Wearable sweat detector device design for health monitoring and clinical diagnosis

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Abstract. Miniaturized sensor is necessary part for wearable detector for biomedical applications. Wearable detector device is indispensable for online health care. This paper presents a concept of an wearable digital health monitoring device design for sweat analysis. The flexible sensor is developed to quantify the amount of hydrogen ions in sweat and skin temperature in real time. The detection system includes pH sensor, temperature sensor, signal processing module, power source, microprocessor, display module and so on. The sweat monitoring device is designed for sport monitoring or clinical diagnosis.

1 Introduction

With the government proposed the concept of "internet plus", online health care services become the development tendency of the future of health care industry. Sweat is a body fluid with present scant use as clinical sample. It's a kind of body fluid detection, is noninvasive, easy to get and able to realize real-time monitor compared to others. In the situation, we focus on sweat detection, design a wearable device to detect both pH concentration of sweat and skin temperature . The main components of sweat is water (99%). Beyond that, the slightly acidic body fluid (pH4.0-6.8) contains some electrolytes (such as sodium, chlorine) and small amount of organics (such as urea, pyruvic and lactate) Very small concentration of proteins, amino acids, metal ions, inhibitors, antigens, antibody and a variety of xenobiotic are also found in sweat[1]. Physical disorders will change the ingredients of sweat, including producing new components or changing the concentration of components. Therefore, sweat detection is a method of both clinical diagnosis and health monitoring. Monitoring pH of sweat during exercise could realize the state of hydration. Besides, the concentration of hydrogen is associated with skin disease. Skin temperature is formed by heat exchange between body and surrounding environment, and is related to body temperature. It has great application in medical and human engineering research, especially in the field of thermal comfort.

Currently there are some wearable devices have been designed and became commercially available[2-8], but most of them only detect physiologically parameters of body, lack of observe physical state from molecular level. Thus, in this paper, sweat pH and skin temperature were selected from two aspects, both physical and biochemistry, to monitor physiological state.

2 System Design

The system of the wearable monitoring device is illustrated in introduction. We design a system to detect the sweat pH and skin temperature when tester doing exercise or perspire after drug stimulation. The device is intergrated by sensors, signal processing circuit, microprocessor, power source and data presentation, realized in situ physiological monitoring in real time. The signal transmission of the system is shown in Figure.1.

2.1 pH and temperature sensors

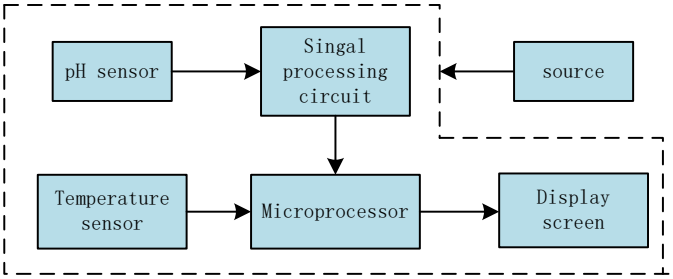

Figure 1: Structure of the system.

In sensor part, we use Antimony electrode as ion selective electrode, for it quick response, easy to operate and accuracy could reach 0.01pH in acidic solution, which achieve the requirement of sweat pH detection, also it is economical and reusable, Antimony electrode is shown in figure 2. And Ag-AgCl electrode is reference electrode. Antimony electrode is metal-metal oxide electrode, the electrode potential is generated on the interface between the metal and the oxide that covered the metal. When the sensor is in contact with the solution, surface is oxidized to generate Sb_2O_3, the potential difference between metal antimony and oxide depends on the concentration of Sb_2O_3, and the concentration of Sb_2O_3 is related to the concentration of hydrogen ion in the solution, its chemical reaction is as Equation (1,2):

$$2Sb+3H_2O \longleftrightarrow Sb_2O_3+6H^+ \quad (1)$$

$$Sb_2O_3+6H^+ \longleftrightarrow 2Sb^{+3}+3H_2O \quad (2)$$

Measuring standard pH solution by pH sensor, result show in Figure 3, V_o is the output voltage of pH sensor. As figure 3 shows, as sulotions pH less than 7, there is a linear relation between voltage output of sensor and solution pH.Fitting the curve, the sensitivity of pH sensor is 58mV/pH.

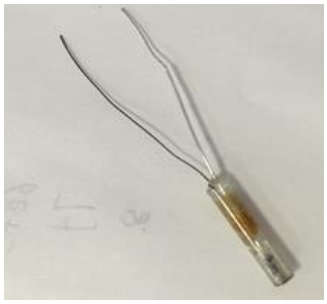

Figure 2: Antimony electrode sensor.

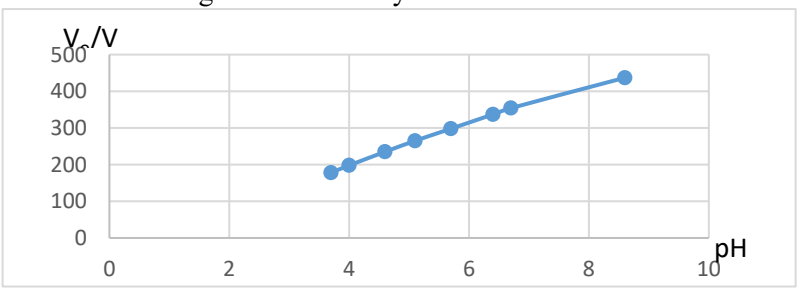

Figure 3: Measurement result of pH sensor

As for temperature sensor, we choose LM35, its sensitivy is 10mV/℃, output voltage is proportional to temperature, extra calibration is not required。

2.2 Singal processing circuit

In order to ensure the output value of the sensor in the microprocessor input range, singal processing circuit is requied. Singal processing circuit include voltage follower, amplifier and high frequency filter. Circuit diagram design and debug circuit are shown in figure 4.

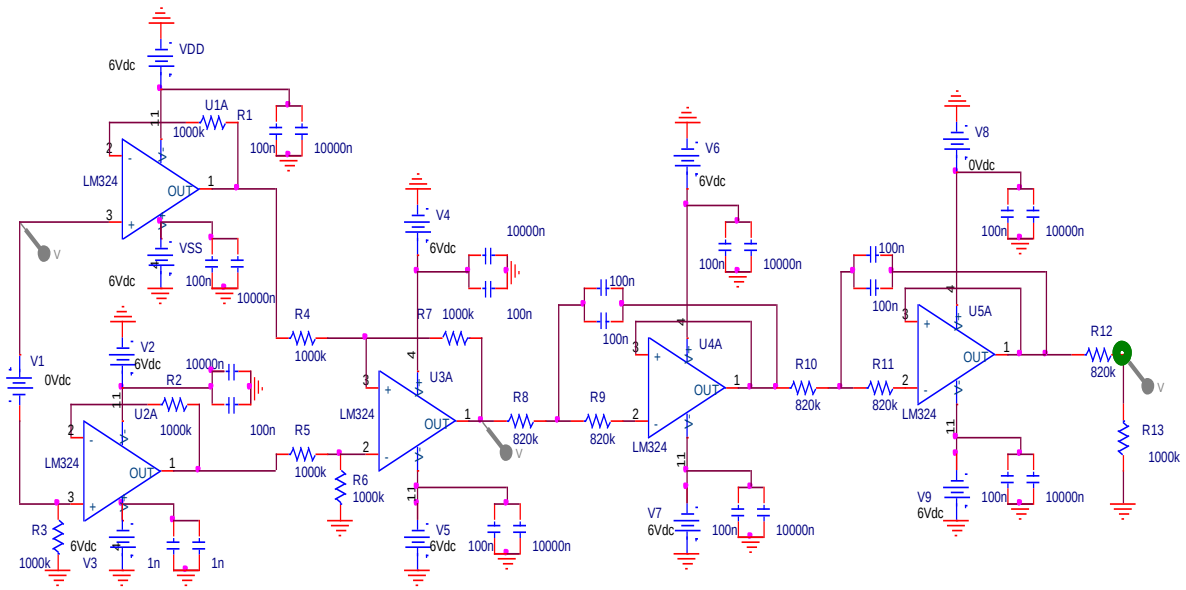

Figure 4: Circuit diagram design and debug circuit

2.3 Microprocessor display screen and source

Wearable devices require a small size of the microprocessor, so we choose Arduino uno single chip. Arduino uno realizes the calculation and conversion of the two analog channel data. Display screen adopt 1602 liquid crystal display, for it low power,small volume and light weigh.

We use Arduino development platform to program, the output anolog voltage signals of pH and temperature sensor respectively input from two analog ports, anolog voltage signals convert to pH and temperature by calculation, then tranmiss to 1602, 1602 shows user these two parameters.About power supply, we choose 3V button battery in series connection.Device and prototype circuit is shown in figure 5.

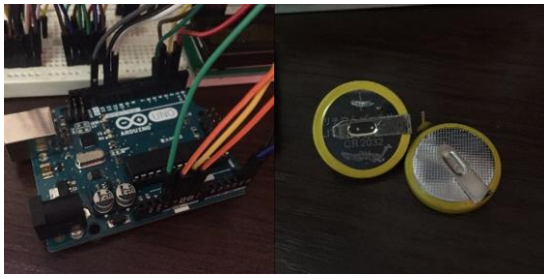

Figure 5: Arduino uno and button battery

3 Conclusion

In this paper, we designed a wearable sweat monitoring device to detect pH in sweat and skin temperature,and finished preliminary debug. A brief introduction about principle and construction is given above. The simulation prove the feasibility of design and sensitivity of the sensor. In further study,

we would add more sensor to detector more parameters, get more comprehensive physiological information; circuit will be painted on PCB board to make device smaller, and easy to encapsulation; signal will be transfer to Bluetooth serial port, upload data to mobile phone to realize online health.

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