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Atmel Microcontroller Based Human Blood Conductivity Measurement System

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Abstract: In this research paper an attempt is made to design and development of microcontroller based portable, economic blood conductivity measurement system by using conductivity cell. This has high performance price ratio with multifunction. The conductivity of blood sample is measured by immersing the conductivity cell in a blood sample. The conductivity cell produces voltage corresponding to the sample conductivity. This voltage is suitably signal conditioned and is given to the instrumentation amplifier. Arduino microcontroller acquires analog voltage through 10-bit on chip A/D converter. The LCD module is interfaced to the microcontroller and acquired conductivity is displayed on it. This paper deals with the hardware and software features of microcontroller based conductivity measurement system. Especially graphic trend curve on LCD allows individuals to easily see how actual blood conductivity varies with respect to time. The results are tested against real time blood sample.

Keywords: A/D Converter, LCD Module, ATMEG 328 microcontroller, Wein-Bridge Oscillator, USART, 1KB EEPROM, 2KB SRAM.

1. Introduction

Blood is the fluid that sustains life. Blood is circulated by the heart through vascular system. The main components of blood are red blood cells, white blood cells, platelets and plasma. These are responsible for supplying oxygen and required nutrients to the human body. These components are also responsible for coagulation of blood during external injury of blood vessels [1].

Coagulation is the process by which blood forms clots. It is an important part of haemostasis. Coagulation begins almost instantly after an injury to the blood vessel. Platelets and other components immediately form a plug at the site of injury [2].

Human blood coagulation plays an important role in the human body and is essential for normal human being. Coagulation results in a solidification of liquid blood at the surface of injured blood vessel [3].

Human blood analysis can be performed in several ways, one of which is conductivity of blood during coagulation. Electrical conductivity of blood is a measure of how well it carries electric current [4]. Its inverse property is a measure of how well it resists electric current. Health care providers will measure conductivity for many reasons such as treating stroke victims, measuring the clotting time [5]. The numerical value of the reading varies with several factors such as heamatocrit, concentration of red blood cells, concentration of electrolysis etc [6]. From this experiment it is proved that the conductivity of blood will decrease with coagulation, which attributes disappearance of calcium ions in the formation of fibrin [7].

Blood coagulation is a complex, dynamic physiological process by which clots are formed to end bleeding at injured site. Blood coagulation in the body is modulated by a number of cellular and other active components. The active components are involved in the process of clot formation such as platelets, red blood cells, white blood cells and finally a fibrin over all these. This is called coagulation cascade [8].

As the cascade becomes activated the blood progress from a non-clotting to a clotting state, causing changes in the molecular charge states and effective charge mobility. In this way by monitoring the conductivity of clotting blood sample the changes in the values of conductivity is observed. These values are associated with the clot formation of the blood [9, 10].

From many literature surveys it reveals that there are many methods to measure the conductivity of human blood an AC bridge principle which causes thermal agitation [10, 11, 12 and 13].

Earlier methods in measuring the blood conductivity during coagulation were not accurate because of masking effects of cell sedimentation, temperature changes, agitation etc. a new accurate method to record blood coagulation is involved in this method taking a blood sample, measuring the conductivity and making the display of the same on the LCD module. A new method described here will take care of above effects, this instrument allows continuous undisturbed conductivity monitoring of the blood sample which increases the accuracy of the system.

2. Hardware Details

The Fig. 1 shows the block diagram of the microcontroller based human blood conductivity system.

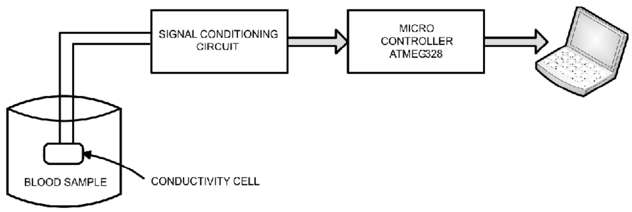

Figure 1: Block Diagram Human Blood Conductivity System

It consists of

- Conductivity cell
- Signal conditioning circuit
- Microcontroller
- LCD display or PC

The conductivity of the human blood sample is sensed through conductivity cell which produces proportional voltage which is further signal conditioned and acquired by the microcontroller through on chip A/D converter. The acquired data is processed and displayed as the measured conductivity in mhos on LCD.

The complete schematic diagram of microcontroller based human blood conductivity measurement system is shown in figure 2.

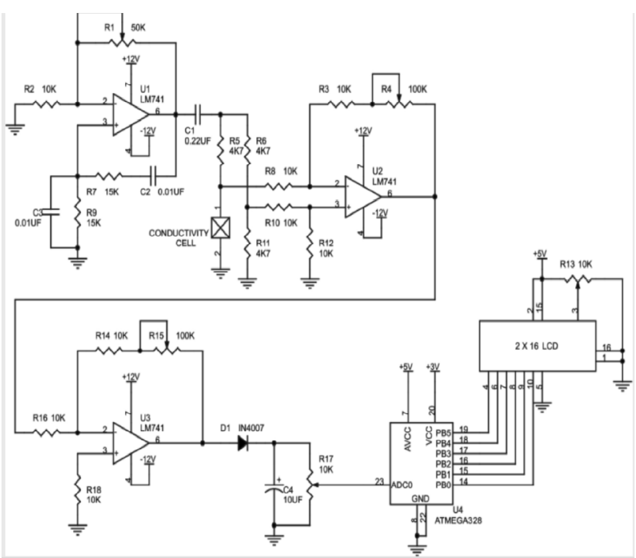

Figure 2: Schematic Diagram of Microcontroller based Human Blood Conductivity Measurement System

(A) Conductivity Cell: The conductivity cell consists of a pair of electrodes that are firmly located in a constant geometry. The cell used in the present study consists of two platinum electrodes of 1 cm--2 cross sectional area that are separated by a distance of 1 cm. the cell constant of the cell used in the present study is 1.01.

(B) Signal Conditioning Circuit: The below fig.2 shows the signal conditioning ciruit.The proposed signal conditioning circuit is designed for this particular application which utilizes AC conductivity measurement. This circuit consists of a stable sine wave oscillator constructed by using an operational-amplifier {WEIN-BRIDGE OSCILLATOR}. This oscillator is designed to generate a sine wave frequency equal to 1 KHz at amplitude equal to nearly 10 VPP. The generated AC sine wave is used as an excitation source for the impedance bridge containing a sample in one of the bridge arm. The AC excitation source is capacitively coupled or coupled through the capacitor to the bridge. The differential voltage is amplified using differential amplifier designed by using an operational amplifier. The differential gain can be varied from 1 to 10. The amplified differential output is further amplified by another with maximum gain of 10, thus amplified AC voltage is rectified and filtered to get the average DC voltage, corresponding to the conductivity of the blood sample. This analog output is converted to 10 bit digital by using an ADC which is inbuilt in the microcontroller which is being used.

(C) Microcontroller: In present system ATMEG 328 microcontroller is used. This microcontroller is a high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. [Google atmel corporation www.atmel.com]

3. Software Details

The program to acquire the data, process and display on LCD is developed in embedded C language.

The detailed flowchart for measurement and display of conductivity is shown in figure 3.

The first step in the process is the initialization of the LCD display which ignites the internal reset circuit. An internal reset circuit automatically initializes the HD44780U when the power is turned on. The following instructions are executed during the initialization. The busy flag (BF) is kept in the busy state until the initialization ends (BF = 1). The busy state lasts for 10ms after Vcc rises to 4.5v. If the electrical characteristics conditions listed under the table power supply conditions using internal reset circuit are not met, the internal reset circuit will not operate normally and will fail to initialize the HD44780U. Finally care should be taken to wait so that the microcontroller powers up to threshold power.

The conductivity measurement of the blood can be impacted by various criterions. One among them would be the curve fitting method. Finally the data is processed using the relations y=mx+c to get the result of the conductivity. Where y is voltage acquired by the ADC, x is conductivity of blood, m is slope and c intercept. For each value of variation in voltage the equivalent conductivity is calculated. The result thus obtained has a specific baseline which ranges from 3.4mhos-1.2mhos illustrating it more specifically if the conductivity measurement falls on or in between the specified range, infer that the clotting has not occurred else confirm the blood clotting has perceived.

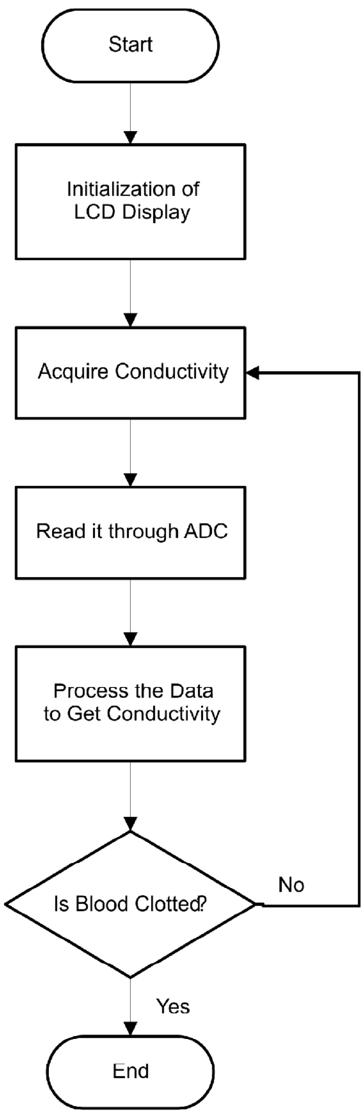

Figure 3: Main Flow Chat of the System

4. Results and Discussion

The designed Instrument is subjected to measure the conductivity of various blood samples at constant room temperature. The measured results are compared with the earlier work. It is found that the proposed measurement system shows almost similar results compared to earlier work.

The below figure 4 shows the graphical representation of variation of actual conductivity with respect to time. It is clear from the plot that the conductivity decreases as time elapses due to disappearance of conductive ions. Once the blood is clotted, conductivity reduces to great deal and becomes almost constant.

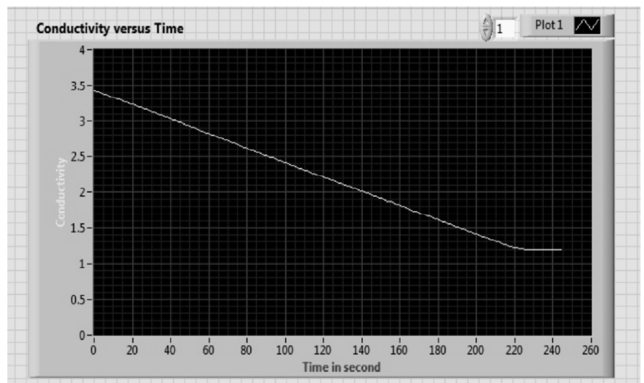

Figure 4: Graphical Representation of Variation of Actual Conductivity with Respect to Time

5. Conclusion

We have designed this system successfully to measure the conductivity. It is concluded that variation of conductivity becomes saturated when blood is fully clotted. From this it is observed that conductivity of blood is inversely proportional to coagulation process. It is concluded that if the saturation point is in between 5 minutes to 8 minutes then that person has normal blood coagulation. If it exceeds 8 minutes then there is a coagulation disorder for which detail investigations are required. The system has achieved better performance.

The incorporation of microcontroller has made the system programmable, compact, portable and low cost. Besides the system can store the measured data can be transmitted to PC through USB for further recording and analysis.

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