

**РАЗРАБОТКА КОМПЛЕКСА ДЛЯ ИССЛЕДОВАНИЯ МЕХАНИЧЕСКОГО НАПРЯЖЕНИЯ  
ИЗОЛИРОВАННЫХ ГЛАДКОМЫШЕЧНЫХ СЕГМЕНТОВ СОСУДОВ И ВОЗДУХОНОСНЫХ  
ПУТЕЙ ЖИВОТНЫХ**

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**DEVELOPMENT OF THE DEVICE FOR INVESTIGATION OF MECHANICAL TENSION OF  
ISOLATED SMOOTH MUSCLE VESSEL SEGMENTS AND AIRWAYS OF ANIMALS**

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**Annotation:** For the purpose of testing and the search for new drug compounds, designed to heal many human diseases, it is necessary to investigate the deformation of experimental samples under influence of these drugs. For this task was created a precision force sensor for measuring the mechanical tension, produced by isolated ring segments of blood vessels and airways. The hardware and software system for the study of changes in contractile responses of smooth muscles of the airways and blood vessels of experimental animals was developed.

### **Introduction**

The fundamental mechanisms for regulation of contractile activity of vascular smooth muscle and the airways are currently actively investigated to find new drugs to correct pathological states. The special relevance of the study of contractile activity of smooth muscle is associated with an increase in the number of vascular (hypertension, pulmonary hypertension, atherosclerosis) and airways diseases (bronchial asthma). Smooth muscle hyperactivity is a key mechanism of these diseases and pathological conditions associated with the development of an inflammatory response under the influence the radiation exposure to the organism [1-3]. Reactive oxygen species, generated during irradiation of the body, can induce carcinogenesis and participate in the growth of malignant neoplasm, contribute to the development of diabetes and diseases of the central nervous system, including Parkinson's and Alzheimer's diseases, causing cataracts and some other diseases [3]. Research of contractile activity of smooth muscle in biomedical experiments is not conceivable without the use of high-precision force sensors available that can measure mechanical tension of small diameter bronchus and blood vessels. So, the actual task is to develop a hardware and software system for medical and biological experiments in this field.

### The operating principle of capacitive sensor

Capacitive sensors can directly measure various quantities - motion, chemical composition, electric fields and many other variables, which can be converted into a movement or dielectric constant. The principle of operation of capacitive sensors for measuring mechanical quantities is based on the measurement of displacements. Movement of the two electrodes with respect to a fixed one creates variable capacitor. A capacitive transducer can be easily adapted to measure the force, if it is attached directly to the plate of the capacitor. Because small capacitance changes can be easily measured, such a sensor will be very sensitive. The capacitive sensor consists of two metal plates separated by an air gap. In this case, the capacitance value is determined by

$$C = \varepsilon_0 \varepsilon_r \frac{A}{h} \quad (1)$$

where C - capacity in farads (F),  $\varepsilon_0$  - the dielectric constant of free space,  $\varepsilon_r$  - the dielectric constant of the insulator, A - area of the overlapping of the two plates, h - the width of the gap between the plates.

Theoretically, reducing the amount of clearance can increase the sensitivity of the sensor to high values. However, it is necessary to consider the electrical and mechanical conditions, which limit the maximum sensitivity. One of the major advantages of the capacitive sensor: for move one of the plates a very small value of the force is required. Another advantage is stability and weak influence of the ambient temperature and pressure, as well as high reliability and linear response.

### Development and research of the capacitive force sensor

The block diagram of the device is shown in Fig. 1.

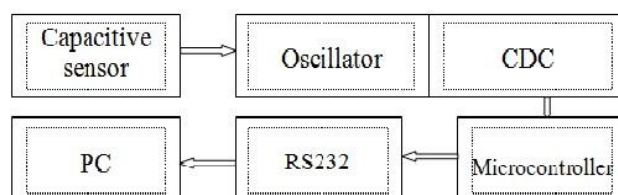


Fig.1 Block diagram of the device

In some applications, the measured capacitance change is sufficiently small compared to a predetermined capacitance. In addition, if instability of the main capacitance is high, it may cause additional problems. In this case, a possible solution would be to use differential capacitance.

To accurately measure the change in capacitance chip AD7745 is used, which is a capacity-digit converter with high resolution. The measured capacitance is connected directly to the input of the chip. The structure includes a 24-bit ADC with 0.01% linearity. Measurement accuracy is  $\pm 4$  fF. However, the maximum measuring range is 17 pF, which can be somewhat extended by using built-in digital-capacity converters. To extend the range of measurements the circuit shown in Fig. 2 is used. In this case, the spreading factor F is the ratio between the output voltage EXCA and EXCB and the attenuated signal at the input of the operational amplifier. Expansion coefficient can be calculated as

$$F = \frac{V_{EXC(A-B)}}{V_{EXCS}} = \frac{R_1 + R_2}{R_1 - R_2} \quad (2)$$

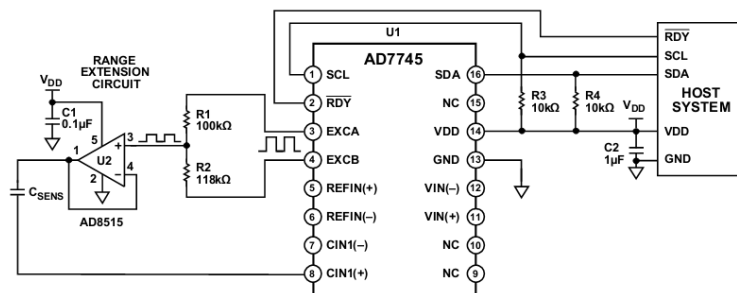


Fig. 2. Diagram the dynamic range [4]

The operational amplifier also serves as a low-impedance source to ensure a full charge capacitance during the measurement.

Calibration of the device was made using weights of a known mass. The capacitance value for each sample was measured. The results of calibration are shown in Fig. 3.

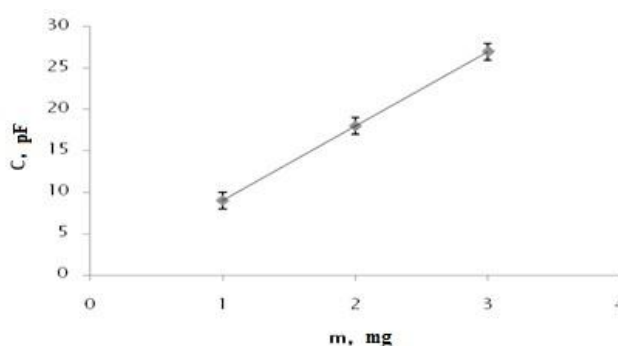


Fig. 3. Calibration curve device

Calibration curve dependence confirms the efficiency of the device. The further test experiments on the blood vessels models are expected.

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