The Basic Principles of Capacitive Blood Pressure Measurement Method and Wireless Data Transmission

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ABSTRACT

Investigation on the use of capacitive pressure sensor chip model to demonstrate the measurement of changes in the length of the signal due to changes in the simulated pressure. Implement wireless transmission of power in order to demonstrate the miniature pressure measurement implant possibility further manufacturing.

KEYWORDS

Sensor, RF power, wireless data.

1 INTRODUCTION

Arterial hypertension – a widespread condition, which is recorded in 30–40% of the population according to various authors. Furthermore, according to current projections, these numbers will increase and by 2025 the number of people with the disease will reach 1.6 billion persons[1,2,3]. It is known that the arterial hypertension – one of the most common modifiable risk factors for cardiovascular disease and worldwide mortality[4,5,6,7]. That is why currently takes measures for the early detection of high blood pressure, onset hypertension preventing, risk factors reduce its developments. For which active new treatments developing the mechanisms of action, anti hypertensive drugs action is study, diagnostics and the patients tactics improving. All these activities are ultimately aimed at the prevention of cardiovascular complications and increase life expectancy.

The most common in clinical practice is the Millar’s pressure-volume (PV) loop catheters. Millar’s catheter is a disposable pressure catheter that delivers accurate and reliable hemodynamics data from within the heart and vascular system. This type of sensor monitoring system involves invasive catheter type. For example, to implement the control of blood pressure using an optical method to use an external optical signal transceiver unit for registering changes in the pressure parameters in real time. Furthermore, the optical signal must pass through a catheter-type waveguide in this case[8]. Membrane sensors are fluid-filled catheter-type, inferior optic sensors in terms of functionality and reliability. However, all kinds of catheter-type sensors have a number of disadvantages: patient position measurement accuracy dependence, use only in a hospital, and others. Thus, the most promising invasive sensors for blood pressure control and comply with the lack of catheterization are solid state sensors, based on the conversion of mechanical energy (pressure) into electrical energy.

As a device for monitoring blood pressure may serve a capacitive pressure sensor on a chip implanted in the bloodstream. This chip represents resonant circuit consisting of an oscillator with the pressure sensitive element (flexible capacitor). Capacity of the blood pressure sensor is a function of the ambient pressure (in which is a pressure sensor). The chip may be connected with a radio-transmitter device and the circuit resonant frequency can be measured remotely and on the basis of transmitted data, one can
conclude on the patient’s blood pressure status. The following is a technical solution and the basic principles of pressure measurement with its use.

2 MATERIALS AND METHODS

The model of capacitive pressure sensor chip is a wireless system. The circuit consists of variable capacitor sensor with an average measured base capacitance of 4 pF, radio-frequency module designed to operate within the 433 MHz band whose frequency range intended for wireless data transmitter, wireless powering designed for transiting of energy with frequency the 13.56 MHz as shown in Figure 1. Variable capacitor is used for modeling of microelectromechanical sensor (MEMS). It was selected because capacitive pressure sensors used for pressure sensing in biomedical applications (CardioMEMS, USA) However, CardioMEMS has some disadvantages, such as the patient position dependence and static use. While developing blood pressure sensor excludes these limitations.

Our model consists of two capacitance-to-time circuits based on low power Schmitt trigger oscillators. In this circuit the reference capacitance compares with sensor capacitance. The current sources in the two capacitance-to-time circuits are matched and provide the equal currents to their corresponding capacitors. The variable capacitor will always have an equal or larger capacitance compared to the reference capacitor resulting in a longer charge-up time. Frequency of oscillator is directly proportional to (1/RC). Pressure reaction was modeling by changing of capacitance on few pF relativity of reference capacitance. Time for reach threshold of Schmitt trigger is directly proportional to the capacitance therefore this time is different for variable and reference capacitor. It is used to convert signal in gate logic into pulse. We can digitize and transmit this pulse on other device or store in memory.

3 RESULTS

For the experiment was used chip connected to the power supply unit through the inductor. The output voltage is equal to 5 V. To measure the length of the signal was connected oscilloscope. Capacitance values over the range of 4–20 pF were tested.

Value of reference capacitor is 5 pF and the resulting frequency of oscillators is average 1 kHz. For validation and testing the pulse of capacitance-to-time circuit served directly in wireless transmission device. In Figure 2 a exhibited capacitance-to-time circuit. Digital conversion of both signal in pulse shown in Figure 2 b.

The model of chip consist of circuit, wireless powering and data transmitter (Figure 3). Thus, it can be concluded that the length of the signal changes depending on changes in capacitance of the capacitor. The length of the signal can be converted into mm. Hg. for measuring blood pressure changes.

Solid state capacitive pressure sensor implanted in the bloodstream can be used as a device for blood pressure measuring. This device is a resonant circuit comprising an oscillator with a pressure sensitive element (a flexible condenser). A blood pressure sensor capacitance is a function of ambient enivironment pressure, in

Figure 1. Model block diagram.
which it is located. Implanted chip can be connected with an external transceiver (radio transmitter). By changes in the resonance frequency between the transmitter and the implant it is possible to conclude of patient's blood pressure status. For realization multi parameters mode recording data such as physiological parameters, both systolic and diastolic blood pressure, pulse frequency and heart rate, the transmission rate of the pulse wave, the sensor for monitoring physiological parameters of the cardiovascular system must include several (at least two) sensitive elements and can be based on microelectromechanical systems (MEMS) or similar technology, which provides the same miniaturization of components. Due to the sensor size, implantation for monitoring physiological parameters of the cardiovascular system is minimally invasive with minimal surgical intervention. The transmitter for registration, primary processing and calculation of physiological parameters of the cardiovascular system, will be equipped with the necessary set of interfaces for the transmission of digital data to a computer located at a medical facility and/or physician. The communication systems such as WiFi or GPRS will be used. Cable USB line will transmit to the computer at a medical facility and/or physician and implement the transmitter battery (if necessary). Communication with a remote workstation (with the operator’s computer) will be carried out through the interface WiFi. GPRS is an alternative system for the transmission of the digital data streams over radio networks will enable the user to exchange data with other devices on the GSM network and external networks, including the Internet. It is also expected to use a different communication channel, for example, Bluetooth in order to ensure inter-operability of the attending physician on the measuring system and the patient.

4 CONCLUSIONS

This work has validated the use of capacitive pressure sensor as a implanted in the bloodstream chip model. We have shown the ability to use capacitive blood pressure measurement...
method and wireless data transmission. A fully wireless transmitter was tested and efficiency of antennas was measured and the power loss was quantified for transmission through free space. These results can be used for ASIC design using MEMS pressure sensor.

5 ACKNOWLEDGMENTS

This work was supported by Russian Foundation for Basic Research grant 13-04-01330 and Federal Target Program of Research and Development grant RFMEFI57814X0053.

6 REFERENCES


