Implanted Electronic Siren to Alarm for Bladder Full with Urine

Du Wenlong, Li Wenyuan*, Wang Zhigong, and Lü Xiaoying

***Abstract*—A Device to detect for the bladder which is full with urine is designed. The device can measure bladder pressure. The pressure signals are processed. When the pressure exceeds 40cm water column, Pressure signal exceeds a fixed voltage. At the same time, Oscillator sends a signal and the signal transmits to the body surface. The receiver accepts the oscillating signal. Then, the alarm alerts. Liquid pressure sensor is used to measure bladder pressure. Signal transmits through a pig bladder to pigskin to verify the feasibility of the program.**

***Keywords*: bladder, sensors, pressure, voltage, alarm**

I. Introduction

Spinal Cord Injury is one of the most clinically severe disability which not only seriously damages the patient's somatic motor and sensory function, and causes people urinating and bowel dysfunction[1]. According to the China Disabled Persons' Federation statistical figures, the total number of Chinese patients with SCI is more than 100 million people and more than 50,000 new cases occur each year[2]. Only coal industry in 1999 statistics, the total number of patients with post-traumatic paraplegia was more than 7700 people who worked in coal industry. In all spinal cord injury patients, severe urinary retention and urinary tract infections caused by bladder dysfunction, or even chronic renal failure is the first cause of death in patients with paraplegia[3]. Therefore, the reconstruction of the patient's bladder function is great significance for improving the quality of life of paraplegic patients and reducing the mortality rate.

Micturition alarm devices are a class of equipment which is able to detect the bladder pressure or volume. It is expected to treat uric meaning missing[4]. Of course, this approach does not make the patient to recover uric meaning. But it sounds to remind patients to urinate with voiding. From the 1970s, a variety of designs has made. Due to the serious deficiencies, some programs remain in the initial report, no follow-up studies; some programs are still with some shortcomings which limit its clinical application[5]. This paper presents a new design and demonstrates the feasibility of the program.

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II. Principle

There is a corresponding relationship between pressure and volume of the bladder, so that we can alarm by detecting the pressure or volume, as shown in Fig 1.

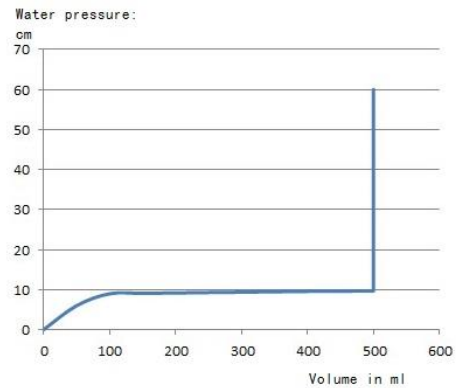


Figure 1. The relationship between bladder volume and pressure.

In this paper, we use pressure to alarm. The whole system is divided into two parts：In vivo and in vitro part. In vivo part is used to measure the pressure of the bladder. Signal is transmitted through the body to the external part of the human body. In vitro part accepts and processes signals. It is Alarm when the bladder is full of urine. The oscillation frequency is controlled by the pressure signal.

In vivo part is consisting of the sensor, circuit, memory alloy and electrode, as shown in Fig 2. Sensor measures the pressure of the bladder. The sensor signal is amplified and filtered. Then the signal is judged. If the bladder pressure is greater than 40cm of water pressure, the signal is greater than a fixed value. Oscillator starts to emit oscillating signal. The oscillation signal is through the electrode, urine, and the human body to the skin. The timer makes a high level signal every 5 minutes. High level signal makes the oscillator starts to emit oscillating signal. The frequency of the oscillation signal is controlled by the sensor signal. The oscillation signal is transmission through the human body to the skin.

The circuits in vivo and in vitro are not common ground. Signal loss is very large in the process of transmission. The urine and human tissues (except the skin) resistance is very small. Signal loss is very small in the urine and human tissues (except the skin). But signal loss is very large in the skin. Therefore, in vitro electrode can be placed in any part of the body skin[6].

Signal is Transmission from electrode to the receiver in vitro. The signal is amplified and filtered. After distinguishing circuit, signal recovers square wave signal. The square wave signal and square wave signal of the oscillator are the same. Frequency represents the bladder pressure. Timer controls counter counting the number of wave in a certain period of time. Then the circuit calculates the frequency of square wave. Bladder pressure value and the time of signal generation are stored. When the bladder pressure is greater than 40cm water column pressure, external receiver controls the buzzer to make a sound. At the same time, the bladder pressure is showed in the display. Other times, the bladder pressure can be queried, downloaded, and displayed on the LCD screen.

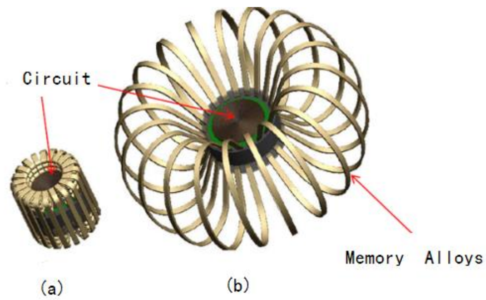


Figure 2. Implantable devices.

III. EXPERIMENT

We use the liquid pressure sensor. The bladder pressure is less than 35kPa, so the sensor range is 0-40kPa. The body part is to be fed into the bladder by cystoscopy. So the diameter of the sensor must be less than the cystoscopy probe diameter 9mm, as shown in Fig 3. The metal sensor cap is made of stainless steel materials to prevent corrosion by urine. The metal cap is cylindrical, to prevent from scratch the urethral or bladder.

The pressure of 0-40cm water column is measured by sensor, as shown in Table Ⅰ.

TABLE I. SENSOR SIGNAL

Water pressure(cm)	0	10	20	30	40	50
Voltage (mV)	-6	-4	-2	0	2	4

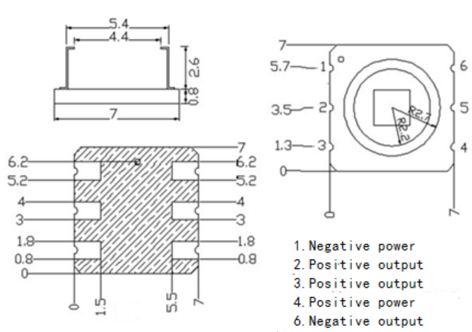


Figure 3. Sensor's three views.

The circuit is made of Components and parts to test the scheme. We will design integrated circuit to ensure that it can be implanted within the bladder. The circuit power must be very low to achieve long-term implantation. The circuit has good stability and excellent heat dissipation. The implanted part makes a signal every five minutes. So we can ensure that users understand the circuit conditions. It is alarm, if in vitro part does not receive the signal every Five minutes.

The power consumption of the sensor is greatly. The power supply time for sensor is very short, so we can ensure that the power consumption of the sensor part is down to the μW level. Similarly, we can ensure that the power consumption of the oscillator part is down to the μW level.

The electrode shape is circular to prevent damage of the bladder and urethra. The size of the electrode can be sent to bladder by cystoscopy. Electrode material must prevent urine corrosion. Memory alloy plays a supporting role for the body part. At room temperature, the shape memory alloy is as shown in figure 2. When the body part is fed into the bladder, the temperature gradually increases. Memory alloy is open. So that the body part can be smoothly send into the bladder. At the same, it can prevent the body part excreted as urine from the bladder.

We use the separation element to achieve the body part. The sensor is used to measure the bladder pressure. Instrumentation amplifier amplifies the signal. The amplified signal compared with the fixed voltage by comparator. If the amplified signal is larger than the fixed voltage, the 555 oscillator send a square wave as shown in Fig 4. The electrode is made of copper wire.

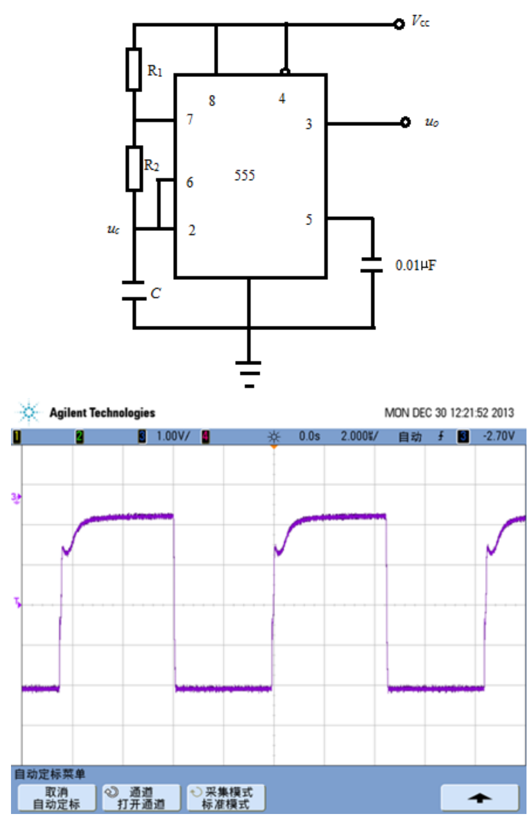


Figure 4. Oscillator schematics and square wave signal generated by oscillator

We use the porcine bladder to test. The signal data which is transmission in human urine, bladder, pigskin and human skin is shown in table Ⅱ.

TABLE II. SIGNAL TRANSMISSION

	Input Signal	Urine	Pig bladder	Urine and pig bladder	Skin 1	Skin 2
Frequency (kHz)	118	118	118	118	118	118
Electrode signal amplitude (V)	1	0.4	0.4	0.4	0.2	0.2
signals Amplitude After comparing (V)	3	3	3	3	3	3

Urine: signal transmission in the urine

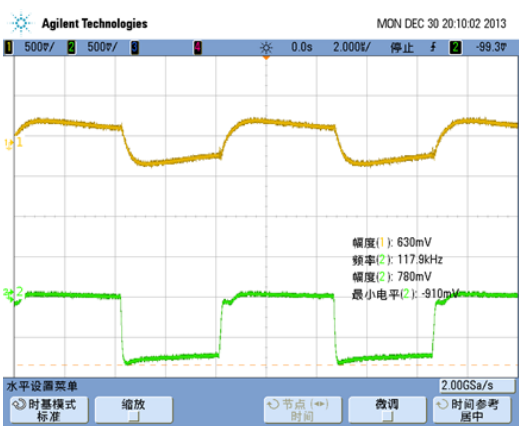
Pig Bladder: signal transmission in the pig bladder

Urine and pig bladder: signal transmission in urine and the pig bladder

skin1: signal transmission from the urine and the pig bladder into the human skin

skin2: signal transmission from the urine and the pig bladder into the human skin, then transmission in the skin for a long distance

Discrete components are used to achieve In vitro part. The electrode attaches to the skin to receive signals. The signals are amplified and filtered as shown in Fig 5. Through the comparator, the square wave signal is recovered, as shown in Fig 6. Experiment site is shown in Fig 7.



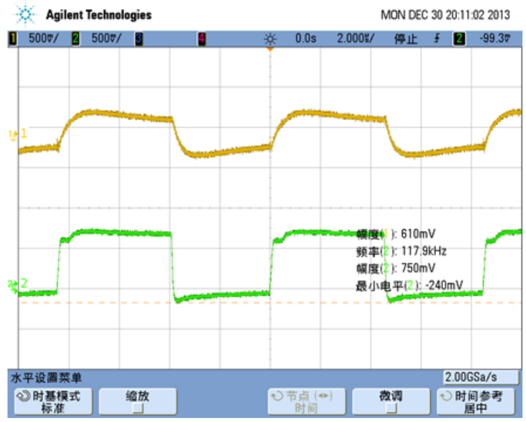


Figure 5. Comparing the filtered signal and the electrode signal

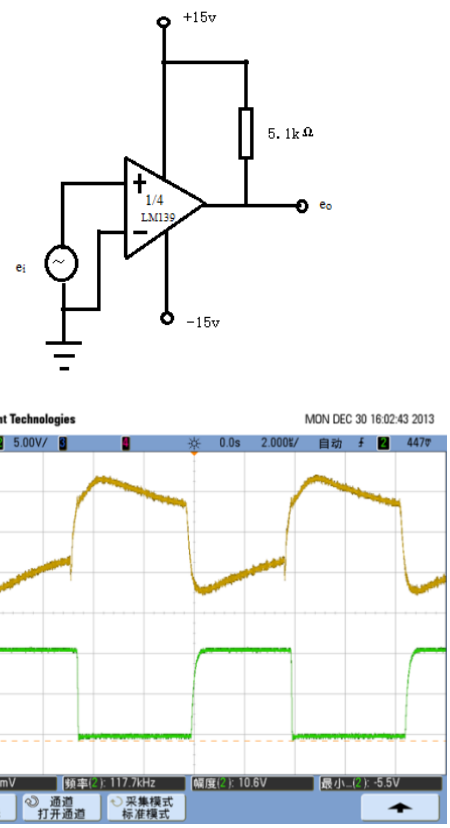


Figure 6. Comparator Schematics and the signal after the comparator.

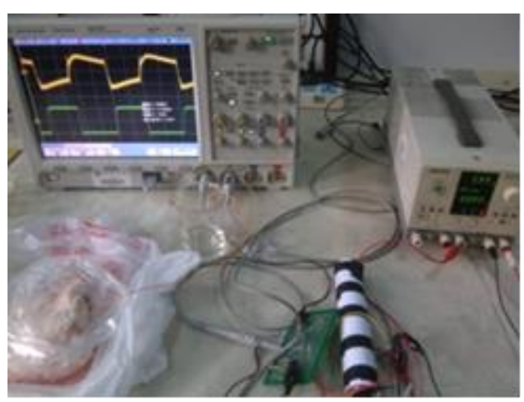


Figure 7. Experiment site

IV. CONCLUSION

In this paper, a new design approach can achieve the detection of bladder pressure. The new device is designed which can alarm when the bladder is full of urine. The previous designed device is implanted into the bladder wall. But it is easy to fall off to the bladder. This device is implanted into the bladder by a minimally invasive manner. The power consumption of body part is very low, so it can be long-term implantation. The volume of the electrode can be extremely small, but the antenna is large when the Signal is transmission through wireless[7],[8]. The experiments prove that the scheme is feasible. The external electrode can touch any position of human skin. The patients can use it very convenient. Memory alloy on the body part plays a supporting role. The body part can be minimally invasive implantation by cystoscopy.

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