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Design and Implementation of Thermal Sensor Based Temperature Measuring Robot Using Arduino Uno

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Abstract- This paper is about the "Thermal sensor based Temperature Measuring Robot" using Arduino Uno circuits. In this technology, Temperature Measuring Robot measured the temperature of the human body and the temperature of any object. The MLX90614 infrared thermometer is a contactless temperature sensor module for Arduino compatible device. An infrared thermometer works to measure the object temperature by the infrared radiation in the form of an electromagnetic wave through the light emitted on the object. MLX90614 is a powerful infrared sensing device with a very low noise amplifier with a 17 bit ADC. It utilizes non-contact temperature sensing to collect the temperature info without touching any surface of the object. The construction is equipped with many sensors. Hardware and software architecture and integration with Robot operating system is described in details. In the last part of the paper we presented the results of implemented measurement technologies and draw conclusions.

Keywords- Arduino Uno, MLX90614, ATmega328p microcontroller, I2C Protocol.

I. INTRODUCTION

"Temperature Measuring Robot" is a large (over 120 cm tall) robot that is intended to work in Airport, Rail station, Bank, School, Collage, University, and especially in Hospitals. The aim of this project is to measure human body temperature, to show the temperature and to tell the temperature [1]. The design of robot was built using Arduino board, whose main component is the ATmega328 microcontroller, which is responsible for the storage of C language control program as well as executing its primary control operation. The Bluetooth technology was selected as a mode of transmission between mobile and robot without Wi-Fi construction.

The system hardware consists of a controller equipped with Bluetooth communication module. It'll be connected to the motors and other alternative components of robotic car [2]. When the robot app is turned on and is connected with the current system via Bluetooth, one will operate the car by giving wireless commands from the app using the functions already programmed in the app. The vehicle will move all four told directions: left, right, front and back.

For forward movement, movement of both the motors will be in the same direction and for backward motion; movement of the motors will be in opposite direction. For left and right movements, either of the motors will rotate and to stop both the motors will stop. Instructions are given to the motors through the mobile app by the user.

II. HUMAN BODY TEMPERATURE

Normal body temperature varies throughout the day. It is controlled in the thermoregulatory center in the anterior hypothalamus [3], [4]. Measurement of body temperature can give information about human body condition.

III. HEALTH OR ILLNESS INDICATOR

Fever is a temperature higher than 38°C. It is a characteristic feature of most infections but also found in numerous noninfectious diseases. There are many patterns of fever such as continuous, remittent, recurring [4]. Higher fevers are usually connected with bacterial infections and lowers with viral infections. There are many reasons for fever such as mononucleosis, influenza, pneumonia, endocarditic, abdominal abscess, meningitis. Autoimmune diseases such as systemic lupus erythematosus, rheumatoid arthritis; hematological and oncological diseases such as many types of leukemia, Hodkin's and non-Hodkin lymphomas, mielodysplastic syndromes, hepatocellular carcinoma, renal cell carcinoma, colorectal cancer or any other type of cancer.

The specific type of fever occurs in sepsis. There are also drugs which may cause fever. There is also fever of unknown origins which means fever higher than 38.3°C occurring at least once per day for more than three weeks with no diagnosis after evaluation with detailed history, physical examination and initial laboratory assessment for more than three days in hospital or outpatient. It is very important to properly measure the body temperature in hospitals, in clinics or even by patients themselves [3], [4].

IV. MEASUREMENT METHODS

There are many methods of monitoring temperature: peripheral, such as tympanic membrane, temporal artery, and auxiliary and oral thermometry and central methods: pulmonary artery catheter, urinary bladder, esophageal, and rectal thermometry. Central methods are less practical than peripheral methods [3], [5]. Nowadays temperature measurement system is being used more in non-contact temperature measurement.

V. SYSTEM DESIGN AND IMPLEMENTATION

Temperature Measuring Robot is equipped with a set of widely used minicomputers: - Arduino Uno that give relatively easy access to a wide set of sensors and standalone sensing devices via I2C connections. Minimizing the cost of temperature measurement system was also one of the goals. First of all, the aim of the whole project was to create a low-cost robot built upon popular components easily available on the market, to allow quick replacement in case of damage.

1. Design of Mechanical Structure:
Motor Driver logic inputs are connected at pins D4, D5, D6, and D7. Right BO Motor is connected in motor driver output pins OUT1 and OUT2 and left BO Motor is connected in Motor driver output pins OUT3 and OUT4. Ultrasonic sensor is connected with arduino at Analog pins A2 and A3. OLED Display and Thermal Sensor are connected with Arduino at pins SCL and SDA. SD Card Module is connected with Arduino at pins D10, D11, D12, and D13. And also, a speaker is connected with Arduino at pin D9. A Li-Po battery is used for power supply unit.

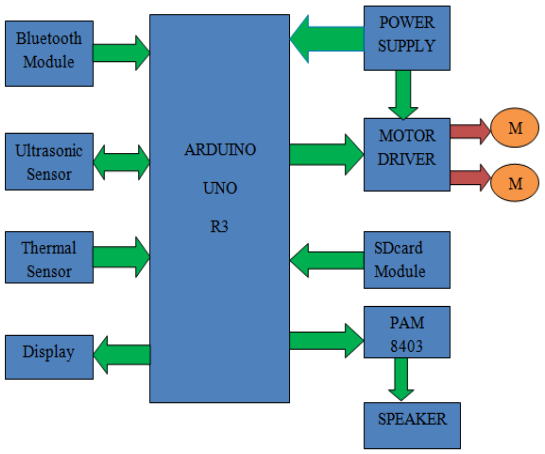

Fig 1. Mechanical structure.

The mechanical structure of the robot is comprised of two layers base and it consist of four wheel differential drive system. It is designed keeping in view that the thermal sensor on robot has to be mounted over a certain height from the ground. The height of this thermal sensor is adjustable according to height of a person so that better measurement can be obtained. So initially the height of the thermal sensor is set up to 4 ft.

VI. THE TRANSPORT PROTOCOLS OF MLX90614

The MLX90614 measures and calculates the temperature of the object and provides the results through the PWM out-put or the SM Bus interface which are built with pins PWM/SDA and SCL [6]. The paper uses the SM Bus protocol. The SM Bus interface is a 2-wire protocol, allowing communication between the Master Device (MD) and one or more Slave Devices (SD). At a given time, only one master device can be present and the MLX90614 can only be used as a slave device.

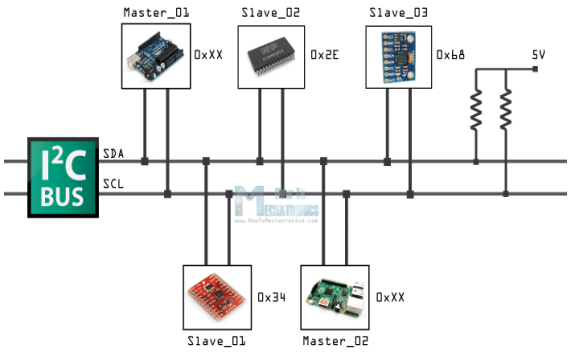

Fig 2. I2C Protocols.

The developed Java coding has to been installed in the mobile phone so that it can communicate with the Bluetooth module. The first step is too clicked the connect button in the mobile phone, so that the mobile phone will communicate with the Bluetooth module. After the mobile phone is successfully connected, the user can start to control the robot.

VII. MLX-90614 (GY-906)

The MLX90614 is a **Contactless Infrared (IR) Digital Temperature Sensor** that can be used to measure the temperature of a particular object ranging from -70° C to 382.2°C. The sensor uses IR rays to measure the temperature of the object without any physical contact and communicates to the microcontroller using the I2C protocol. [7] There are two versions, one for 3V power and logic levels and one for 5V power and logic levels.

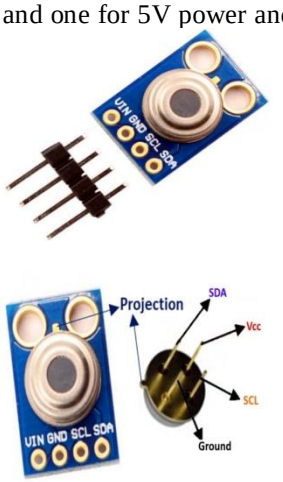

Fig 3. Thermal Sensor (MLX-90614). [8]

VIII. MLX-90614 PIN-OUT CONFIGURATIO

Table 1. Pin-out Configuration of MLX-90614.

Pin No	Pin Name	Description
01	Vcc (Power supply)	Vcc can be used to power the sensor, typically using 5V
02	Ground	The metal can also act as ground
03	SDA – Serial Data	Serial data pin used for I2C Communication
04	SCL – Serial Clock	Serial Clock Pin used for I2C Communication

IX. MLX-90614 TEMPERATURE SENSOR SPECIFICATIONS

- Operating Voltage: 3.6V to 5V (available in 3V and 5V version)
- Supply Current: 1.5mA
- Object Temperature Range: -70° C to 382.2°C
- Ambient Temperature Range: -40° C to 125°C
- Accuracy: 0.02°C
- Field of View: 80°
- Distance between object and sensor: 2cm-5cm (approx.)

X. MICROCONTROLLER (ATMEGA328P)

ATmega328P is one of the high performances AVR technology microcontrollers with a large number of pins and features. It is designed by 8-bit CMOS technology and RSIC CPU which enhance its performance and its power efficiency gets improved by auto sleeps and internal temperature sensor. It has 32KB internal built in memory. It has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. This **ATmega328P** IC comes with internal protections and multiple programming methods which helps the engineers to priorities this controller for different situations. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, and real timer counter with separate oscillator. It is mostly used in Arduino. The IC allows multiple modern era communications methods for other modules and microcontrollers itself, which is why the microcontroller ATmega328P usage has been increasing every day.

XI. I2C PROTOCOL

The data signal is transferred in sequences of 8 bits. So after a special start condition occurs comes the first 8 bits sequence which indicates the address of the slave to which the data is being sent. After each 8 bits sequence follows a bit called Acknowledge. After the first Acknowledge bit in most cases comes another addressing sequence but this time for the internal registers of the slave device. Right after the addressing sequences follows the data sequences as many until the data is completely sent and it ends with a special stop condition.

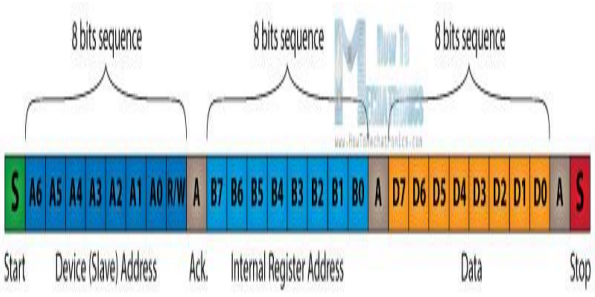

Fig 4. data is completely sent and it ends.

Let's take even closer look at these events. The start condition occurs when data line drops low while the clock

line is still high. After this the clock starts and each data bit is transferred during each clock pulse [9].

The device addressing sequence stars with the most significant bit (MSB) first and ends with the least significant bit (LSB) and it's actually composed of 7 bits because the 8th bit is used for indicating whether the master will write to the slave (logic low) or read from it (logic high).

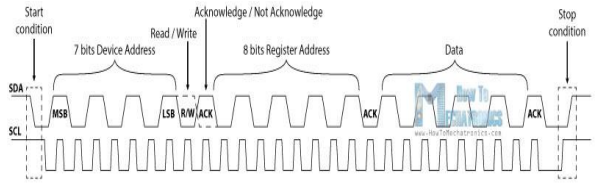

Fig 5. 8th bit is used for indicating.

The next bit AKC/ NACK is used by the slave device to indicate whether it has successfully received the previous sequence of bits. So at this time the master device hands the control of the SDA line over to the slave device and if the slave device has successfully received the previous sequence it will pull the SDA line down to the condition called Acknowledge. If the slave does not pull the SDA line down, the condition is called Not Acknowledge, and means that it didn't successfully received the previous sequence which can be caused by several reasons. For example, the slave might be busy, might not understand the received data or command, cannot receive any more data and so on. In such a case the master device decides how it will proceed.

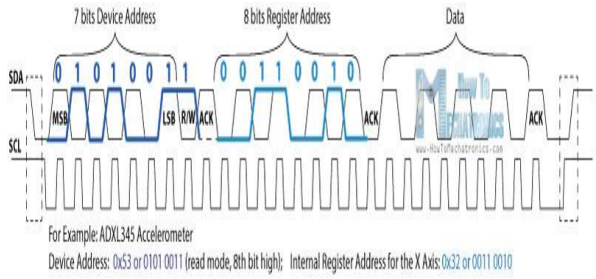

Fig. 6 SDA line down.

Next is the internal registers addressing. The internal registers are locations in the slave's memory containing various information or data. For example the ADX345 Accelerometer has a unique device address and addition internal registers addresses for the X, Y and Z axis. So if we want to read the data of the X-axis, first we need to send the device address and then the particular internal register address for the X-axis. After the addressing, the data transfer sequences begin either from the master or the slave depending of the selected mode at the R/W bit. After the data is completely sent, the transfer will end with a stop condition which occurs when the SDA line goes from low to high while the SCL line is high.

XII. ADVANTAGES

- It can measure any object temperature.
- It can measure temperature within five second.
- It has low power consumption.
- It detects the objects and calculates the distance by using Ultrasonic sensor.
- Audio signals ensure optimal position of the user for proper work of Thermo Controls measuring equipment.
- The result is presented on the screen within 5 seconds.
- The resulting temperature is told through the speaker.
- And also we can control the temperature measuring robot car by using android Smartphone via Bluetooth.
- This robot also has forward, backward, left and right steering features.

XIII. RESULT

In these projects, I used an Ultrasonic Sensor which sense the distance between the object and the temperature measuring robot. While distance is less than 20cm then operate thermal sensor (MLX-90614). The thermal sensors sense the temperature by using MLX-90614 and send signal to the Arduino. Arduino send the signal to the display then we can see the temperature. And also, while the distance is larger than 20cm then disconnected the thermal sensor and operate the car. The car is controlled by via the Smartphone.

XIV. CONCLUSION

In this project, we presents the development of a smart temperature measuring system based on MLX90614 Infrared Thermometer coupled with Arduino microcontroller. The Infrared temperature measurement module can measure human body temperature accurately and remotely.

FUTURE WORK

- This technology will be able to measure temperatures over greater distances in the future.
- In the future the process will be controlled automatically.
- It will be able to measure the temperature of more than one person at a time in future.

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