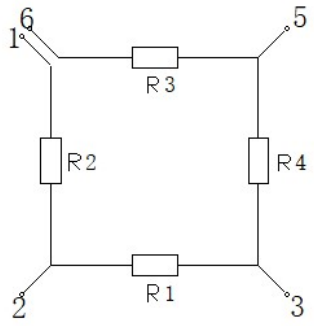
2. Theory

Pressure is a non-electrical physical quantity. It can be measured with a pointer gas pressure gauge. If a pressure sensor is used to convert the pressure into electrical quantity, it can be measured and monitored with a digital voltmeter. The gas pressure sensor used in this instrument is MPS3100, which is a bridge composed of piezoresistive elements. Its electrical schematic is shown in Figure 1.



PIN	
1	GND
2	V+
3	OUT+
4	
5	V-
6	GND

Figure 1 Electrical schematic of the bridge using piezoresistive elements

The working voltage of the gas pressure sensor is +5 V. Its measurement range is 0-40 kPa. It can output a voltage of 0-75 mV (typical value) with the change of the gas pressure. Due to cause of the manufacturing technology, when the sensor is at 0 kPa, its output is not zero (typical value ± 25 mV). It can be corrected by connecting a small resistor in series with pins 1 and 6. The linearity of the MPS3100 sensor is excellent (typical value is 0.3% SF),

1) The ideal gas law

The state of the gas can be determined by the following three quantities: volume V, pressure P, and temperature T. Under normal atmospheric conditions, the gas can be regarded as an ideal gas (the gas pressure is not large), and the ideal gas abides by the following laws.

a) Boyle's law: For a certain amount of gas, assuming that the temperature T of the gas remains unchanged, the product of its pressure P and volume V is a constant.

$$P_1V_1 = P_2V_2 = \ldots\ldots = P_rV_r = \text{Constant}. \tag{1}$$

b) Gas law: the product of the pressure P of any certain amount of gas and the volume V of the gas divided by its thermodynamic temperature T is a constant, that is

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \ldots\ldots = \frac{P_rV_r}{T_r} = \text{Constant}. \tag{2}$$

2) Measurement of heart rate and blood pressure

The heart rate and blood pressure of the human body are important physiological parameters. The frequency of the heartbeat, the waveform of the pulse and the level of the blood pressure are the important basis for judging the health of the human body. Therefore, measuring the heart rate and blood pressure of the human body is also an important content that medical students must master.

a) Heart rhythm, pulse wave and measurement

The frequency of the heart beat is called the heart rate (times / min). The heart squeezes the blood vessel in the periodic fluctuations to cause the elastic deformation of the arterial wall. The pulse wave is obtained by measuring this stress wave at the blood vessel. Because the heart passes through arterial blood vessels, capillaries supply blood to the whole body, so the closer to the heart the greater the intensity of the pulse wave will be measured, and vice versa.

At the blood vessel where the pulse wave is strong, the pulse wave can be sensed with a finger outside the body. With the development of electronic technology and computer technology, pulse measurement is no longer limited to the traditional manual measurement method or stethoscope measurement method. The use of piezoresistive sensors to detect pulse signals, and data processing through single-chip technology, the intelligent pulse testing has been achieved. At the same time, the detected pulse wave can be observed through an oscilloscope, and the heart health diagnosis can be performed by comparing the pulse waveform.

This technology is advanced, practical and stable, and it is also the development direction of biomedical engineering. However, considering that pulse wave (PPG) has not only a parameter of pulse frequency, but also indirect parameters such as blood pressure, blood oxygen saturation, and so on. Pulse wave observation is very important in medical diagnosis.

b) Blood pressure and measurement

Human blood pressure refers to the pressure generated by the pulsating blood flow in the arterial blood vessel to the blood vessel wall laterally perpendicular to the blood vessel wall. The peak value of the pressure perpendicular to the wall of the aortic blood vessel is the systolic pressure, and the valley value is the diastolic pressure.

Blood pressure is an important physiological parameter that reflects the state of the cardiovascular system. Especially in recent years, the incidence of hypertension in the middle-aged and elderly population has been increasing, and is often an important factor that causes some diseases of the cardiovascular system. It becomes more and more important in health work.

The clinical blood pressure measurement technology can be divided into direct method and indirect method. The indirect method of measuring blood pressure does not require surgery and measurement is simple, so it is widely used in clinic. Among the indirect blood pressure measurement methods, there are currently two commonly used methods, namely, Auscultation method and Oscillometric method.

The auscultation method was proposed by the Russian doctor Kopotkoc in 1905, and is still widely used in clinical practice to date. However, the auscultation method has its inherent shortcomings: First, there has been controversy on whether the diastolic blood pressure corresponds to the fourth phase or the fifth phase, and the resulting discriminant error is very large. The second is to judge the systolic pressure and diastolic pressure by listening to the Korotkoff sound. The reading is affected by the user's hearing, subjective errors are easily introduced, and it is difficult to standardize.

In recent years, many blood pressure monitors and automatic electronic sphygmomanometers have adopted the oscillometric method to measure blood pressure

indirectly. The oscillometric method of measuring blood pressure is consistent with the Korotkoff sound method. All pressurize the cuff to block the arterial blood flow, and then slowly decompress, during which small sound and pressure pulses will be heard from the arm. The Korotkoff sound method is based on manually recognizing the sound from the arm and interpreting the systolic and diastolic blood pressure. The oscillometric method relies on the sensor to identify the small pulse transmitted from the arm to the cuff and differentiate it to obtain the blood pressure value. Considering that the current hospital blood pressure measurement still uses the Korotkoff sound method, so this experiment requires mastering the Korotkoff sound method to measure human blood pressure.