influencing the process of voltage/impedance map measurements ([2], [3] and more published works and studies). A detailed description of problem and related issues exceeds the capacity of this paper and will be a part of our future prepared incoming publications.

Acknowledgement
This work was financially supported by grant of Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences No. VEGA-1/0987/12 and No. VEGA -1/0823/13.

References

[1] ZHANG C. L. Skin resistance vs. body conductivity: On the background of electronic measurement on skin, In: *Subtle Energies and Energy Medicine* **14** (No.2): 151-174, 2003.

[2] KUKUČKA M., KRAJČUŠKOVÁ Z. Automatized multi-electrode voltage map measurement of active points on skin. In: *Communications: Scientific Letters of the University of Žilina* 13 (No.1) 51-55, 2011.

[3] WEISZE A., KUKUČKA M., KRAJČUŠKOVÁ Z., ĎURAČKOVÁ D., STOPJAKOVÁ V., Advanced sensing method in voltage maps measurement process. In: *Radioelektronika 2015 : Proceedings of 25th international conference. Pardubice, Czech Republic. April 21-22, 2015*. 2015, 364-368.