

# Digital Thermometer: Design & Implementation using Arduino UNO Based Microcontroller

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**Abstract**— Temperature is an important parameter for diagnosing any disease. Temperature is a measurement of average kinetic energy of the molecule in an object or system which can be measured by means of thermometer. There are various method available to measure body temperature which are analog and digital thermometer. An analog thermometer is device that measure temperature or temperature gradient a thermometer has two important elements which are temperature sensor mercury in glass thermometer in which some physical changes occur with temperature and this physical changes converts into numerical value (visible scale). The measure drawback of analogy thermometer is poor accuracy and poor sensitivity this drawback is overcome by digital thermometer which is based on sensor & processor.

**Key words:** Temperature, Thermometer, Arduino, Sensor lm35, AT Mega 32

## I. INTRODUCTION

Measurement of body temperature is a crucial step in medical diagnostic procedure and Thermometer is an indispensable device for this purpose. There are basic two types of Thermometers: (1) Mercury based Thermometer (2) Digital Thermometer. Now a days, Digital Thermometers have captured the market by displacing mercury based Thermometers. We have gone one step ahead by adding facility to record the readings along with the date and time of the measurement, and further forward these reading to the doctor using a GSM module.

It has been found that aged patients are required to visit the doctor on regular basis for minor check-ups. So to avoid this inconvenience we have developed a new instrument which allows patient to measure the body temperature and forward it to the doctor very easily.

Normal human body temperature, also known as normothermia or eutheria, depends upon the place in the body at which the measurement is made, the time of day, as well as the activity level of the person. Nevertheless, commonly mentioned typical values are:

Oral (under the tongue):  $36.8 \pm 0.4$  °C ( $98.2 \pm 0.72$  °F)  
Internal (rectal, vaginal):  $37.0$  °C ( $98.6$  °F)

### A. Block Diagram

The digital thermometer is designed using LM35 temperature sensor, Arduino UNO board & LCD. LM35 temperature sensor senses the temperature & converts it into analog value (mV) as shown in figure 1. Then this analog value is fed into analog channel of Arduino UNO. Arduino UNO receives this analog value & convert it into digital signal using in built ADC. After that digitized value is displayed on LCD display.

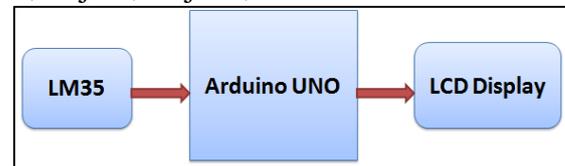


Fig. 1: Block diagram of Digital Thermometer using Arduino

## II. CIRCUIT DESIGN

### A. Power Supply

The power supply requirements for the three sections of the project are all 5V (LM35 Data sheet, 2014; Arduino UNO Data sheet, 2015; LCD data sheet, 2015). An LM7805 voltage regulator was used to provide steady 5V supply for the three sections.

### B. Lm35 Temperature Sensor Circuit

The fundamental necessity of the research is the conversion of the measured temperature into a corresponding electrical signal. There are many transducers capable of performing this, among which are thermocouple, thermistor and LM35 IC series. For convenience, availability and many inherent advantages a version of the LM35 series is chosen. The LM35 series are precision integrated-circuit temperature sensors, whose output voltages are linearly proportional to the Celsius (Centigrade) temperature.

The LM35 thus has an advantage over other temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming and has low output impedance, linear output, and precise inherent calibration that make interfacing to readout or control circuitry especially easy. As it draws only 60  $\mu$ A from its supply, it has very low self-heating (LM35 Data book, 2010). One common temperature sensor in the LM35 series available in the market is LM35DZ. There are other temperature sensing components in the same series like LM334, DS1820 etc. The LM35DZ is a precision semiconductor temperature sensor giving an output of 10mV per degree Centigrade rise. According to its data sheet (LM35 Data book, 2010) an RC circuit should be connected across the output and ground of the LM35DZ, if a long cable is used. This is to reduce the capacitive effect of the cable. A capacitor of 1 $\mu$ F and a resistor of 100 ohms were connected across the IC as shown in figure 2.

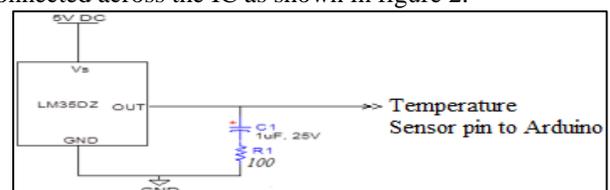


Fig. 2: LM35 Temperature Sensor Circuit

### C. LCD Circuit

The LCD employed is a 16 x 2 type capable of displaying 32 characters in alphanumeric form. It has a wide range of LCD driver power from -3 to 1V with high speed MPU bus interface of 2MHz when the supply voltage is  $V_{cc} = 5V$ . It can also be configured as 4 bit or 8 bit interface enabled to transmit or receive data in either 4 bits or 8 bits. It consumes very small power with automatic reset circuit that initializes the controller/driver after power on. Internally there is an oscillator that has external resistors (LCD Data book).

The LCD was configured to drive its dot-matrix under the control of 4-bit output of the microcontroller. A regulated supply of 5V was used to supply the chip which is within the recommended supply voltage of the chip. A 100Ω resistor was included as a current limiting resistor. The pin 16 of the chip is the  $V_{cc}$  while pin 1 is the ground and was connected to the 0 line of the supply. Since only four bits are used to receive data from the micro, the upper nibble of the byte line was used while the lower nibble (Do to D3) was connected to the ground as recommended in the data sheet. To achieve this, pins 7, 8, 9 and 10 (upper nibble) were grounded while pins 11 to pin 14 (lower nibble) were connected to receive the 4-bit data from the main micro.

A variable resistor is provided to adjust the brilliance of the LCD. The value as recommended in the datasheet is from 10k to 30k. For this, a 10k variable resistor was used to vary the brightness of the LCD. Pin 5 of the LCD is used as the enable pin to activate the device and set it for operation. Pin 4 is the reset pin that is used to clear the registers of the LCD. The data transfer from the microcontroller is completed after the 4 bit data has been transferred twice. The order of transfer is that the four lower order bits (D4 to D7) are transferred before the four higher order bits (Do to D3). The circuit configuration of the LCD circuit is as shown in figure 3.

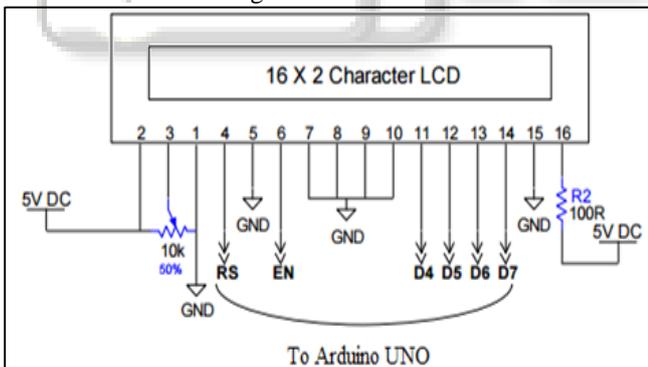


Fig. 3: LCD Circuit

### D. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button as shown in figure 4. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

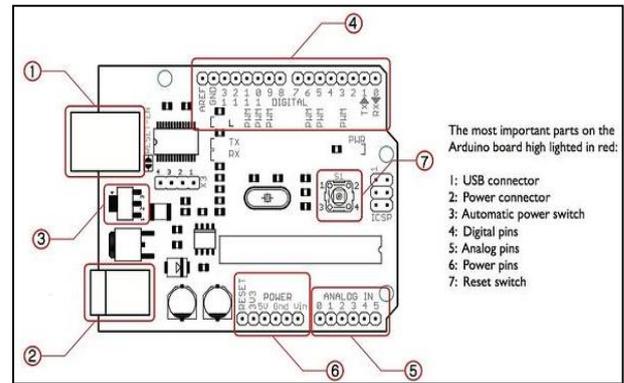


Fig. 4: Arduino UNO board

#### 1) Features Of Arduino Uno Board

- Microcontroller ATmega328
- Operating Voltage 5V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 14 (of which 6 provide PWM output)
- Analog Input Pins 6
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA
- Flash Memory 32 KB (ATmega328) of which 0.5 KB used by bootloader
- SRAM 2 KB (ATmega328)
- EEPROM 1 KB (ATmega328)
- Clock Speed 16 MHz

#### E. Arduino UNO Software Flow Chart

The temperature condition at any instant as sensed by the LM35 is displayed on a Liquid Crystal Display (LCD). To do this the Arduino UNO is programmed to copy the output of the ADC (which is inbuilt ADC) and convert the result to ASCII then transferred to the LCD to be displayed. The flow chart in figure 5 shows the software algorithm of the Arduino UNO microcontroller.

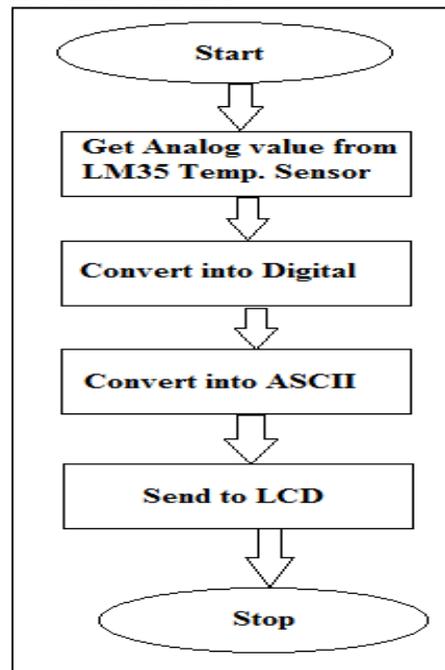


Fig. 5: Arduino UNO software flow chart

### III. CIRCUIT CONSTRUCTION & TESTING

#### A. LM35 Circuit

The LM35 temperature sensor circuit was constructed using the components listed in Table 1.

S/N	Component	Description	Quantity
1	Temperature Sensor	LM35	1
2	Capacitor	1 $\mu$ F	1
3	Resistor	75 K $\Omega$	1
4	Wires	Twisted	

Table 1: Lm35 Circuit List Of Components

The LM35 circuit was constructed with the capacitor connected very close to the IC. The wires were covered up with a tape which will ensure that the leads and wires are all at the same temperature at the surface, and that the LM35 die's temperature will not be affected by the air temperature to ensure accuracy. The wire was twisted together to reduce the length hence making it more convenient and beautiful.

#### B. Interfacing of LM35 with Arduino UNO

As shown in figure 6, Output of LM35 temperature sensor is given to analog channel A1 of Arduino for sensing real time temperature.

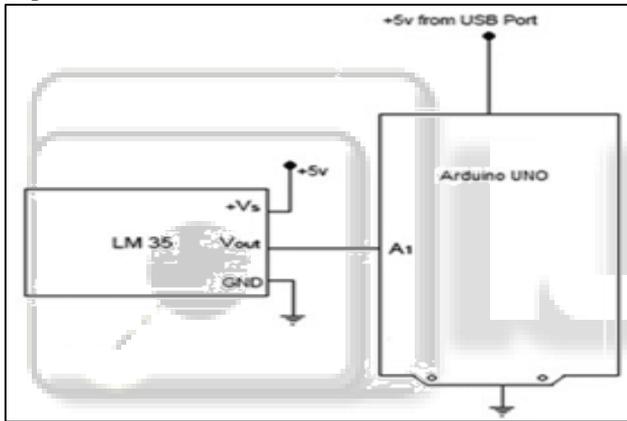


Fig. 6: Interfacing of LM35 with Arduino

#### C. LCD Circuit

The LCD display unit circuit was constructed on the circuit board using the components listed in Table 2.

S/N	Component	Description	Quantity
1	LCD	16 x 2 LCD	1
2	Capacitor	100 $\mu$ F	1
3	Resistor	10 K $\Omega$	1

Table 2: LCD Circuit List Of Components

#### D. Interfacing of Arduino with LCD

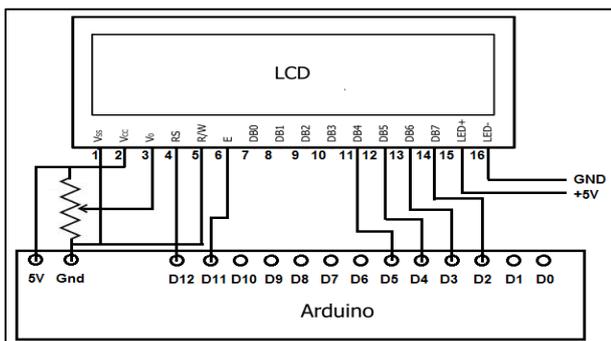


Fig. 7: Interfacing of Arduino with LCD

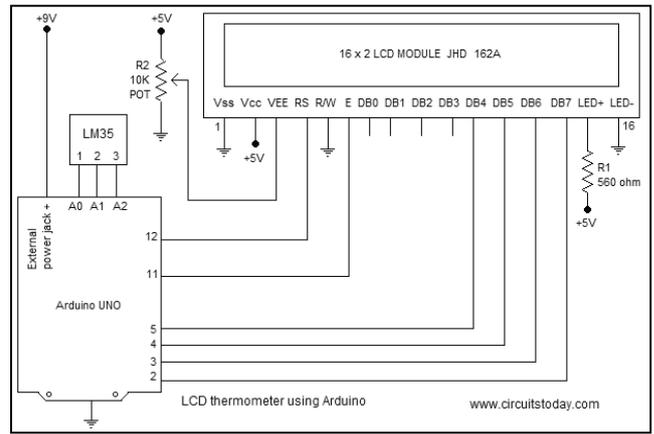


Fig. 8: Circuit Diagram of Digital Thermometer

Interfacing of Arduino with LCD is as shown in figure 7. Circuit diagram for Arduino based digital thermometer is shown in the above figure 8. Here 16x2 LCD unit is directly connected to Arduino in 4-bit mode. Data pins of LCD namely RS, EN, D4, D5, D6, D7 are connected to Arduino digital pin number 7, 6, 5, 4, 3, 2. A temperature sensor LM35 is also connected to Analog pin A0 of Arduino, which generates 1 degree Celsius temperature on every 10mV output change at its output pin.

### IV. EXPERIMENTAL RESULTS

Practical test have been conducted to evaluate the real time performance of the system. An experiment was carried out in which few patients from hospital was tested. The temperature sensor was put under arm and also pinched in two fingers. Analog signal is converted to digital signals with in-built ADC of ATmea328.

Normal body temperature can range from 97.8 degrees F to 99 degree F which is equivalent to 36.5 degrees C to 37.2 degree C for a healthy adult. For most people 98.6 F (37o C) is baseline. If the temperature is 103 F (39.4o C) or greater the fever is too high, then the doctor need to pay attention towards patient.

The result of the experiment to compare the accuracy of the constructed digital thermometer is tabulated in table

Actual Temperature	Using Digital Thermometer	Difference
25	24.2	0.8
30	28.4	1.2
32	31.0	1.0
34	33.1	0.9
36	34.2	1.8
40	38.9	1.1
42	40.7	1.3

Table 3: Experimental Result Analysis

### V. CONCLUSION

A digital thermometer has been designed using Arduino UNO controller as heart of system. From experimental results we can conclude that digital thermometer using Arduino is highly accurate & it nullifies the effect of external parameters. Either a digital and glass thermometer can be used when taking an oral (mouth), rectal (bottom), or auxiliary (arm pit) temperature. So it can be used to measure temperature of different parts of body.

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