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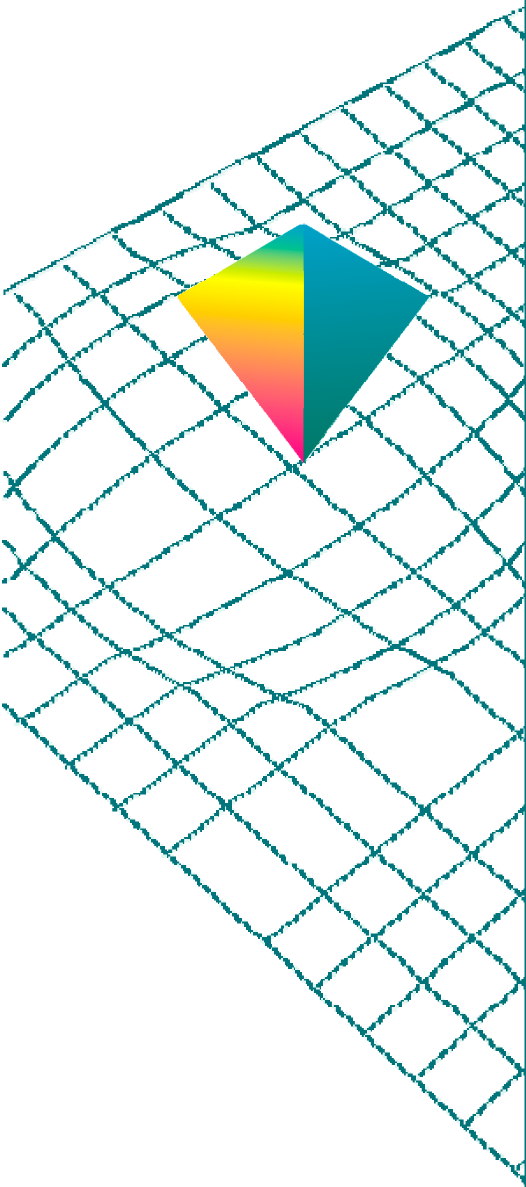

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50. Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
19.-23. September 2005

László Valenta / János Halas / Tibor Szabó / István Bacsó

Position-control of a Pneumatic Muscle by the aim of conductive silicon-rubber

ABSTRACT

In this paper an application of a novel type of displacement sensor and actuator will be demonstrated. The actuator is a so called Pneumatic Muscle by FESTO, which was introduced a few years ago. The displacement sensor is a carbon doted silicon rubber. The doting by carbon makes the silicon rubber electrically conductive; the Department of Mechatronics, Optics and Instrument Technology works on diversified aspects of this material.

THE ELECTRICALLY CONDUCTIVE SILICON RUBBER

If the rough material of the silicon rubber is filled by 10-30 nm sized acetate carbon, after the vulcanization an electrically conductive rubber is reached. The higher the amount of carbon the higher the conductance, and the answer function of elongation is continuous, so the rubber conducts the electricity by tunnel conductance, not by contact conductance. The conductance is temperature dependent and can be calculated as:

$$\rho = \frac{AT}{1-\alpha T} + B \qquad \text{(Eq. 1.)}$$

where A, B and α are empiric constants.

Applying the electrically conductive silicon rubber other special properties can also be utilized. Such properties are the easy and safety manufacturing, the large range of thermal usage, the excellent environmental resistance and the hard water-repellent.

THE PNEUMATIC MUSCLE

The contracting cylinder (Fig. 2.) – can be called to pneumatic muscle – works like the human muscle. That is a type of membrane contracting cylinder which has two main elements. One of them is a tube which is made of a relatively soft, leak-free gasket material. The other is a net which contains fibers in rhomboid shape. These fibers do not change their geometry. The net gives the strength to the cylinder and wears the mechanical stress. In the cylinder – like in every cylindrical body – radial and axial forces arrive due to the inertial pressure. In the case of the Pneumatic Muscle the net establishment is designed to take all the forces. When the system gets to be under pressure the shape of the net changes, the length of the tube will be smaller and the diameter will be larger, and the tube will produce an axial pulling force. This pulling force can be affected by the pressure .

Fig. 2. The Pneumatic Muscle

THE SCHEMATIC OF A DEMONSTRATION DEVICE

Using the conductive rubber like a strain gauge the resistance changing is measured due to the pulling force. After the digitalization of the measured voltage – dependent to the resistance of the rubber – a digital proportional control is realized by a microcontroller and a personal computer independently.

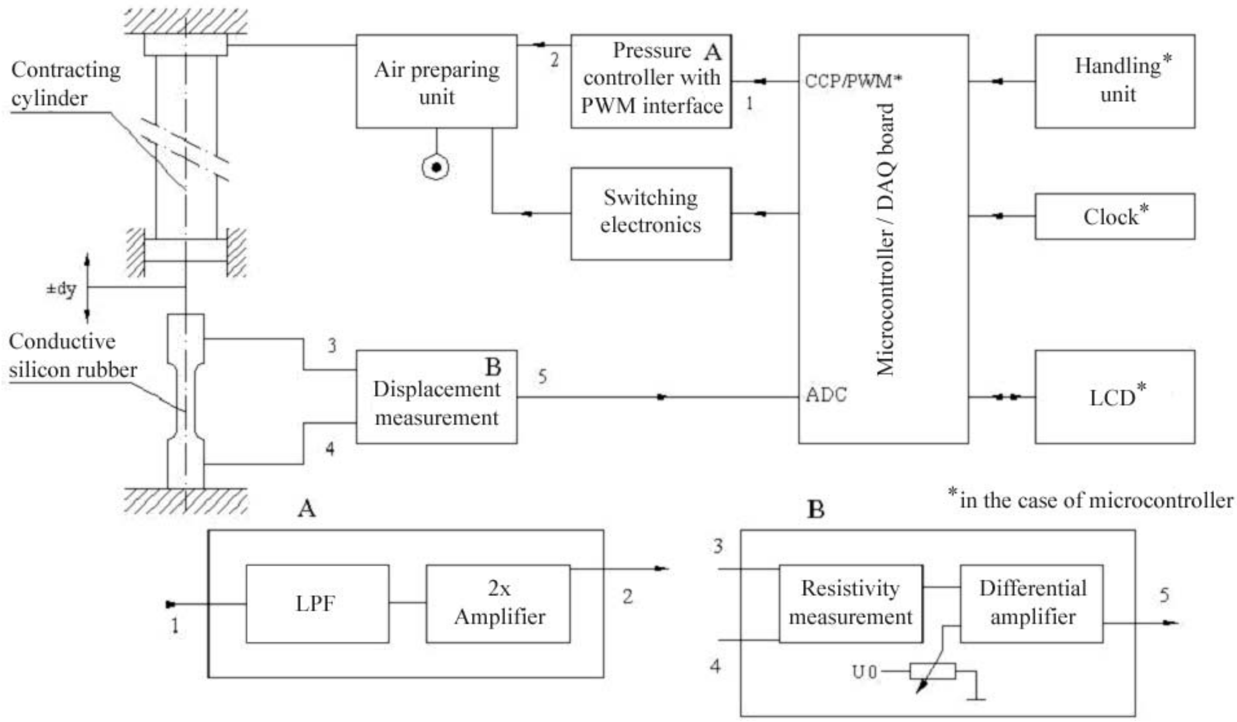

Fig. 3. Schematic of the demo equipment

The microcontroller or PC controls the applied pressure by an electrical valve. The Pneumatic Muscle is initially loaded by a known weight, and there is a possibility to set up a reference value – independently to the stress relaxation – by a helical potentiometer.

THE CONTROL CIRCUIT

In the control circuit the microcontroller or PC reads the rubber's resistance dependent voltage on its analogous input through an interface circuit. The control rutin calculates an appropriate driving voltage for the required position of the cylinder. This voltage is amplified and used to control the valve to produce the appropriate pressure.

The first task was to measure the resistivity change of the rubber. To measure the resistivity change a simple circuit was used (Fig. 4.). The output of this circuit is linearly dependent to the resistivity of the rubber band. This analogous voltage is read on the analogous input of the controller.

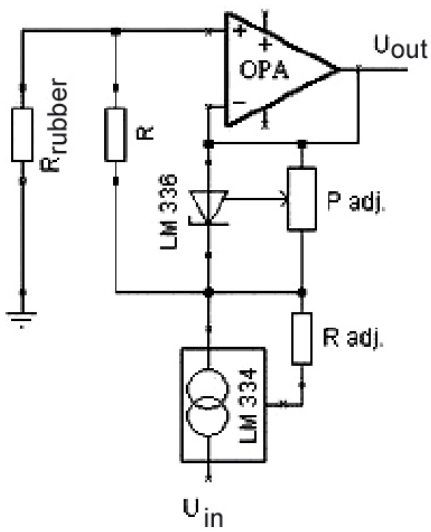

Fig. 4. Measuring the resistivity

The output of the controller is a PWM sign, which is filtered by a low pass filter and amplified to drive the electric valve.

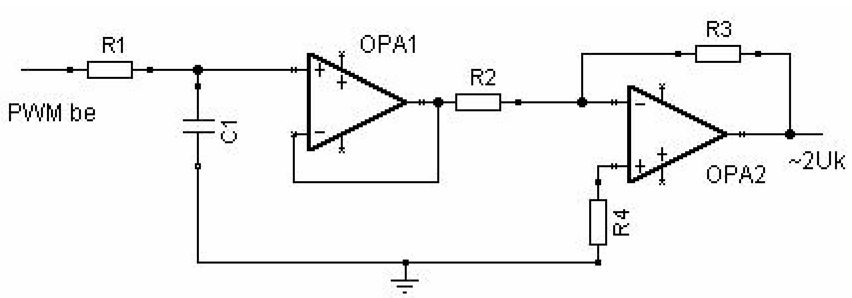

Fig. 5. Filtering the PWM sign

THE CONTROL SOFTWARE

The control of the Pneumatic Muscle was solved by a microcontroller and a PC too. The above circuits were used in both cases.

In the case of the microcontroller certainly additional electronics are needed, but the equipment is more mobile. The user can set the required position up by the am of switches and an LCD display. The control circuit is based on a PIC microcontroller from Microchip.

The PC has several advantages, like a possibility of a more difficult control method and a more demonstrative user interface. The control software was written in National Instrument's LabVIEW software.

CONCLUSION

A novel application of electrically conductive silicon rubber has been worked out at our department. At the beginning of usage this material we had to make a lot of measurements to know the material properties. We have reached that state when we know enough to build up a demonstrative equipment which was introduced in this paper.

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