Braille Thermometer: Thermometer for deaf-blinds

Conference Paper · December 2014

DOI: 10.1109/ICECE.2014.7026867

2 authors:

Md Didarul Islam
University of Nebraska–Lincoln

Abdullah Saif Mondol
Leibniz Institute of Photonic Technology

Braille Thermometer: Thermometer for Deaf-blinds

Design and Implementation of Braille Thermometer and Its Performance Comparison with Clinical Thermometer

Md. Didarul Islam,[1] Abdullah Saif Mondol[2]
Department of Electrical and Electronic Engineering[1], Faculty of technology and bionics[2]
Uttara University[1], Rhine – Waal University of applied sciences[2]
Dhaka, Bangladesh[1]; Kleve, Germany[2]
*s102bueeet@yahoo.com

Abstract— **This paper introduces a new clinical thermometer named as 'Braille Thermometer' which will be used for measuring the body temperature of patients who are blind and also have hearing problem (deaf-blind). It is actually a microcontroller based device which collects temperature through a temperature sensor and indicates this temperature in a dial which is marked in Braille numbers. In this paper, the temperature readings of the Braille thermometer are also crosschecked with the readings of a clinical thermometer where input temperature was taken from the same source.**

***Index Terms*—Braille numbers, thermometer, deaf-blind, microcontroller, temperature sensor, stepper motor.**

INTRODUCTION

Clinical/ medical thermometer is available in the market. But these things are of no use to the blind people. Modern science has created audible thermometers too, which will tell the temperature aloud. Number of those people is not negligible who is blind and also have hearing problem at the same time. Considering people who have such condition, known as deaf-blinds, Braille thermometer is a great attempt. Patient can know their body temperature with the help of Braille numbers. This thermometer can indicate temperature from 98^{o}F to 108^{o}F (only integer temperatures, not fractions). At the end of this paper, the temperature input and corresponding indication is plotted with the help of MATLAB.

RESEARCH METHODOLOGY

In this Braille thermometer, human body temperature is measured in Fahrenheit. But the temperature sensor used here, calculates everything in Celsius. So, the following formula has been used to convert the temperature from degree Celsius to degree Fahrenheit [1]:

$$T_C = \frac{5}{9}(T_F - 32)$$

This temperature sensor has the following relation between input temperature and output voltage:
For 1^{o}C input temperature, the output voltage will be 10 mV; which is discussed in the Modeling & Design section.
In order to get the desired output, corresponding to a specific input signal, the microcontroller used here needs to convert analog signal into digital signal. The conversion result can be formulated as follows [2]:

$$ADC = \frac{V_{IN} \times 1024}{V_{REF}} \quad (1)$$

Where V_{IN} is the input voltage and V_{REF} is the selected reference voltage.

MODELING & DESIGN

The model of the Braille thermometer is constructed with six major components. These components are:

1. 5V fixed DC supply.
2. Temperature sensor.
3. Microcontroller.
4. Motor driver.
5. Stepper motor.
6. Braille dial.

These major sections and their interconnections are illustrated in Fig. 1:

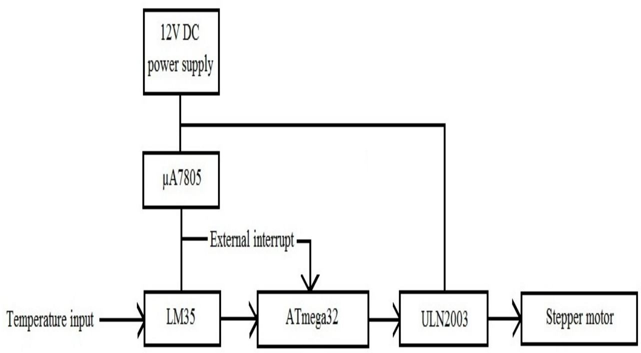

Fig. 1 Block diagram of the Braille thermometer.

In this Modeling and Design section, the entire component's power supply, input and output connections are described. Also the signal transferring between two segments is explained sequentially.

Fixed 5V DC Supply

For both ATmega32 microcontroller and temperature sensor LM35 to operate, a constant 5V DC supply is required. This is done with the help of µA7805 IC. If an input DC voltage greater than 5V is given between pin 1 and pin 2 (ground), with the following circuit arrangement, then a constant output of 5V is found between pin 3 and pin 2 of µA7805 IC [3]:

978-1-4799-4166-7/14/$31.00 ©2014 IEEE

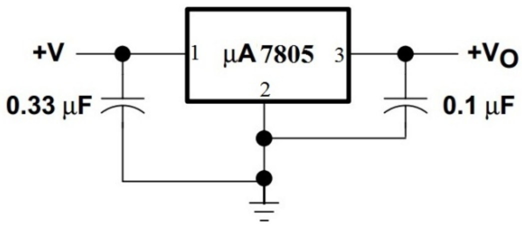

Fig. 2 Fixed 5V DC output regulator using μA7805 IC.

Temperature Sensor

LM35 IC is used as the temperature sensor for Braille thermometer which can detect temperature from -55°C to 150°C [4]. Here temperature is being measured from 98°F to 108°F, in Celsius scale 36.67°C to 42.22°C, which is quite within the range of the temperature sensor.

The constant 5V which acts as the supply voltage for this IC, is connected between pin 1 and pin 3 (ground). LM35 is an analog sensor which converts the surrounding temperature to a proportional analog voltage [5]. Now an output voltage corresponding to room temperature can be found between pin 2 and pin 3. If anyone holds the LM35 IC with his hand, output voltage will change according to his/her body temperature. From LM35 datasheet, few input temperature and output voltage relationships can be found like below [4]:

TABLE I
FEW TEMPWRATURE INPUTS AND THEIR COORESPONDING OUTPUT VOLTAGES FOR LM35 TEMPERATURE SENSOR.

Input temperature (°C)	Output voltage (mV)
-55	-550
25	250
150	1500

Microcontroller

Taking an input signal and converting this signal into an desired output signal, microcontroller is required. ATmega32 microcontroller is chosen for that purpose, considering its connection and coding simplicity.

Now, the output voltage of the LM35 temperature sensor will act as an input signal to the ATmega32 microcontroller's Analog-to-Digital Converter. For this microcontroller, Port A (pin 33 to 40) is the ADC [2]. Pin 40 is selected as the input pin of the microcontroller. The operating principle of the ADC is illustrated in equation (1). 5V fixed DC supply is selected as the reference voltage of the Analog-to-Digital Converter, which is connected to the pin 32 [2] of ATmega32. When the microcontroller gets an external interrupt signal, it will give output signal to its selected output port (Port C chosen here). Pin 16 (INT0) of ATmega32 microcontroller is used here to accomplish that job [2], where with the help of a push button an external interrupt is given whenever the output of the microcontroller is required. The microcontroller code was written and converted to HEX file with AVR studio software. The HEX file was loaded in the microcontroller with the help of PonyProg software, while the microcontroller was connected to a computer's parallel port with a DB 25 connector [6]. The necessary hardware required to load the program in ATmega32 microcontroller is shown in Fig. 3.

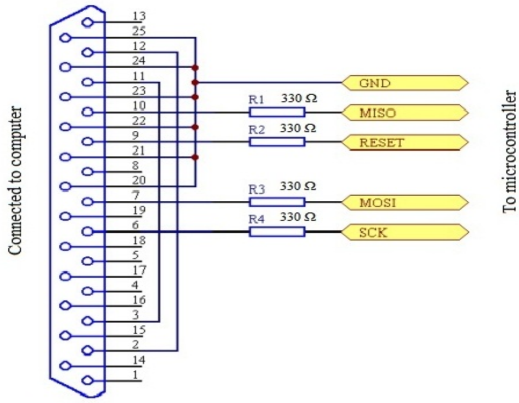

Fig. 3 Hardware used to load program in ATmega32.

The output of the microcontroller is connected to the motor driver.

Motor Driver

ULN2003 motor controller is a Darlington array IC which is generally used for interfacing between low level logic circuitry and power loads. Motor driver is necessary here, because stepper motor cannot be directly operated from a microcontroller. In order to drive a stepper motor, high current is required, which is supplied by that IC. This particular IC has seven drivers. ULN2003 IC's Pin 9 is provided a fixed 12V DC supply and pin 8 of is connected to ground [7].

Stepper Motor

It will be a convenient and feasible design if a stepper motor of 30° step angle is used here. If the step angle is a factor of 30, then it will work too. Stepping motor M42SP-6NPK is used here whose step angle is 7.5° [8]. So, in order to give a 30° rotation, the motor will have to move 4 steps.

Stepper motor M42SP-6NPK has four wires of color Red, Orange, Blue and Yellow. If a square pulse is given between the Red and the Orange wire, then the motor will rotate in clockwise direction. Whereas a square pulse between the Blue and the Yellow wire will rotate the motor in counter clockwise direction.

Braille Dial

The whole motor, indicator setup is mounted on a dial where temperature is written in Braille numbers from 98°F to 108°F.

The temperature indicating Braille dial has 12 sections. These sections are:

98°F	99°F	100°F	101°F	102°F	103°F
104°F	105°F	106°F	107°F	108°F	START

Their corresponding Braille numbers are as follows [9]:

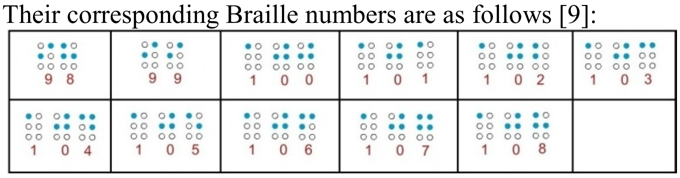

Fig. 4 Braille numbers from 98 to 108.

The Braille thermometer with its power supply and the program loader is shown in Fig. 5:

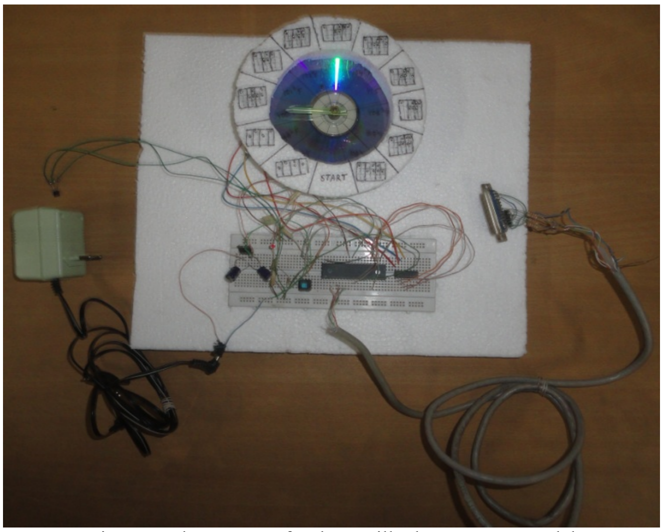

Fig. 5 Hardware setup for the Braille thermometer model.

OPERATING PRINCIPLE

Firstly, the overall circuit will have to be powered up with a 12V DC power supply. From here a fixed 5V DC supply will be generated. In this setup, the temperature sensor and the microcontroller will require 5V fixed DC supply and the motor driver needs 12V DC voltage. Then, when a person holds the temperature sensor, it gives the output voltage corresponding to the input temperature as discussed in the Research Methodology section. Human body temperature is an analog signal and corresponding output voltage of LM35 is also an analog signal. So, the output signal of LM35 will have to be converted to digital signal, since microcontroller deals only with digital signals in its algorithm part. That's why output of the LM35 temperature sensor is connected to the ADC (Analog to Digital Converter) of ATmega32. When the microcontroller's ADC gets an analog input voltage, it converts the analog signal into digital signal as mentioned in equation (1). With an appropriate microcontroller code, ATmega32 can produce desired output voltage at selected output pins corresponding to a particular input. The coding part describes the relation between input temperature and the corresponding number of pulses generated in the output pins to rotate the stepper motor specific degrees. By connecting the bidirectional stepper motor to the microcontroller's output port, the stepper motor can be rotated from 0^o to 360^o both clockwise and anticlockwise. The stepper motor will have an indicator needle connected to its rotor. Patient will have to follow the indicator with hand and read the corresponding temperature by touching the Braille numbers on the dial.

But, as mentioned earlier, stepper motor cannot be directly operated from microcontroller. In order to do that stepper motor should be connected with microcontroller through a Darlington array IC like ULN2003.

Initially, the stepper motor's indicator will be fixed at a position named as 'START'. Now according to the temperature sensor's input the stepper motor will rotate clockwise few degrees, stay there for 30 seconds and again rotate anticlockwise those particular degrees. That means after waiting 30 seconds, the indicator will return to its initial position. The complete algorithm of Braille thermometer's operation is chronologically explained through a flowchart:

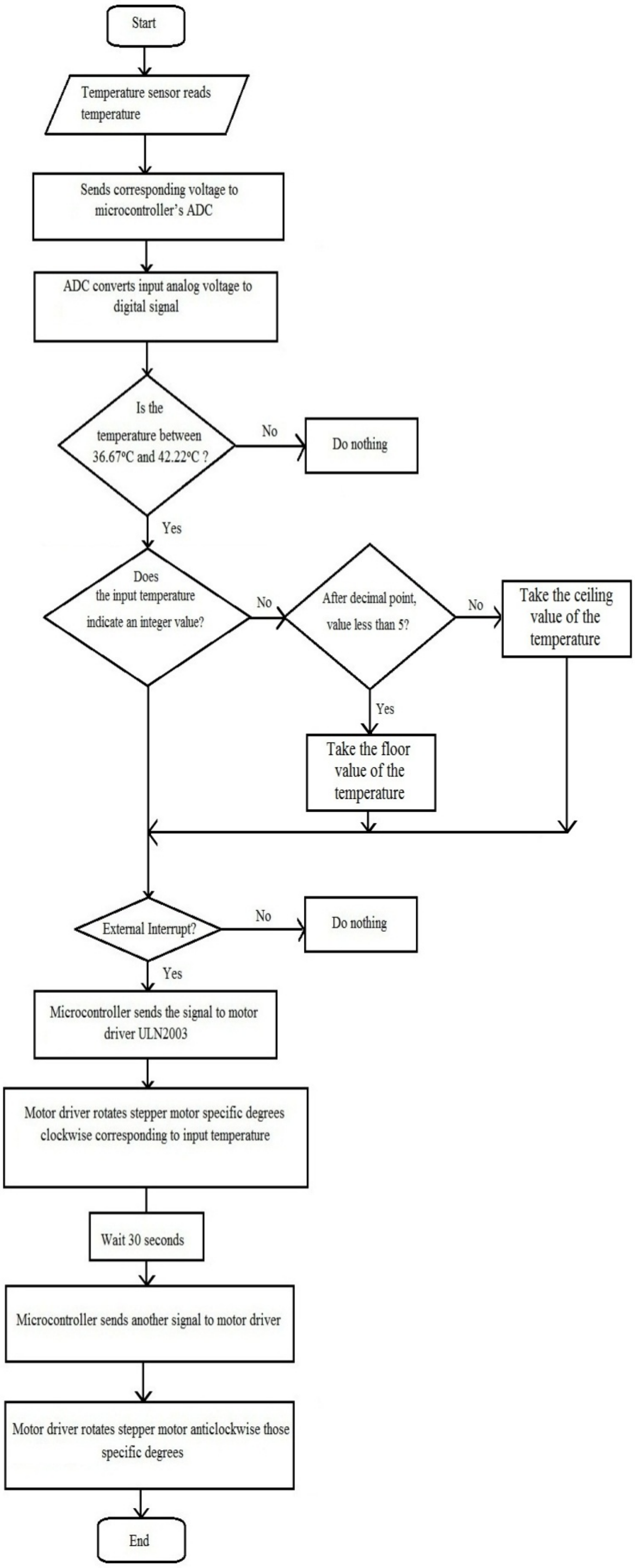

Fig. 6 Flowchart for the operating principle of Braille thermometer.

Results & Discussions

In order to check the Braille thermometer's performance, its temperature sensor was heated from 98°F to 108°F with a temperature variable heater. For a particular temperature, Braille thermometer's reading was taken. At the same time, the heater's temperature was also measured by a clinical thermometer. From this comparison it was observed that, for an integer temperature, the reading of the Braille thermometer and the reading of the clinical thermometer was same. Fig. 7 shows how Braille thermometer and clinical thermometer are reading temperature of a heater at the same time.

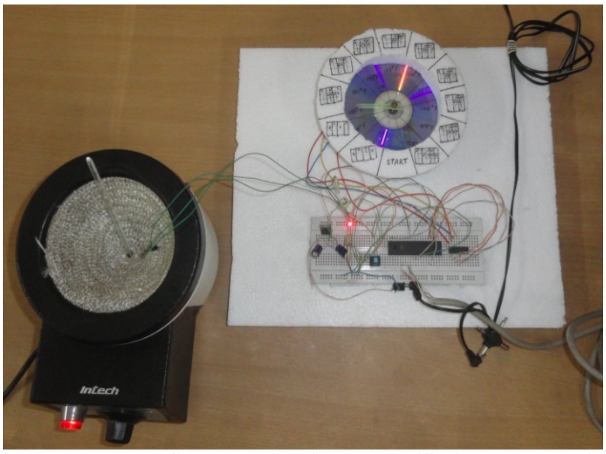

Fig. 7 Temperature reading comparison between Braille thermometer and clinical thermometer.

For 98°F to 108°F temperature, the Braille thermometer's stepper motor rotation was recorded and a temperature versus rotation graph was plotted using MATLAB.

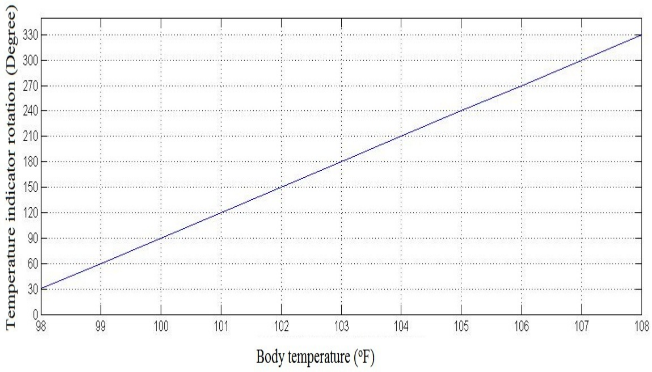

Fig. 8 Graph between temperature and corresponding motor rotation.

Here only integer temperature has been used for calibrating the Braille thermometer. Whenever a fractional temperature is given as input, the microcontroller follows a simple algorithm to convert the fractional temperature into an integer one. If, after the decimal point, the temperature is less than 5, the microcontroller will consider its floor value (e.g. for 100.25°F it will consider it as 100°F). But after the decimal point, if the temperature is equal or greater than 5, the microcontroller will convert it into the ceiling value (e.g. 100.5°F will be interpreted as 101°F).

Conclusion & Future Work

From the previous comparisons and observations it can be concluded that, this Braille thermometer model is only perfect for integer values of body temperature. This is not completely a practical expectation, because, for many medical applications, a little bit temperature change may hold a large significance. Considering this single limitation, Braille thermometer can be an excellent device to measure a deaf-blind patient's body temperature by himself/herself.

For future work/research, Braille thermometer can be constructed in such a way that it will indicate fractional temperatures (e.g. one digit after decimal point) too. But on a single dial, accommodating so many (101 values, if all the values between 98°F to 108°F is show) Braille numbers is not easy to manage. On the other hand, for a deaf-blind patient, it will be very difficult to pinpoint his/her temperature. The idea of solving this problem is: for fractional temperatures, the patient will read the integer part of the temperature from the Braille dial as this model does. And for measuring the fractional part, there will be another vibrating motor, which will vibrate according to the value of the fractional temperature (e.g. for 0.5°F the vibrating motor will vibrate 5 times). In this research work, the circuitry was powered by an adapter. Light weight rechargeable battery can be used to reduce the weight, which will be convenient for carrying too. For professional construction, instead of breadboard; veroboard or Printed Circuit Board (PCB) can be used for wire connections. Finally, the motor used (M42SP-6NPK) has a weight of 96 grams. This can be replaced by a motor of small size and weight (e.g. stepper motor PN 16305. Its weight is around 9 grams and has a 30° step angle [10]). Thus Braille thermometer can be made more accurate, compact, portable and easy to use.

References

[1] David Halliday, Robert Resnick, Jeart Walker, "Fundamentals of Physics," 7th edition, pp. 480

[2] Information available at: http://www.atmel.com/images/doc2503.pdf Accessed on: 6th June 2014

[3] Information available at: http://www.ti.com/lit/ds/symlink/ua7805.pdf Accessed on: 7th June 2014

[4] Information available at: http://www.ti.com/lit/ds/symlink/lm35.pdf Accessed on: 7th June 2014

[5] Mahmud, K. ,Alam, M.S. , Ghosh, R : "Design of digital thermometer based on PIC16F77A single chip microcontroller"-2013 3rd International Conference on Consumer Electronics, Communications and Networks (CECNet), IEEE, pp 246-249,ISBN:978-1-4799-2859-0,November 2013

[6] Information available at: http://www.qsl.net/ba1fb/avrisp.gif Accessed on: 6th June 2014

[7] Information available at: http://www.ti.com/lit/ds/symlink/uln2003a.pdf Accessed on: 7th June 2014

[8] Information available at: http://www.datasheetarchive.com/dl/Datasheets-SL3/DSASL0049076.pdf Accessed on: 7th June 2014

[9] Information available at: http://www.ridbcrenwickcentre.com/louisbraille/facts/braille-punctuation/ Accessed on: 6th June 2014

[10] Information Available at: http://www.aeroflex.com/ams/motion/datasheets/stepper_30_degree.pdf Accessed on: 7th June 2014