Design Of An Electronic Thermometer For Simultaneous Temperature And Time Measurement

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ABSTRACT

The conventional mercury-in-glass thermometer exhibits many deficiencies. These deficiencies include fragility, susceptibility to measurement errors and exposure to hazardous material content. The presented design for the electronic thermometer is smart, cost-effective, user friendly and has better functions (e.g. time, date and temperature readings). The thermometer was simulated in Proteus lite and programmed using Mikro C pro. The PIC16f877A microcontroller was interfaced with DS1307 real time clock chip to keep the time and date. The thermometer can be used for applications that require a simultaneous temperature and time measurement. In addition, the reprogrammable microcontroller presented in the design makes the thermometer adaptive to most temperature measurement cases.
Keywords: Microcontroller, Temperature, Thermometer, Programming.

INTRODUCTION

The thermometer is a temperature-measuring device, which for the human body takes small measurements that is centered on 37˚C. Hospitals, chemical industries and laboratories usually employ separate instruments for the measurementof temperature and time. Environmental hazards caused by mercury and its toxic effect on the human body has resulted in the replacement of the mercury-in-glass thermometer in almost all facilities especially the healthcare facilities (Akinloye, 2016), (Dicristina, 2010). Mercury-in-glass thermometers may explode if mistakenly used in a reaction where temperature exceeds its range. Again, reading error can be introduced as a result of error due to parallax. There are existing electronic/digital thermometers that employ sensors whose electrical properties vary in some way with temperature change. These temperature sensors (LM35) combined with signal conditioning elements, signal processing elements and data presentation/display elements form an electronic thermometer which could be analog or digital (Mahmud, et al.,2013). Some electronic thermometers use wireless transmission techniques via Bluetooth technology to transmit measured data to smart phones (Qiao, et al., 2013). Generally the electronic thermometer is portable, has permanent probes, and a digital display. They typically use a power source (battery). These thermometers ate faster and more convenient to use. Employing a timing device on a thermometer allows a user to take record of measured temperature and time simultaneously with much ease and it also reduces the risk of errors. A precision temperature sensor, real time chip and microcontroller that can perform computations will eliminate errors by enhancing the device's accuracy, flexibility and programmability (Mahmud, et al.,2013), (Auwal, et al., 2017). This means that the product can easily be modified to any application. For instance, by changing the application program, the device can suit different uses instead of redesigning the electronic circuit. The aim of this design is to incorporate the measurement of temperature and thermometer into one device. In this paper, an electronic thermometer with a reprogrammable microcontroller will be designed, simulated and implemented to read temperature and time simultaneously.

Design methodology

The design of the electronic thermometer is divided into two sections: the hardware section and the software section. The hardware design forms the main circuitry of the electronic thermometer. It is made up of the power supply unit, sensing unit, processing unit, real time clock, and display. Figure 1 gives the block diagram of the system.

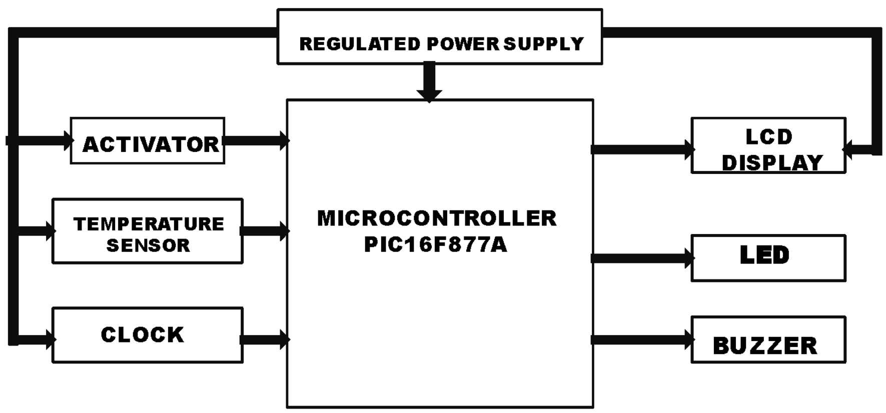

Figure 1: Block diagram

Microcontroller unit

The control module is built with the microcontroller IC. The central controller is Microchip PIC16F877A. PIC 16F877A is an upper range and 16 series low cost 8 bit microcontroller [2, 3]. It consists of 33 I/O (Bi directional lines) with 25mA current in per pin. It also has 5 channel built-in A/D converter and serial communication. Its synchronous serial port can be configured as either 3-wire serial peripheral interface (SPI) or the 2-wire Inter-Integrated Circuit (I^2C) bus. Universal Asynchronous Receiver Transmitter (UART) is another useful feature of this device. The PIC16F877A microcontroller has 5 Ports which are Port A, B, C, D, and E. Port A is the analog input pin by default, however it will be used as a digital input/output and it must be declared as (ANSEL=0). Port B, C, D, and E are also digital input/output pins which are 8, 8, 8, and 3 bit respectively.

Display unit

The display unit, a 16x2 LCD, acts as an information interface between the microcontroller and the measurement being taken.The display was connected to PORT B of the microcontroller and interfaced to the microcontroller using 4-bit mode. The 4-bit mode uses only 4 pins of the LCD i.e. pin D4, D5, D6, and D7 for data communication. Pin D4, D5, D6, D7, RS, E of the LCD were connected to pin RB0, RB1, RB2, RB3, RB4, RB5 of the microcontroller respectively while VEE, VDD and VSS were connected to the Potentiometer, +5volt and ground respectively. The R/W pin was grounded because the microcontroller will only send information to the LCD.

Sensory unit

The sensory unit comprises the LM35 which is an integrated-circuit temperature device with an output voltage linearly-proportional to the centigrade temperature (55^{o}C to 150^{O}C). The LM35 has three pins out which must be configured to communicate with the microcontroller. Pin 1, 2, 3 are connected to +5 volt, the microcontroller, and ground respectively. Pin 1 has a voltage range from 4-20V.

Real time clock

DS1307 is a low power serial real time clock with full binary coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM (Non Volatile Static Random Access Memory). Data and Address are transferred serially through a bidirectional I2C bus. The RTC provides year, month, date, hour, minute and second information. The end date of months is automatically adjusted for months fewer than 31 days including leap year compensation up to year 2100. It can operate either in the 24-hour format or the 12-hour format with am/pm indicator. DS1307 comes with built-in power sensing circuit, which senses power failures and automatically switches to back up supply. It uses an external 32.768kHz crystal oscillator and does not require any external resistors or capacitors to operate. Pin X1 and X2 were connected to the 32.768KHz crystal oscillator while the positive terminal of a 3 volts battery was connected to Pin V_{bat} and the other terminal of the battery grounded. Pin SCL and SDA are both connected separately to pin 18 and 23 of the microcontroller and also connected to pull-up resistors.

Alarm and indicator unit

The alarm unit, the piezo buzzer, is an electromechanical device having two pins out. The buzzer is amplified with an NPN transistor. The indicator used is the light emitting diode (LED). Different LEDs were used to indicate variation of temperature, and each LED was connected to a 330-ohm resistor. The resistor regulates the current passing through the LED. The green LED was connected to pin 39 of microcontroller to indicate when there is contact between the LM35 and the measured point. The blue LED was connected to pin 19 of the microcontroller to indicate Normal temperature while the yellow and red LEDs were connected to pins 20 and 21 of the microcontroller to indicate Low and High temperatures respectively.

DESIGN & IMPLEMENTATION

The physical implementation of the electronic thermometer is shown in figure 4. The assumption in the implementation is that the device will be used to measure human body temperature. After initialization, as soon as the system's probe comes in contact with the human body, the temperature reading begins to increase or decrease until the temperature reading remains fixed. A check button is pressed and if the temperature is within 35.7^{o}C – 37.5^{o}C, a blue LED is turned on and NORMAL TEMPERATURE is displayed. If the temperature is less than 35.7^{o}C a yellow LED is turned on displaying WARNING! HYPOTHERMIA SUSPECTED. If the temperature is above 37.5^{o}C it blinks a red LED and buzzer an alarm for three times and then displays WARNING! HEATSTROKE SUSPECTED. The system's flow diagram of operation and circuit design is presented in Figure 2 and Figure 3 respectively.

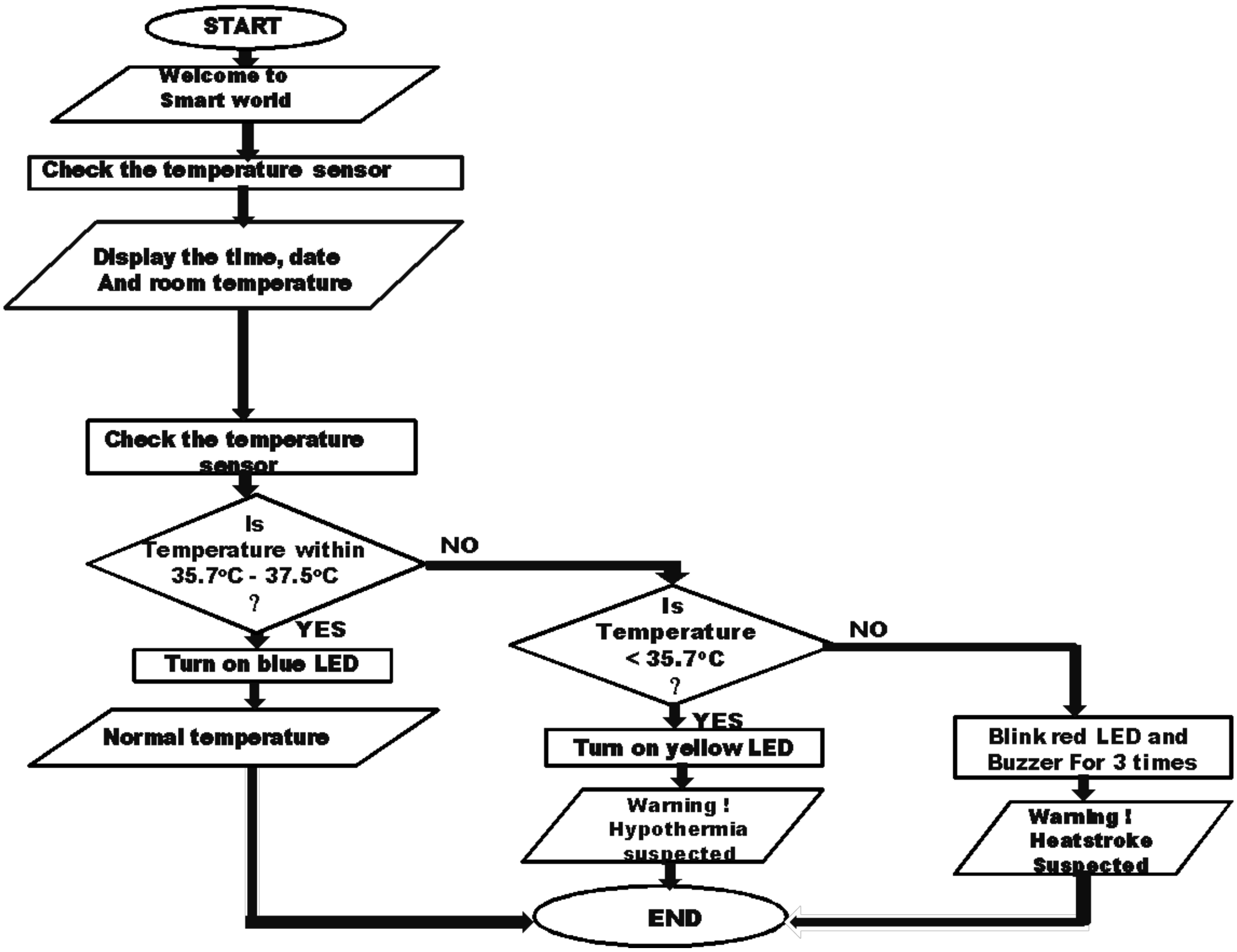

Figure 2: Flow chart of operation

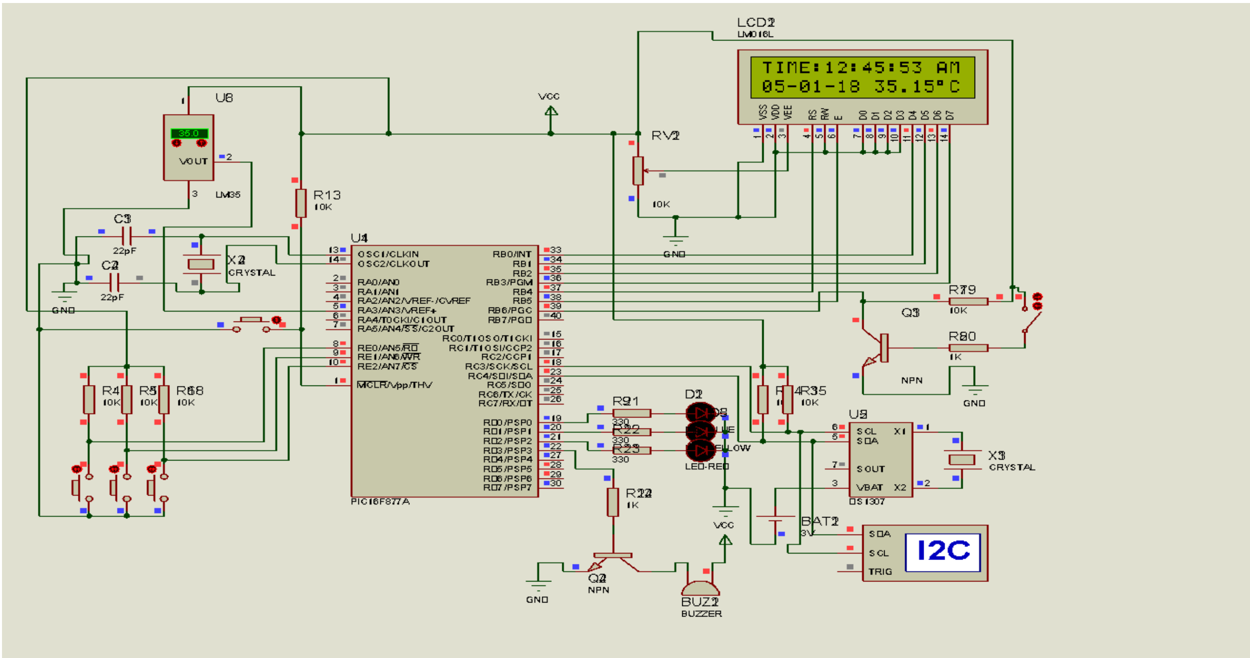

Figure 3: Circuit design on Proteus Lite

Figure 4: Implementation of the electronic thermometer

CONCLUSION AND RECOMMENDATIONS

The successful design and implementation of the electronic thermometer was achieved, through research, simulation and physical implementation. The electronic thermometer monitors and displays temperature as well as alerts its user on variation in temperature reading. Its design and implementation focused on the medical field to detect illnesses relating to low and high body temperatures. This project is not an invention, but an alternative way of achieving an aim that has already been realized through a more modified method. Although electronic thermometer has been invented in the past, this project includes an alarm system as well as a timing and display technique to enrich it. Recommendations are based on design considerations and available resources. The design can be improved upon by adding an SD-card unit for data logging of various reading in real time, enabling medical professionals to take consecutive reading. The project can be modified further to have some sort of control and a very small time delay probably nanoseconds. This could help protect medical personnel, security personnel and individual from getting infected by contagious diseases at hospitals or accidents at laboratories and industries.

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