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Research Article

System design and implementation of an IoT electronic pulse sphygmomanometer

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ABSTRACT

A sphygmomanometer is a standard testing tool for monitoring blood pressure and plays a vital role in modern medical diagnosis. Traditional smart electronic sphygmomanometers are complex and costly; this paper designs a low-cost electronic pulse sphygmomanometer through microcontroller control. This design collects the gas pressure information through the barometric pressure sensor and inputs it into the analog-to-digital converter. It converts the collected analog signal into a digital signal and then completes the determination of blood pressure and pulse through the recognition algorithm. Finally, this design is found to have the advantages oa f wide range of applicationslightweightht, low price, etc., and has important application value.

1. INTRODUCTION

With the development of the economy, people's material standard of living has been greatly improved [1-5]; people in the pursuit of a more prosperous and more exciting life at the same time, a variety of high oil and high-fat intake so that people's bodies are often in a state of sub-health, which has led to the incidence of cardiovascular disease has risen sharply [6-11]. The highest incidence of cardiovascular diseases is high blood pressure, which can cause many other diseases, such as cerebral hemorrhage, myocardial infarction, heart emaciation, renal failure, etc. Therefore, timely detection and timely treatment become very important [12-19].This design combines a microcontroller with a sphygmomanometer to design a sphygmomanometer that collects information from a pressure sensor, goes through a series of recognition algorithms to calculate the blood pressure and pulse, and displays it on a display screen, which measures not only the blood pressure but also the heartbeat. This sphygmomanometer is designed to be lightweight and can be carried around and put into your pocket, reducing pollution compared to mercury sphygmomanometers. It is easy to operate, even for the elderly, and children can use it quickly and conveniently.

2. OVERALL SYSTEM DESIGN

The electronic pulse sphygmomanometer comprises a cuff, pressure sensor, analog-to-digital converter, STC89C52, LCD1602, electric air pump, and solenoid valve. Measurement by the microcontroller on the electric pump, solenoid valve control automatically inflates and deflates the pressure in the cuff to the pressure sensor will be converted to electrical signals transmitted to the analog-to-digital converter after the analog-to-digital converter sent to the microcontroller to deal with the final determination of the blood pressure and pulse, and then through the display will show the final results. The overall structure of the system block diagram is shown in Figure 1.

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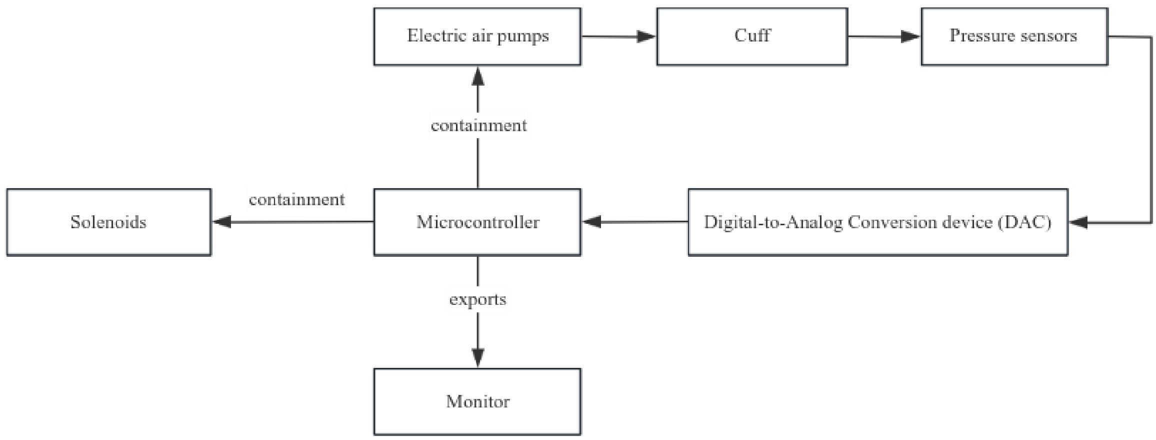

Fig. 1. Block diagram of the overall system structure

2.1 Hardware Design

1- Microcontroller module

The microcontroller module adopts STC89C51 microcontroller, STC89C51 microcontroller endurance long, small load CMOS 8-bit microcontroller, with 8K bytes of system-programmable FLASH memory, containing 8k bytes of Flash, 512 bytes of memory, 32 I/O ports, can realize the full-duplex serial communication transmission, and the microcontroller can work at 0Hz below. The microcontroller can work under 0Hz. In energy-saving mode, two different software can be supported; in the state of working without executing instructions, the CPU pauses and stops running so that the RAM can be used, and the timer will continue to work after the power supply is disconnected by counting, serial and interrupt, and the storage in the RAM can be saved after the power interrupt. The microcontroller oscillator stops running until the reset road is reset, and the max. The operating frequency is up to 35MHz. According to the operating voltage of the air pump and solenoid valve, the power supply is selected as 6V, and the microcontroller operating voltage is 5V, so it is necessary to connect a voltage reduction circuit to the microcontroller. Here, the choice is the LM7805 voltage regulator chip to supply the microcontroller's power supply. 7805's main features are: adapted to most of the circuits, will not damage the hardware; with overheating and power-off protection; with a short-circuit protection; the output transistor has special protection; the power supply circuit is shown in Figure 2:

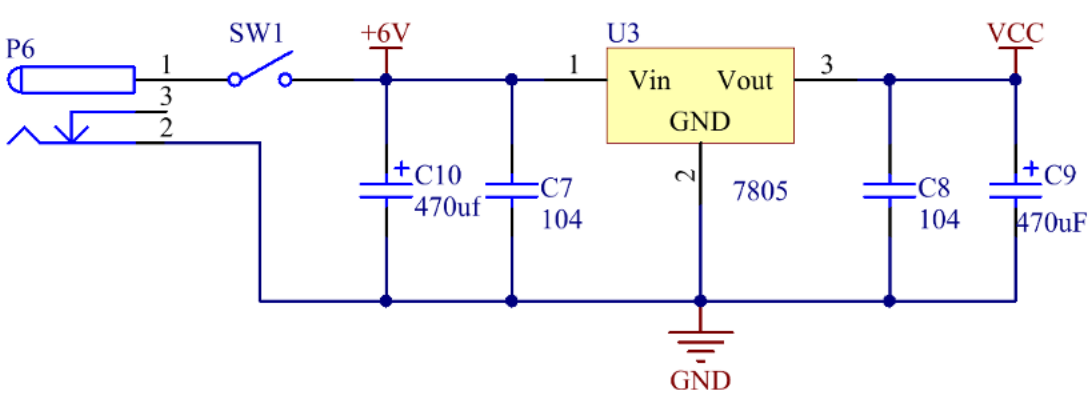

Fig. 2. Power supply circuit design

The signals collected by the barometric pressure sensor XGZP6847 inside the cuff are analog signals, which the microcontroller cannot recognize, so an analog-to-digital converter is needed to convert the analog signals before

transmitting them to the microcontroller for processing. The TLC2543 analog-to-digital converter is chosen here to perform analog-to-digital conversion of the signals collected by the barometric pressure sensor.
Compared with the ADC0832 analog-to-digital converter, the serial interface of the TLC2543 analog-to-digital converter has been upgraded from 8-bit to 12-bit, the transmission speed is faster, and the sampling rate and sampling accuracy are also higher so that it can complete the accurate conversion of analog signals. The circuit diagram connecting the air pressure sensor XGZP6847 and the TLC2543 analog-to-digital converter is shown in Figure 3:

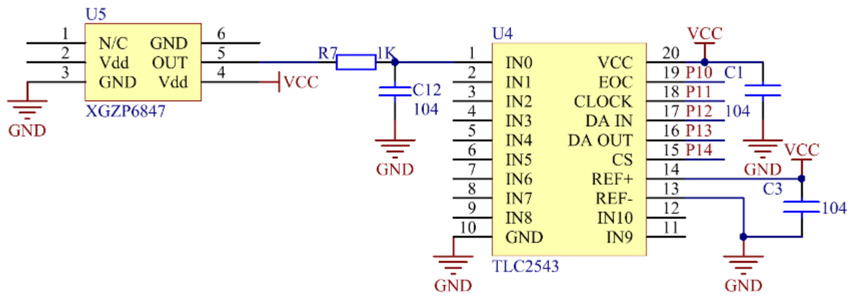

Fig. 3. Conversion circuit design

2- Pressure sensors

Barometric pressure sensors are one of the most common high-precision sensors in various automatic controls, often used in various scenarios. According to the built-in set function, it can detect the pressure signal into a usable electrical signal, and then the electrical signal will be transmitted to the next device. This design utilizes the XGZP6847 pressure sensor, which begins to measure barometric pressure after the cuff is filled with gas and transmits it to the analog-to-digital converter. This sensor has a wide measuring range, is small in size, is easy to install, has accurate measurements, and is often used in medical care, monitoring, and measurement.

3- Liquid crystal display

Adopted LCD1602 liquid crystal display LCD1602 liquid crystal display can display numbers, characters, letters, etc., and can be displayed in a two-line arrangement; the function is very comprehensive, the number of pins is less compared to the LED digital tube, it is easier to allocate, drive more information, the interface is also more concise.
LCD1602 display module is a commonly used character-based liquid crystal display module with 16 columns and two lines of the display area. This display module is simple, easy to use, and usually used in various circuit designs and DIY projects. Control signal line: connect the I/O pins of STC89C52 to the RS and EN pins of LCD1602, and select the I/O pins P2.5 and P2.7 of STC89C52 as the control signal inputs of RS and EN; data line: connect the I/O pins P0.4, P0.5, P0.6 and P0.7 of STC89C52 to the D4 to D7 pins of LCD1602. D4 to D7 pins of the LCD1602 for the transmission of data and commands; backlight control: LCD1602 backlight control pin A connected to the 5V power supply, VO pin in series with an adjustable resistor, you can realize the control of the backlight. The display circuit is shown in Figure 4:

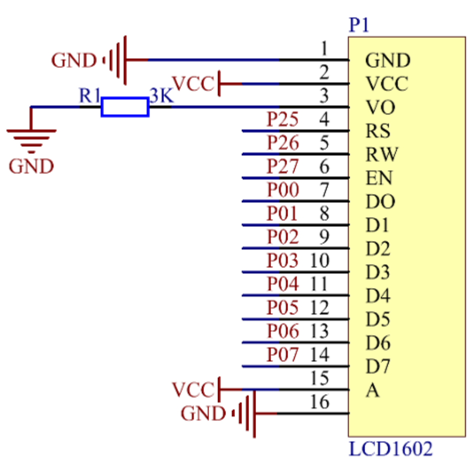

Fig. 4. Display circuit design

i. Air pump

Instead of a manual pump, an air pump with a 6V electric drive is used here, which is more powerful and less audible. Air pressure is generated and transmitted into the cuff through the hose by continuously pressurizing the compressed air under the action of electricity. When the cuff is filled with gas, air pressure is generated to compress the blood vessels, from which the blood pressure and pulse rate can be measured.
The inflatable circuit is mainly controlled by the electric air pump, which is responsible for inflating and pressurizing the cuff after the power supply is turned on, the key is pressed, and the signal of inflating is received, which is used to detect the blood pressure and pulse rate. Here, by the electric air pump interface, 1k resistor, diode, and transistor composition of the entire circuit, the additional diode is added to eliminate the electric potential generated by the electric air pump work. The inflation circuit is shown in Fig. 5:

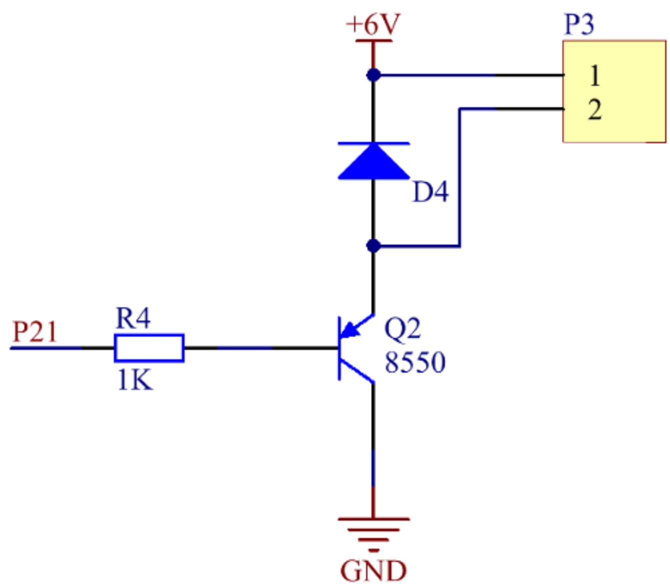

Fig. 5. Inflatable circuit design

The deflation circuit is mainly controlled by a solenoid valve, which provides stable and unchanging pressure for blood pressure testing or deflates the gas in time to protect the device when the gas pressure is too high, and there is a risk of hardware damage. The air release circuit adopts the same design as the inflation circuit, only the electric air pump is replaced by a solenoid valve. The air release circuit is shown in Figure 6:

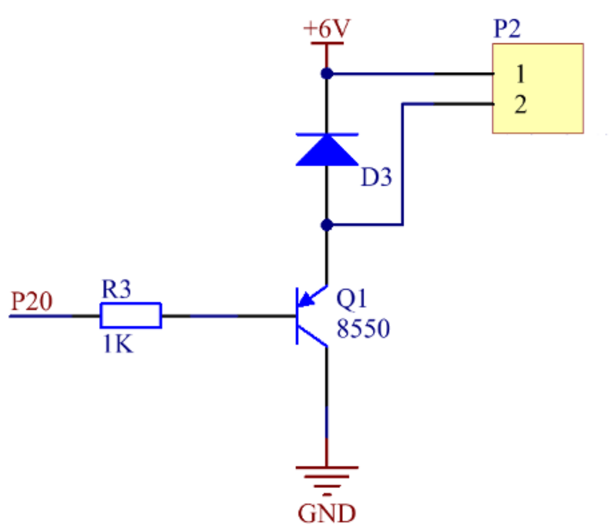

Fig. 6. Air release circuit design

ii. Solenoids

Solenoid valves, also known as relief valves, can be automatically opened and closed by the initial setting of the safety pressure value; its role is to provide a stable, unchanged safety pressure to prevent excessive pressure leading to the destruction of hardware equipment to protect the product and user safety.
The main application areas of solenoid valves are to control the direction of the fluid; solenoid valves only allow the direction of the fluid and the direction of the current of the solenoid coil; used to control the pressure, solenoid valves can be used to control a variety of different pressure ranges of the fluid, used to measure the pressure of different ranges of gases, the use of the pressure control function.

iii. Alarm Module

The buzzer, which is responsible for sounding an alarm when the detection of diastolic, systolic, and pulse is complete, alerting the person being detected and allowing him or her to determine his or her status, sounds when the PNP triode is at a high level.
The reason for choosing this type of triode is that when the STC89C52 microcontroller is just powered up, all I/O ports will generate a momentary high level; if you choose the NPN type of triode, will make the buzzer ring for a short period when it is switched on, and choosing the PNP type of triode can avoid this situation. The buzzer circuit is shown in Figure 7:

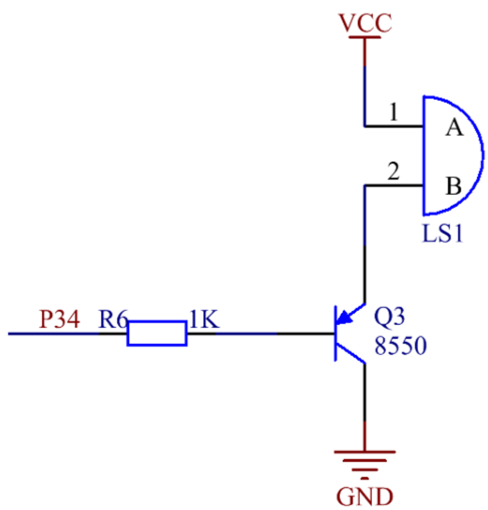

Fig. 7. Buzzer circuit design.

2.2 Software design

The software program can be divided into three parts: "Main Program Part", "Blood Pressure Detection Part" and "Program Display Part".

1- Main programming

This design is based on first turning on the power supply and then starting the electric air pump inflatable detection; detection is complete, the electric air pump begins to work, and continuous pressurization is transmitted to the cuff, in the cuff after the air pressure reaches the set value, the air pressure sensor will be collected to the analog-to-digital converter after analog-to-digital conversion is input to the microcontroller, and then after the arithmetic processing in the display to show the results. The specific process is shown in Figure 8:

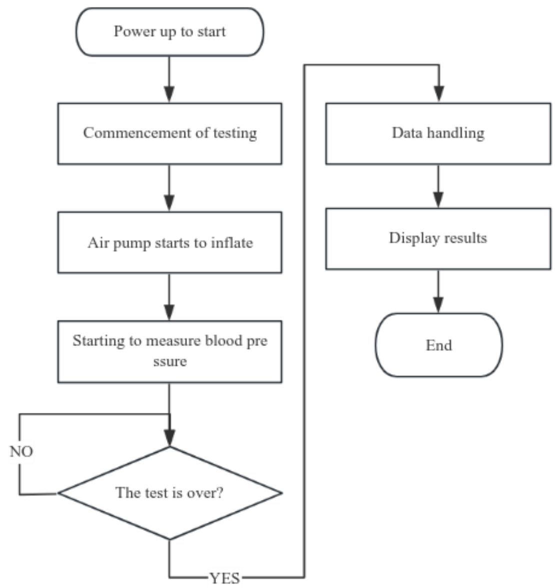

Fig. 8. Main program flow chart

2- Blood pressure detection programming

After connecting the signal to start detecting the blood pressure, the system first finds out the maximum amplitude value of the blood flow pressure when the blood vessel is compressed by the air pressure according to the inflation data and then finds the position where the amplitude value of the pressure is half of the maximum amplitude value, and the value of the blood pressure measured by the system in this process is the systolic blood pressure; at the beginning of the process of deflating, it finds out the maximum amplitude value of the blood's impact pressure on the wall of the blood vessel when the blood vessel is recovered, and then finds the point where the maximum amplitude value is 0.75 point, the blood pressure value measured by the system in this process is the diastolic blood pressure. The specific process is shown in Fig. 9:

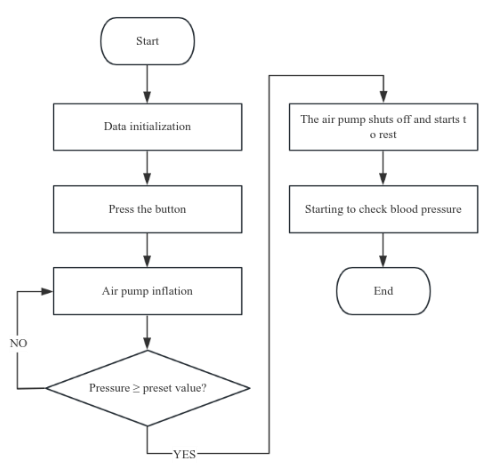

Fig. 9. Blood Pressure Testing Flowchart

i. Display programming

After the measurement of blood pressure and after the analog-to-digital converter processing transmission to the microcontroller, the microcontroller, to complete the determination of blood pressure and pulse, needs to be displayed through the LCD1602. LCD1602, because it is a character-type display, the display can display all the data, so it is set to display the top of the high-pressure, the following display of the low-pressure, and the right side of the display of the pulse. In displaying this process, LCD1602 needs to go through the logic judgment of voltage; only after determining that there is no error will display the characters. Otherwise, it will trigger the alarm setting and transmit it to the buzzer; the specific process is shown in Figure 10:

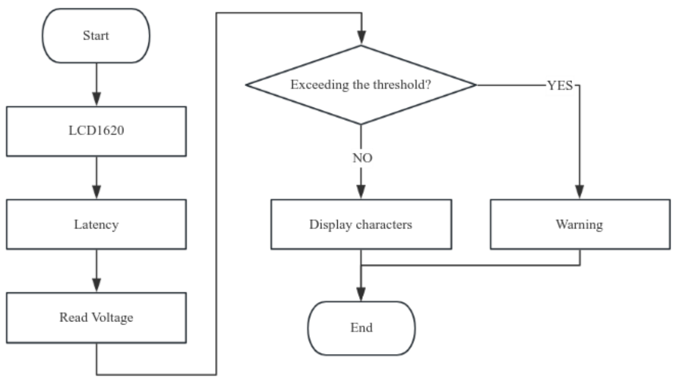

Fig. 10. Show Flowchart

3. SYSTEM TESTING

3.1 Preliminary

Since human blood pressure and heart rate cannot be entered in the simulation software, a data-changing sensor, and a sliding varistor are used inside the simulation to simulate. Instead, they have all the normal functions in the real thing, and the simulation shows that the steps are normal, and the changes in the blood pressure and heart rate of the person to be tested can be detected perfectly, as shown in Fig. 11:

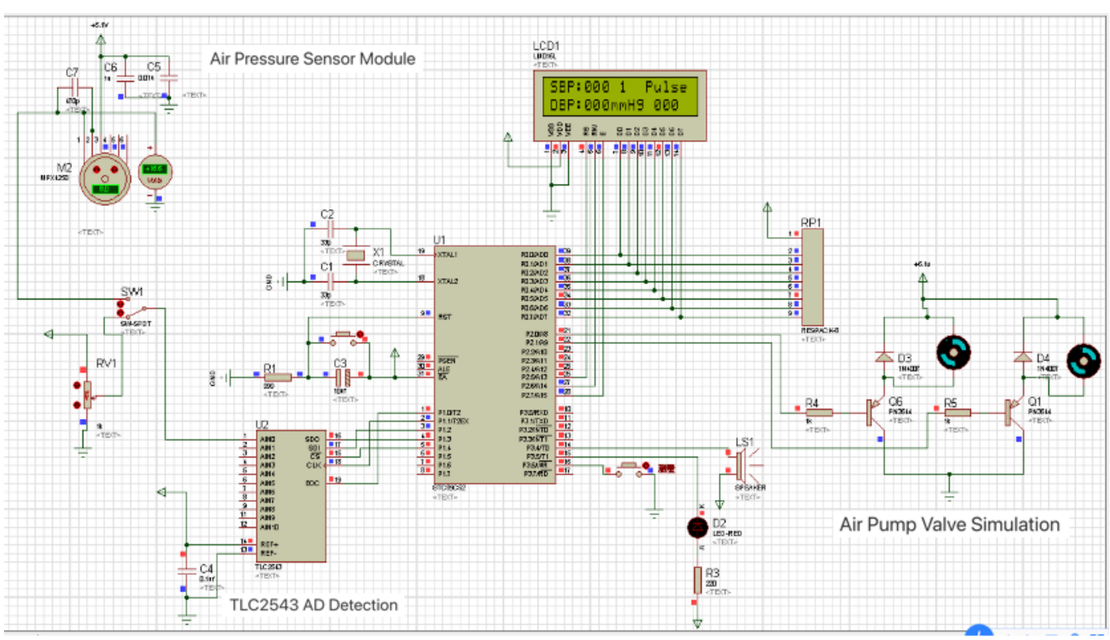

Fig. 11. System simulation diagram

3.2 Functional Testing

After the system is switched on, the measurement begins; this test covers a number of aspects, including whether the pin connection is solid, whether it can be used normally during the test, etc., in order to determine the goodness and merits of the design product, and thus determine whether the hardware can be carried out in accordance with the preconceived idea or not. Before starting the measurement, the person being measured waited quietly for three minutes and took several deep breaths to calm down, which was used to reduce the error. Clenched both fists during the measurement and placed the arm flat, in accordance with the process of blood pressure measurement; after the test, the functions of the sphygmomanometer can be used normally in order to ensure the accuracy of the instrument and the reliability of the experiments more than one group of experiments, in order to prevent the influence of accidental errors, the person being measured were asked to sit still for three minutes, and could not exercise strenuously, the results of five measurements are shown in Table 1:

TABLE I. MEASUREMENT RESULTS

Number	Systolic blood pressure	Diastolic blood pressure	Pulse
1	132	77	89
2	137	79	81
3	133	74	86
4	135	78	90
5	139	80	88

4. CONCLUSION

Through the test, this design has good accuracy and stability, and it can measure the systolic and diastolic blood pressure and pulse of the subject very well. Compared with the previous mercury sphygmomanometer, this design is easy to carry, convenient to use, and more rapid measurement. Because of the use of an electric air pump, it also saves time and labor, with important application value.

Conflicts Of Interest

The author's disclosure statement confirms the absence of any conflicts of interest.

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