DEVELOMENT OF PORTABLE TEMPERATURE DETECTOR using ARDUINO

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***Abstract*— this paper is about a portable device for temperature detecting based on Arduino Uno board and LM35 temperature sensor. This device allow user to read the real-time temperature value from sensor; to display the temperature reading at the LCD display panel; user can set the require temperature to trigger a LED light; Some experimental results are carried out to determine the accuracy and persistency of the device performance.**

***Keywords*— Arduino; LM35 temperature sensor; temperature detector device; temperature measurement.**

I. INTRODUCTION

Nowadays, temperature monitoring is very important due to the increasingly demand on livestock business, medical sectors, laboratories, industries and also in our home to improve their product effectiveness and to comply with the demand [1]. For example, at the big rabbit farm, there were many nest that contain many rabbits. The pregnant rabbit is very sensitive to the temperature change. A lack of caution to the temperature inside the rabbit nest will cause the rabbit cannot produce enough milk to their does [2]. Nevertheless, the need of reading body temperature of animal is important too, we can determine whether the animal is sick or pregnant through its body temperature especially rabbit. Another example that we can look is in the IT industries, certain application such as big server computer in a server room need temperature measurement and control to maintain the temperature in a specific range to ensure the application can run smoothly and to avoid accidents and damage to the device and equipment [3].

This paper will present on the development of the portable temperature detecting device are done using Arduino microcontroller [4], and LM35 temperature. This device is proposed to easier the user to detect temperature at any place and also to overcome the difficulty of detecting the temperature portably.

II. LITERATURE REVIEWS

1. TEMPERATURE MEASUREMENT APPLICATION.

Temperature is one of the basic thermodynamic properties. When an atom crashes with other atoms as its moves, its transfers to them part of its kinetic energy, thus dropping some of its own energy in this continuous bouncing. An atom that having a smaller kinetic energy, after a collision gains some energy. After that, the body of material consisting of such tense atoms reaches the energetic equilibrium. This condition can be described by an average kinetic energy. The average kinetic of the molecules is called absolute temperature [5]. The temperature measurement is called when a physical system is being measure its cold and hot properties. There were many scales that we can calibrate to measure the temperature such as Celsius, kelvin, Fahrenheit and many mores. At early states as early as 170AD, Claudius Galenus has been invented the standardized of temperature measurement. Early device to measure temperature is called thermoscopes. The Grand Duke of Toscani is the first man to invented sealed thermometer in 1641 [6]. Nowadays, there were many method to measuring the temperature [7]. The invasive temperature measurement technique involve the setup of a physical sensor direct contact with the component or medium. The liquid in glass thermometer, thermistor, semiconductor device, capacitance thermometer, bi-metallic strip and thermocouple is among of this type of temperature measurement. Second is semi-invasive temperature measurement techniques, this technique required the part that we want to detect the temperature is preserved in some method to enable remote observation, for example the observe surface can be spray with thermochromic liquid crystal (can change color with temperature) and then observe with a camera. Other material that can be used to observe the temperature is thermographic phosphors and heat sensitive paints. The thermographic phosphors technique can offer sensitivities of 0.05 °C and an accuracy of 0.1%–5% of the Celsius temperature reading [8]. Third is noninvasive temperature measurement techniques, this technique is where the medium of interest is observed remotely. Mostly, noninvasive techniques measure temperature from the electromagnetic spectrum except the acoustic temperature measurement which depend on the measurement of the speed of sound. This type of measurement method is used at the high-dangerous application such as furnace or plasmas. Example of this noninvasive technique is infrared thermography, refractive index methods, absorption and emission spectroscopy, line reversal, spontaneous Rayleigh and Raman scattering, acoustic thermography and many more. Photosensitive techniques such as absorption and emission spectroscopy, scattering and luminescence are sensitive in the visible region mostly because lasers are used as part of the system [9].

2. IMPORTANC OF TEMPERATURE MEASUREMENT.

The temperature measurement is important to control and monitor the process in industries and other sectors like healthcare, meteorology, livestock business and science and technology. All these need a precise and accurate temperature measurement. In healthcare sector, the doctor need a proper and precise temperature measuring equipment to check the temperature of a patient. In industries, the process that need critical monitoring on temperature rely on precise and accurate temperature sensor. A slight different in set point temperature can ruin the entire process in the factory. For example, the Titanium Oxide pigment manufacturing factory. In science and technology, any experiment must be done in temperature control room, so that the temperature won't affect much on the experiment that has been conducted. This condition need the temperature measurement to control the room temperature. In the meteorology side, the forecasting of weather need a very accurate temperature measurement. Forecast based on temperature and rain are important to agriculture sector.

3. LIMITATION OF THE TEMPERATURE MEASUREMENT.

Every device that has been invented all the year of humankind have a limit. This limitation is overcome by inventing more detail and enhanced device. Same goes to the temperature measurement device, every material and technique that used has a limitation. The biggest aspect when measuring something is to confirm the measuring device itself does not affect the medium it is measuring. The accuracy of the temperature measurement device is the major problem here, it depend by the basic sensor characteristic. The most accurate element for temperature measurement is platinum and thermistor. The other limitation in temperature measurement is the long-term stability, it's defined by how reliable a sensor remain its accuracy over time. The exposure of sensor to high temperature medium can reduce the sensor stability. Thermocouple and semiconductor type sensors are the least stable sensor [10]. Other than that, the linearity of a temperature sensor play an important role to temperature measurement. It's define the effectiveness over a range of temperature sensor's output consistently changes [11]. However this issue has been improve since the microprocessors are used in temperature sensor signal conditioning circuits. Furthermore, the response time of the temperature sensor determine how quickly a sensors detect temperature. These factor depend on the mass of the sensor element and its size. The semiconductor type of temperature sensor has the slowest respond time. [12] Below is the table of advantages and disadvantages of temperature measuring sensor.

Table 1: This table showing the advantages and disadvantages

	NTC Thermistor	Platinum RTD	Thermocouple	Semiconductor
Sensor	Ceramic (metal-oxide spinel)	Platinum wire-wound or metal film	Thermoelectric	Semiconductor junction
Advantages	• Sensitivity • Accuracy • Cost • Rugged • Flexible Packages • Hermetic Seal • Surface Mount	• Accuracy • Stability • Linearity	• Temperature Range • Self-Powered • No Self-heat • Rugged	• Ease of Use • Board Mounting • Rugged • Overall Cost
Disadvantages	• Non-linearity • Self-heating • Moisture failures (non-glass only)	• Lead resistance error • Response time • Vibration resistance • Size • Package limitations	• Cold-junction compensation • Accuracy • Stability • TC extension leads	• Accuracy • Limited applications • Stability • Response time

of four type of temperature sensor which is NTC thermistor, platinum RTD, thermocouple and semiconductor.

III. SYSTEM HARDWARE

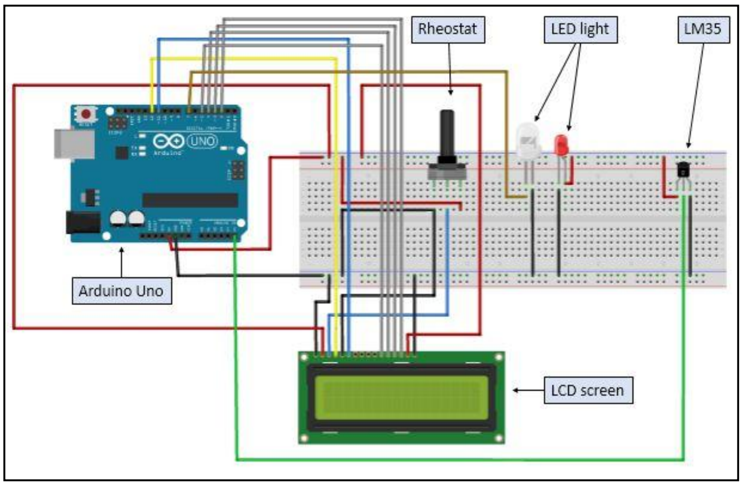
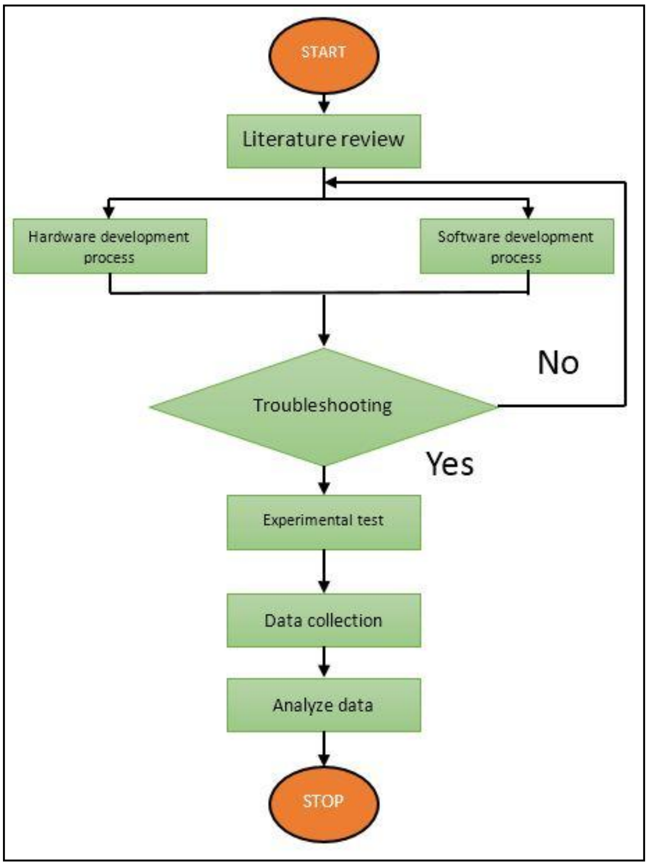


Fig. 1 The full wiring diagram of the system

Fig. 1 Show the wiring diagram of the proposed temperature sensor system. It contained the Arduino Uno Rev 3 board, LM35 temperature sensor, Led, and LCD display. The sensor detected the temperature. The analog signal that generate by the temperature sensor is send to Arduino board for signal conversion using an ADC. The data then is show at the LCD display.

IV. METHODOLOGY



V. **Fig. 2** Flowchart of Methodology

This project consisted of two main development stages which is the software and the hardware. The project methodology flowchart is shown in **Fig. 2**.

A. Literature Review.

At the early time before started doing this project, a literature review about the past research has been made to gather some brilliant idea and relevant reference about the detail of the temperature sensing topic. Moreover, the electrical and electronic components that might be used in this project also being study out to know which the best component is.

B. Hardware Development.

Hardware development is a process of combining together all the electrical components such as the Arduino Uno Rev 3 board, the LM35 temperature sensor, the LCD display and all the wiring to create the temperature detecting device that have been proposed.

Fig. 3 The completed portable temperature detector

1. SN-LM35DZ temperature sensor

The LM35DZ is use in this project. It is precision integrated temperature sensors. The output voltage that comes out from this sensor is linearly proportional to the Celsius temperature with a gradient of 10mV/°C. This temperature sensor has an accuracy of ± ¾ °C over a full -55 to +150°C range and ± ¼ °C at room temperature [10]. This temperature is very suitable for remote application. The advantages of this IC temperature sensor are it is low cost, small physical size and high linearity.

Fig. 4 SN-LM35DZ temperature sensor

2. 16x2 LCD screen.

Liquid Crystal Display (LCD) is an electronic display module that was used in this project to display the output of temperature sensor from Arduino to user. The 16 pin module is preferred than other display module such as Seven segments because it is very economical and easily to program, and also can show the custom characters. It can display 16 characters per line.

Fig. 5 LCD display 16X2

PIN ASSIGNMENT		
Pin no.	Symbol	Function
1	Vss	Power supply (GND)
2	Vdd	Power supply (+5V)
3	Vo	Contrast Adjust
4	RS	Register select signal
5	R/W	Data read /write
6	E	Enable signal
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
15	A	Power supply for LED B/L (+)
16	K	Power supply for LED B/L (−)

Fig. 6 Pin Assignment for 16x2 LCD screen.

C. Software Development.

At this stage, the core of this project was developed. The Arduino program is written by using Arduino IDE 1.0.6, this application provides complete facilities to user for software development of Arduino. It consisted of source code editor and debugger. For the portable usage, the LCD screen will show the real-time temperature that was detected. The programming of the Arduino is shows in **Fig. 7**.

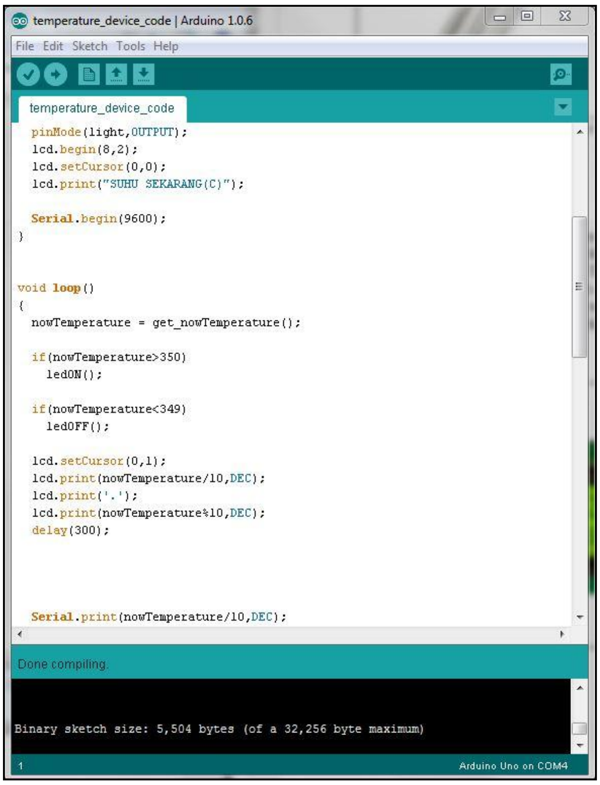


Fig. 7 Arduino program code using C++ programming language.

D. Troubleshooting.

At this stage, our project hardware and software is being tested all out to find any problem regarding both of the software and the hardware. A slight modification will be made if any problem is found. In this project, the biggest problem that occurred is the connection between the Arduino and the LCD screen. The problem was solve by tighten the wiring connection of this two parts.

E. Experimental Test.

To test the functionality of this project, several experiments were carried out. Three type of experiment were carried out in this project to find the error of the temperature sensor reading. These experiments were repeated three times to get the best average error.

F. Data Collection.

At this process, the data of the conducted experiment has being collected. The data then is stored in Microsoft Excel file and can be review at any time. Data from the temperature sensor is being taken repeatedly to ensure the accuracy of this sensor. This data can be used to prove that the temperature sensor is accurate or not.

G. Analyze the Data.

The data that has being collected from the experimental stage has been analyzed here. This process involves examining the relationship, patterns and error of the temperature sensor reading. The maximum and minimum error was determined. The data reading from the experiments was being compared here to find the mean error. The advantages of this stage are the information gathered can be used to improve the accuracy and performance of the proposed system.

III. RESULTS AND DISCUSIONS

In this section, the performance of the proposed system is evaluated. The test A setup for this device is shown in **Fig. 8**. This test A is focus on the contact with hot medium. Both the sensor and thermometer were submerged in the boil water.

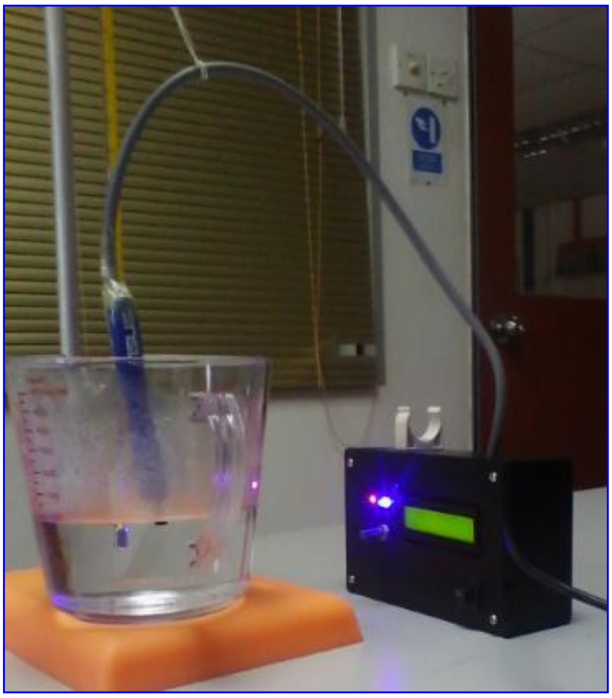


Fig.8 Test A both of the tip of the sensor and thermometer were submerged in the hot water.

For the test B, it will focus on the medium temperature detection test. The thermometer and temperature device sensor were placed in the beaker that contain half boil water. **Fig. 9** shows the experiment setup.

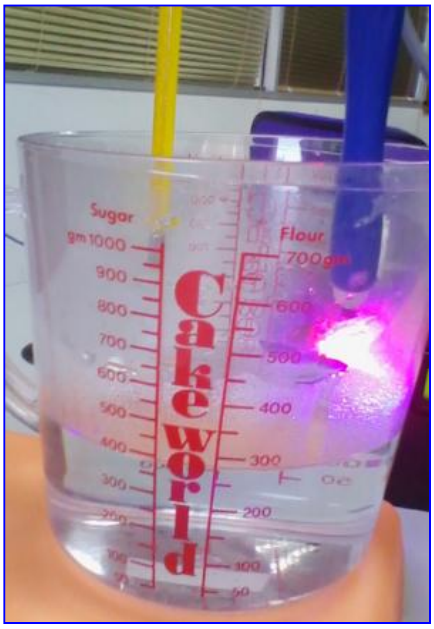


Fig. 9 both temperature device and thermometer were taken the reading of half boil water.

TIME INTERVAL	TIME TAKING READING	GLASS THERMOMETER	TEMPERATURE DEVICE (°C)	DIFFERENCE	PERCENTAGE ERROR (%)
0	13:10	75.0	73.0	2.0	2.67
5	13:15	67.0	65.3	1.7	2.54
10	13:20	58.5	56.1	2.4	4.10
15	13:25	52.0	50.2	1.8	3.46
20	13:30	47.5	46.2	1.3	2.74
25	13:35	44.8	42.9	1.9	4.24
30	13:40	42.0	40.5	1.5	3.57
35	13:45	39.5	38.1	1.4	3.54
40	13:50	37.2	36.1	1.1	2.96
45	13:55	36.0	34.9	1.1	3.06

Fig. 10 Tabulated Data for Test A (1)

TIME INTERVAL	TIME TAKING READING	GLASS THERMOMETER	TEMPERATURE DEVICE (°C)	DIFFERENCE	PERCENTAGE ERROR (%)
0	14:10	73.0	70.3	2.7	3.70
5	14:15	62.5	60.4	2.1	3.36
10	14:20	57.0	55.4	1.6	2.81
15	14:25	53.0	51.3	1.7	3.21
20	14:30	49.0	47.3	1.7	3.47
25	14:35	46.0	44.3	1.7	3.70
30	14:40	43.0	41.8	1.2	2.79
35	14:45	41.0	40.0	1.0	2.44
40	14:50	39.0	37.7	1.3	3.33
45	14:55	37.2	36.2	1.0	2.69

Fig. 11 Tabulated Data for Test A (2)

TIME INTERVAL	TIME TAKING READING	GLASS THERMOMETER	TEMPERATURE DEVICE (°C)	DIFFERENCE	PERCENTAGE ERROR (%)
0	10:40	36.0	36.2	-0.2	-0.56
5	10:45	33.0	31.6	1.4	4.24
10	10:50	30.0	30.2	-0.2	-0.67
15	10:55	28.0	29.1	-1.1	-3.93
20	11:00	27.5	28.5	-1.0	-3.64
25	11:05	26.0	26.0	0.0	0.00
30	11:10	25.5	25.3	0.2	0.78
35	11:15	25.0	24.6	0.4	1.60
40	11:20	24.8	24.2	0.6	2.42
45	11:25	24.2	23.7	0.5	2.07

Fig. 12 Tabulated Data for Test B (1)

TIME INTERVAL	TIME TAKING READING	GLASS THERMOMETER	TEMPERATURE DEVICE (°C)	DIFFERENCE	PERCENTAGE ERROR (%)
0	11:30	40.0	37.0	3.0	7.50
5	11:35	34.0	31.2	2.8	8.24
10	11:40	30.8	30.2	0.6	1.95
15	11:45	28.9	29.0	-0.1	-0.35
20	11:50	27.0	27.3	-0.3	-1.11
25	11:55	26.0	26.8	-0.8	-3.08
30	12:00	25.5	25.9	-0.4	-1.57
35	12:05	24.8	25.0	-0.2	-0.81
40	12:10	24.0	24.7	-0.7	-2.92
45	12:15	24.0	24.5	-0.5	-2.08

Fig. 13 Tabulated Data for Test B (2)

According from the data obtained from Test A shown in Fig. 10 and Fig. 11 it has been analysed that the highest percentage error was 4.24% and the lowest percentage error obtained was 2.44% this error is taken by the difference of reading using the glass thermometer and the temperature device, while in the Test B shown in Fig. 12 and Fig. 13 the data obtained having the highest percentage error of 8.24%, the negative value of percentage error in Test B is neglected. These error occurred while the system is been evaluated, and may cause due to instrumentation setup. Totally, for the test A, from this two set of reading, we found that the maximum accuracy of the temperature detector device is 97.56% and the minimum accuracy is 95.76%. While, for the test B, we found that the maximum accuracy of the temperature detector device is 100.00% and the minimum accuracy is 91.76%. Although the device tolerance is not quite acceptable as the standard that is +- 0.5 degree Celsius tolerance as stated by the NIST (National Institute of Standard and Technology), this can be fixed by calibrating and fixing the device algorithm calculation

IV. CONCLUSION

This study is focusing on the development of portable temperature detector device using Arduino which based on the Arduino UNO platform to measure the temperature of a medium by invasive method. The device is easy to be used as it is use power bank as its power source. This portability allows user to use the device at wherever they want. This device constantly measures the temperature parameter using the Arduino UNO Rev 3 board and LM35 temperature sensor. The system has been developed and the quantitative data from the finding is shown in the result section.

The LM35Dz temperature sensor has been introduced, namely as the temperature sensor in order to measure temperature of an object. For the Arduino to function, they're certain coding and algorithm used to program the Arduino. The program is used to display to real-time temperature at the 16x2 LCD panel and convert the signal voltage from the sensor to Celsius

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