

Real Time Body Temperature and Perspiration Measurement System

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ABSTRACT: In this paper, a design strategy for measurement of Body Temperature and Perspiration is proposed. Human Body Temperature and Perspiration measurement provides vital information about the normal functioning of the body. The system includes Temperature Sensor, Perspiration Sensor, Microcontroller, UART and PC. In the proposed system, the Body Temperature and Perspiration is measured continuously in real time. The Silicon Labs' C8051F380 microcontroller acts as an interface between the sensors and PC. The data acquired from the microcontroller is transmitted to PC through UART Serial Communication. MATLAB tool is used for displaying output on PC.

KEYWORDS: Body Temperature, Perspiration and Microcontroller

I. INTRODUCTION

Body temperature and perspiration are the two vital signs that have to be measured constantly in a patient. Body temperature measurement is important to detect illness. This temperature can vary depending on the age, person, time of day and location from where the temperature is measured. The normal body temperature is 37.0°C [1]. The body temperature can be measured from mouth (oral), anus (rectal), arm (axillary) or ear (tympanic). The axillary temperature usually varies between 34.7°C to 37.3°C [2]. A high body temperature is one of the first signs that tells that the body is ill. The monitoring of body temperature can also determine whether the treatment given to the human body is working or not. So monitoring the body temperature is necessary in patients who are in their old age, for whom this information can be used to avoid them going into critical state.

Perspiration is the production of fluids secreted from the sweat glands in the skin. It is one of the early symptoms of heart problems. If the body sweats more than usual even when the body is not exercising or being active then it indicates abnormal functioning of the body [3]. Excessive perspiration indicates that pumping blood through clogged arteries takes more effort from the heart, so the body sweats more to keep the body temperature down. The perspiration measurement provides critical information about the human body. The high perspiration rate can give away signs of illness. The perspiration is related to the body temperature. When a person is too hot, excess heat will be carried onto the skin's surface. Then the person begins to sweat and body cools down. For a person who is in old age or with a heart condition, measuring body temperature and perspiration provides important information about the state of his body. The Body Temperature and Perspiration Rate are monitored continuously with accuracy and diligence. The accurate measurement of body temperature and perspiration has its impact on diagnosis and treatment.

II. RELATED WORK

There are a few existing approaches for the measurement of Body Temperature and Perspiration. The current technology for measuring the body temperature consists of the Infrared temperature sensor. Here the data from the

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temperature sensor is transmitted to the microcontroller and this data will be sent to the computer using ZigBee Technology [4]. The infrared sensor which includes thermocouple and thermistor is used to measure body temperature and transmitting data to the user's mobile phone using Bluetooth Technology in real time [5]. Another method to measure body temperature is a temperature probe consisting of digital temperature sensor that provides dual channels to measure the body temperature. This sensor operates in the range 16°C to 42°C and data is transmitted through the Bluetooth module and the software interface used is the serial communicator software embedded into Proton Development Suite [6]. To measure perspiration, the current technology involves a sweat sensor which composes gold and polyamide electrodes. The sensor works on the principle that when the resistance decreases the sweat level increases [7]. A moisture sensor is embedded in a shirt that measures the sweat level. Here the conductive part of the sensor is made from multifilament polyamide silver. Acid sweat solution and base sweat solution are applied to the sensor to test the variations in the measured resistance of the sweat sensor [8].

III. METHODOLOGY

Real time Body Temperature and Perspiration measurement system is designed based on Data Acquisition and Signal Processing. The data acquisition involves acquiring data from the sensors. The microcontroller is used to control and provide feedback to other hardware devices. Signal Processing involves processing the output from the microcontroller and displaying it on PC using MATLAB Tool. The main components of this system are Temperature Sensor, Perspiration Sensor and Microcontroller.

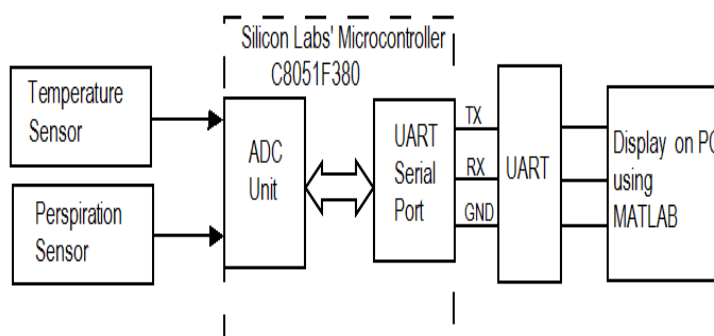


Figure 1: Block Diagram of Temperature and Perspiration Measurement System

Figure 1 represents the block diagram of Body Temperature and Perspiration Measurement System. The Temperature Sensor is used to measure the Body Temperature. The output is obtained in Voltage per degree Celsius and it will be in analog form. The Perspiration Sensor is used to measure the sweat rate and the output will be in analog form. This output will be given to the Silicon Labs C8051F380 Microcontroller [9]. The output from the microcontroller is sent to PC through Universal Asynchronous Receiver Transmitter (UART) Communication. Then the output transmitted through the UART is acquired into MATLAB and the output is displayed.

A. TEMPERATURE SENSOR

The temperature sensor used in this project is LM35. The LM35 series are precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature [10]. The output of LM35 is measured for 10mV/°C. It has accuracy of 0.5°C. The output voltage of LM35 linearly varies with temperature.

B. PERSPIRATION SENSOR

The perspiration sensor is designed using the conductive ink. Conductive ink is a water based dispersion of carbon pigment in Natural Resin. The conductive ink used in this design composes of water, natural resin, conductive carbon,

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humectant, diazolidinyl urea [11]. It is highly viscous and shear sensitive. Its surface resistivity is $55\Omega/50$ microns [12]. It works with low voltage DC power sources. It can be used as a potentiometer. It is also compatible with standard printing process. To demonstrate working of the perspiration measurement, a locally available Water Drop Sensor is used. Water Drop Sensor is a 3 pin device. The 3 pins are input supply, ground and output analog voltage. The overall resistance of the sensor is around $1M\Omega$. The resistor value will be high until a drop of water shorts the sensor and the resistance value decreases [13]. As the number of drops of water on the sensor increases the resistance reduces and the output voltage increases.

The output from the Temperature sensor and Perspiration sensor is given to the Analog to Digital Converter. The 10 bit Analog to Digital converter converts the analog inputs from the sensors to digital form. Then the output is sent to the PC through UART Serial Communication. The temperature sensor and perspiration sensor is given as input to the microcontroller at Port Pin 1.1 which is an analog pin. The sensors are given to the single channel Analog to Digital Converter of the Silicon Labs' Microcontroller C8051F380. The outputs from the sensors are in analog form and it is given to the microcontroller, which converts analog to digital form. The output from the microcontroller is given to the PC through UART. Then the output is displayed through MATLAB.

C. BODY TEMPERATURE SIGNAL PROCESSING

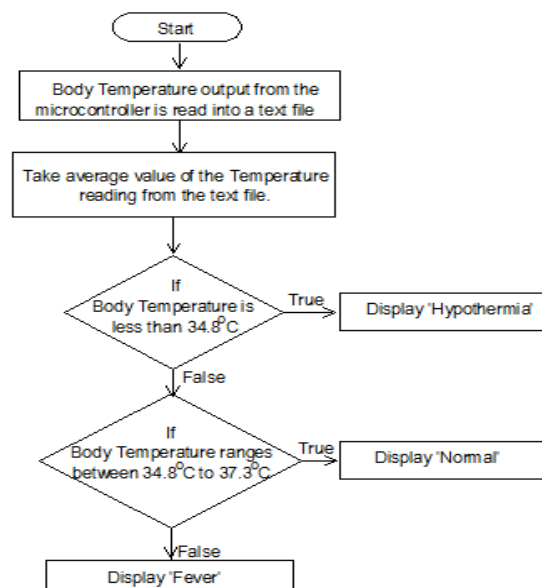


Figure 2: Flowchart for Body Temperature Measurement Classification

Figure 2 represents the classification of Body Temperature based on the measured Temperature. The data acquired from the microcontroller is stored in the text file using MATLAB tool. The average value of the temperature reading is taken from the text file. If the measured Body Temperature is less than 35.1°C then the person is hypothermic. If the measured Body Temperature ranges between 35.1°C to 36.8°C then the person has normal body temperature. If the measured Body temperature is greater than the normal range then the person has fever.

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IV. RESULTS AND DISCUSSION

A. BODY TEMPERATURE MEASUREMENT

Table 1: Comparison between Thermometer and Temperature Sensor Reading

Person	Thermometer Reading	Temperature Sensor Reading
1	35.6°C	35.3°C
2	36.7°C	36.5°C
3	36.2°C	35.87°C
4	36.2°C	35.79°C
5	36.4°C	36.02°C

An experiment is conducted where Body Temperature is measured from 5 individuals by placing the thermometer and temperature sensor under their armpits. The readings represent the normal body temperature of each person. After comparing the two readings correction factor for the temperature sensor is 0.324. The measured Body Temperature Reading using the Temperature Sensor is compared with Thermometer readings as shown in Table 1.

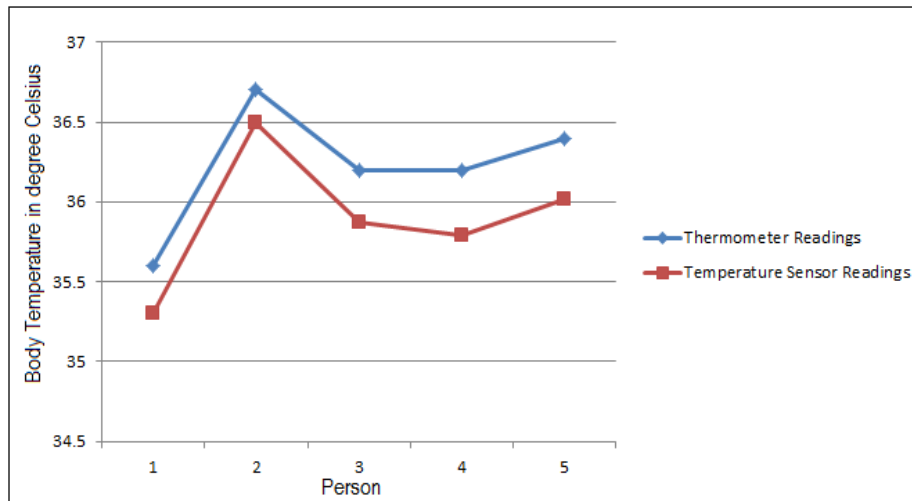


Figure 3: Variation of Thermometer and Temperature Sensor Readings

Figure 3 represents the chart for comparison between Thermometer and Temperature Sensor Readings. The Body temperature readings are measured from 5 individuals and it forms the x-axis and Temperature readings in degree Celsius forms the y-axis. The difference between the Thermometer readings and Temperature Sensor can be clearly distinguished.

B. PERSPIRATION MEASUREMENT

The perspiration sensor is designed using the conductive ink. Here the conductive ink is placed on a small patch of cloth and probes are connected from the two ends of the conductive ink pattern. Then a blotting paper is placed on it. The blotting paper absorbs water and spreads it onto conductive ink. Water in measurements of 0.05ml is sprayed on to the cloth with the help of a syringe. The resistance is measured using a multimeter.

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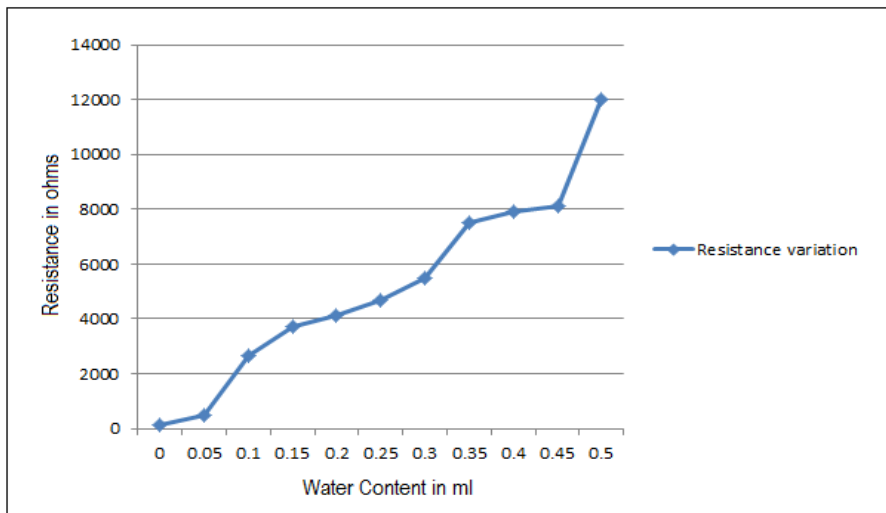


Figure 4: Graphical Representation of Resistance Variation using Conductive Ink

The resistance is measured with respect to water content in millilitres (ml). Figure 4 represents the graphical representation of resistance variation. As the amount of water on the conductive ink increases the resistance increases. Water content on the conductive ink is represented on the x-axis and resistance values are represented on the y-axis.

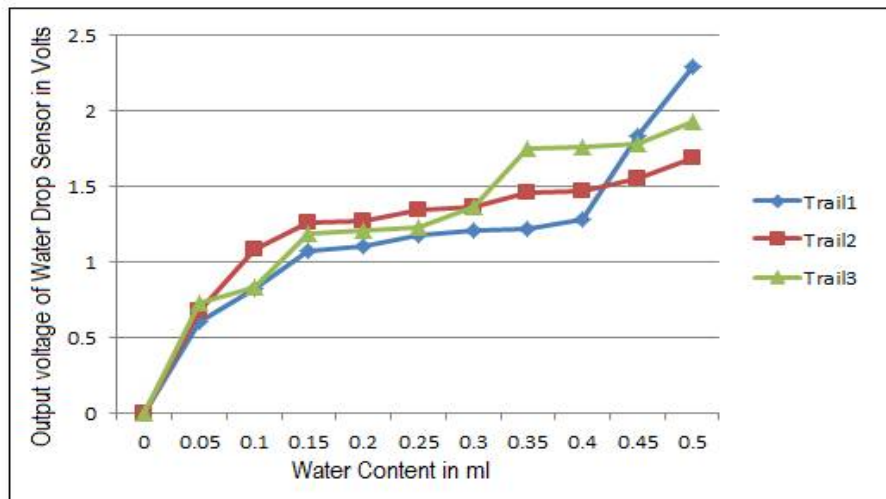


Figure 5: Graphical Representation of Different Trails of Water Drop Sensor

Figure 5 represents the three different trails on the Water Drop Sensor in the graphical form. The x-axis represents the water content on the water drop sensor and y-axis represents the output voltages of the water sensor. As the water content on the sensor increases, the output voltage increases. Water Drop Sensor is interfaced with Microcontroller Silicon Labs' C8051F380, the analog voltage is converted into digital form. Then data is acquired using the MATLAB tool.

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V. CONCLUSION

Using temperature sensor, a body temperature measurement system was successfully designed and analysed. Here the temperature sensor readings were compared with digital thermometer and the output of the temperature sensor closely matches with the digital thermometer. The conductive ink is tested for variation in resistance with respect to the water added on to the ink. Also, water drop sensor was tested to demonstrate the perspiration measurement and variations in the output voltages with respect to the water quantity on the sensor was analysed. Further experimentation is required to design a wearable perspiration sensor using conductive ink and it has to be calibrated to measure perspiration rate.

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