International Conference of Sciences, Engineering & Environmental Technology (ICONSEET), 6(36): 290 – 297, 2021
ISSN 0794-9650
www.repcomseet.com

Design and Development of a Non-Contact Forehead Infrared Thermometer (NCFIT)

Akanni, A. A.[a*], Kasali, A. A.[b], Badrudeen A. A.[a], Glory O. A.[a], Ojo, O. A.[a], Ayofe, O.A.[a], Ogheneruemu, K.L.O.[a], and Oreoluwa O. E.[c]

[a]Department of Computer Engineering, Federal Polytechnic Ede, Osun State, Nigeria.
[b]Innovation Technology Centre, Federal Polytechnic Ede, Osun State, Nigeria.
[c]Department of Computer Engineering, Redeemer's College of Technology and Management, Mowe, Ogun State.

[a]*abideenamosa@gmail.com

Abstract - This paper discusses the Design and Development of a Non-Contact Forehead Infrared Thermometer (NCFIT) which measures temperature contactlessly by placing the thermometer in front of the forehead of human body at a few centimeter for a few seconds. The designed NCFIT comprises an LMX90614 infrared sensor, ATMEGA328P microcontroller, Liquid Crystal Display (LCD), Buzzer alarm and Power supply. Power is fed into the designed NCFIT by a 9VDC battery, and then passed via a voltage regulator to give 5V DC output which is used to power microcontroller and LCD. The LMX90614 sensor uses 3.3V DC which was achieved by passing 5V DC through a voltage regulator. The LMX90614 sensor output value is fed into the ATMEGA328P microcontroller programmed in C|C^{++} while microcontroller sends the measurements in form of digital signal to the LCD. The LCD displays measured temperature parameter and if, during measurement, the normal body temperature is exceeded, the microcontroller triggers the buzzer to sound an alarm.The designed NCFIT temperature ranges from -70^{0}C to 380^{0}C for object temperature and -40^{0}C to 125^{0}C for ambient temperature with a high accuracy of 0.5^{0}C and 0.02^{0}C resolution. The designed NCFIT was tested and its performance was satisfactory. It can be used not only in medical but also in daily life, research laboratories, industries as well as in any applications that require accurate measurement of temperature.

Keywords: Digital thermometer, Infrared thermometer, Liquid Crystal Display, LMX90614 sensor, Mercury thermometer, Microcontroller, Non-contact.

1. Introduction

In normal life, so also in health care, assessment of body temperature is one of the oldest identifying methods and still an integral sign of well-being and disease while accurate temperature measurement is analytically important due to the fact that inaccurate temperature measurement may result in the patients remain not diagnosed and not treated. (Madam et. al.,2012)

The standard human body temperature is 37^{0}C yet differs in the day as the least temperature happening in the morning (2:00a.m. – 4:00a.m.) and maximum body temperature happening in the late afternoon or evening, while vigorous training most particularly in scorching climate also causes rise in body temperature (Hadgu & Rajalakshmi, 2016). The temperature or temperature gradient can be evaluated by a device called thermometer using a variety of principles. The most commonly used temperature recording apparatuses are mercury thermometer, digital thermometer and liquid crystal forehead thermometer. (Rahman et. al., 2012).

Hadgu & Rajalakshmi (2016) posited that children body temperature can be measured at different anatomical sites such as mouth, rectum, and axillary using different types of thermometer. It is quite pitiable that in most developing countries especially Nigeria, a number of hospitals still use contact digital thermometers with drawback of: battery issue, cleaning, easily damaged if dropped and required contact with the body. However, with the current Covid-19 pandemic, non of the aforementioned thermometers is satisfactory or worthy to be used for human body's temperature measurement owing to the contagious nature of Corona virus. Consequently, there is the need to come up with a contactless thermometer that supersedes the aforementioned thermometers hence, this study. Notwithstanding, as the whole world is witnessing Covid-19 pandemic, non-contact digital thermometer is a promising candidate that can prevent the risk of spreading contagious deadly diseases such as Corona virus, the Flu etc.

In the words of Oge et. al.(2008), a perfect method of measuring the body temperature should be dependable, non- invasive, non-disturbing, culturally allowable, user-amiable, and clean. (Karamanorglu and Korkmas 2015; Nakitende et. al. 2018) investigate that various non-contact measurements methods are superior to contact methods in terms of solace, effectiveness and contamination control as regards body temperature measurement. Megha et. al. (2014) state that forehead is a perfect region for the body temperature measurement simply because it is supplied by temporal artery the reciever of high blood flow from the carotid artery. It should be noted that a rise in temperature to 38^{0}C or above in adults is a symptom of fever caused by infection.

The designed NCFIT is capable of minimizing the risk of spreading contagious diseases such as Corona virus, the Flu, etc. It has a number of good qualities that are lacking in contact digital thermometer and mercury-in-glass thermometer such as safety, fast, strong and convenient to use. It is an effective tool for identifying fever, which is a primary symptom of Covid-19. The beauty of NCFIT is that it is the easiest method to take the temperature of adults, children and babies.

In fact, all the aforementioned qualities of the NCFIT qualify it to be a good candidate for human body's temperature measurement especially during this present Covid-19 pandemic and even years after for generations yet unborn.

2. Literature Review

Anuj (2013) published a paper on designing Infrared Controlled Thermometer and found that the system can be used where other probe sensors are not suitable or do not give accurate data. The system does not state the kind of infrared thermometer and the nature of the object(s) that the thermometer can measure its temperature.

Abayomi- Alli et. al. (2014) propose a paper on Digital Thermometer with Timer (Digithermo) where they used LM35D infrared sensor with AT8904051 microcontroller to measure the temperature in chemistry and chemical engineering Laboratories. The system is unsuitable to measure human body temperature; nothing like alarm when the temperature of the object being measured exceeds threshold.

Gang et. al. (2015) suggest a paper on non-contact Infra-Red Thermometer using MLX90614 sensor with STM32F107 microprocessor for the safety inspection at the subway, airport, ferry, railway, etc. They used the sensor to measure the temperature of corrosive and toxic liquids in different bottles with different shapes, sizes, materials and thickness. The system does not measure ambient temperature.

Mahammad et. al. (2016) offer a paper on Digital Proximity Type IR Thermometer based on Arduino UNO R3 as the main control device with MLX90614 infrared sensor which could be used to take the temperature of a virus infected/burned patient. It does not measure ambient temperature; doesn't reveal the nature of the object(s) whose temperature could be taken with the thermometer.

Benjamin et. al. (2016) propose a paper on Digital Thermometer with clock where they used LMX90614 infrared sensor with ATMEGA328PU Microcontroller for contactless measurement of human body temperature and DS1307 Real Time Clock (RTC) for keeping time accurately during the measurements. It does not state the part of the body that could be measured with the designed system; nothing like alarm to notify the user when the temperature exceeds threshold value.

Guangh (2016) published a paper on non-contact infrared thermometer where he employed TN901 infrared sensor with STC89C52MCU to measure the temperature of human body. Very convenient for people with bad eyesight. It is unsuitable for measuring adults temperature; does not state the part of the infants and young children that could be measured.

Jing (2017) advanced a paper on a Non-Contact Infrared Thermometer where he used MLX90614 temperature sensor with SCL Microcontroller. It is designed to measure temperature indoor; does not display ambient temperature.

Abubakar et. al. (2017) offers a paper on Digital Thermometer that utilized LM35DZ infrared temperature sensor with PIC16F877A microcontroller to measure the temperature. It does not state the nature of the object(s) whose temperature could be measured with the thermometer.

However, the proposed system, Non-Contact Forehead Infrared Thermometer (NCFIT) uses MLX90614 temperature sensor with ATMEGA 328P microcontroller to measure the human body temperature at different regions of the body such as Forehead, Oral, Ear and Armpit. The system also measures the ambient temperature as well as sounds an alarm when the temperature exceeds the normal body temperature which is a symptom of fever and fever is among the symptoms of Corona-virus disease or Flu.

3. Methodology

The designed NCFIT is divided into two: Hardware module and software module. The hardware module comprises sub-modules such as: power supply, microcontroller, Liquid Crystal Display (LCD), Buzzer and MLX90614 infrared sensor. All these modules work unanimously to form a single device. The software module (Control Program) consists of C|C^{++} programming language used in the design as shown in the block diagram below.

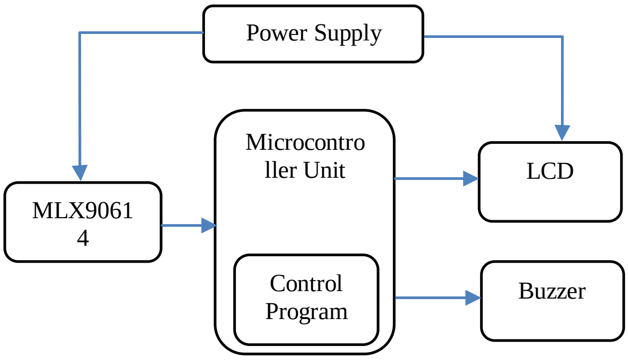

Figure1: Block diagram of the designed NCFIT

3.1 Hardware Module

3.1.1 Power Supply Unit

Power is fed into the designed system by a 9VDC battery, then passed via a voltage regulator to give 5V DC output. This is used to power ATMEGA328P microcontroller and LCD. The LMX90614 infrared sensor uses 3.3V DC which was achieved by passing 5V DC through a voltage regulator.

3.1.2 Microcontroller Unit

This designed system uses ATMEGA328P microprocessor which receives analog signals from LMX90614 infrared sensor connected to it and then converts the analog signals to digital signals which can be displayed by the output unit, Liquid Crystal Display (LCD). (Stand Alone Microcontroller Circuit, 2015).

3.1.3 Display Unit

This unit comprises 16 $\times$ 2 Liquid Crystal Display (LCD) which displays the object temperature and ambient temperature. It is a flat panel display that uses the light modulating properties of liquid crystals. Liquid crystal do not emit light directly and a low power device.

3.1.4 Temperature Sensor (MLX90614)

MLX90614 infrared sensor is four-pin, SMBUS-based device produced by Melexis company. When interfaced with a microcontroller, it changes surrounding temperature to digital value so that the temperature could be read. Consequently, it is used in digital thermometer. Its characteristics include: simple circuit, smaller size, more economical with wider applications. It is suitable for on-site temperature measurement in harsh environments such as environmental control, process/equipment control (Jose et. al., 2014 ; Mahammad et. al., 2016).

3.1.5 Buzzer Piezo

A buzzer piezo is an audio signaling or sounding device, that may be mechanical, electromechanical, or piezoelectric. Its uses include alarm devices, timers etc. But, this designed system uses it as an electrical alarm. (The free dictionary, 2015). A Piezo buzzer advantages include: excellent frequency response, small size, wide voltage usage range, high sound level, low power consumption and easy compatibility.

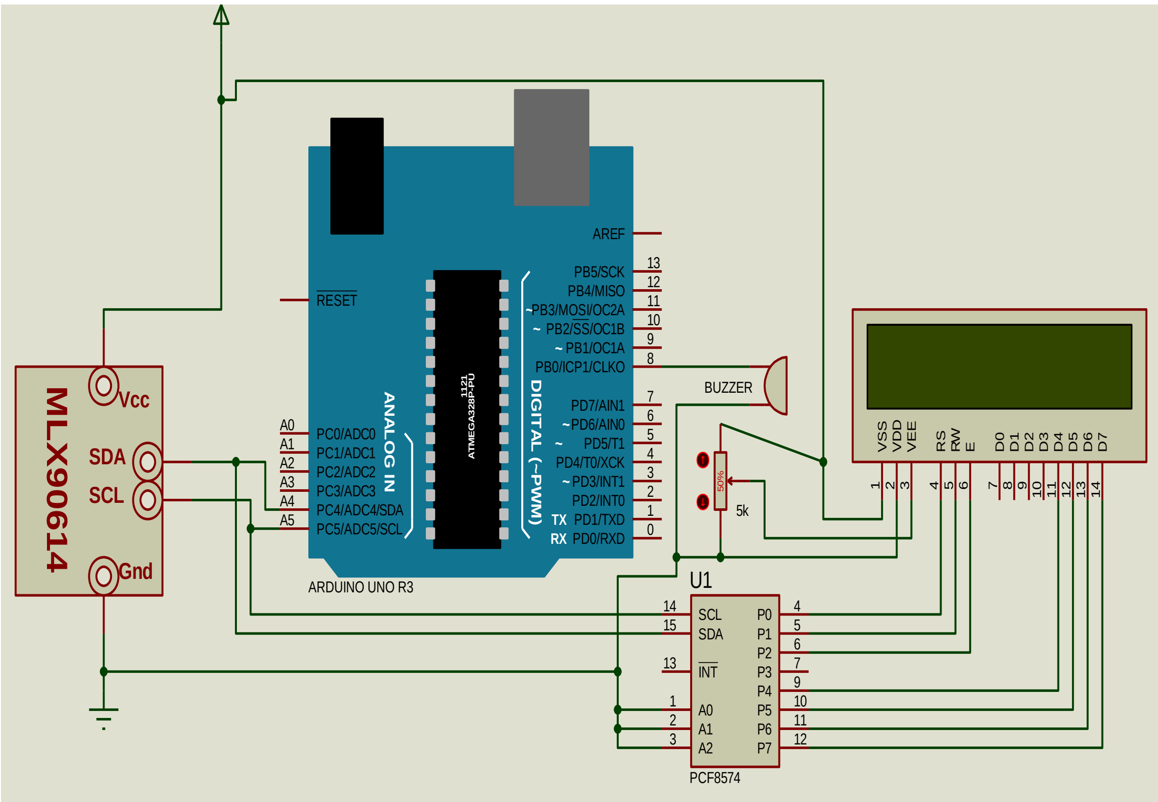

Figure 2: Circuit diagram of the NCFIT

4. Software Module

A microcontroller is insignificant without the programming language. For any task to be accomplished on a microcontroller, there must be a set of explicit instructions. A collection of such instructions is called a program. The software (control program) utilizes C|C^{++} programming language in the designed system.

5. Principle of Operations

Power is fed into the designed system by a 9V DC battery, and then passed via a voltage regulator to give 5V DC output which is used to power ATMEGA329Pmicrocontroller and LCD.

The LMX90614 temperature sensor uses 3.3V DC which was achieved by passing 5V DC through a voltage regulator. The LMX90614 sensor has two devices embedded in it: thermopile detector (Sensing unit) and Digital Signal Processing (DSP) (Computational Unit). When the designed system (NCFIT) is placed in front of the forehead of a human body, thermopile detector measures the Infrared energy emitted by the forehead and converted the thermal energy into electrical energy signal.

DSP processes signal from the thermopile detector and then converted it to temperature value using a 17-bit in-built ADC and output the data through 12C communication protocol. The output value is fed into the ATMEGA328P microcontroller while microcontroller sends the measurements in form of digital signal to the LCD and the LCD displays measured temperature parameter.

However, if the normal body temperature is exceeded, the microcontroller activates or triggers the buzzer to sound an alarm.

6. Experimental Results

In order to confirm the accuracy of the constructed NCFIT, a test was conducted to compare the temperature measurements of the constructed NCFIT and mercury-in-glass thermometer. The two thermometers were utilized to measure the body temperature of four persons at the same time of the day (morning).

Table 1 shows the results of the measurements when the constructed NCFIT and mercury-in-glass thermometer were used to measure the temperature of different regions of the human body: Forehead, Oral, Ear and Armpit respectively for four persons.

Table 1: Comparison of constructed NCFIT and Mercury-in-glass thermometer.

Constructed NCFIT Vs Mercury-in-glass thermometer

	Region	Constructed NCFIT (^0C)	Mercury-in-glass Thermometer (^0C)
1st Person	Forehead	35.6	-
	Oral	36.8	36.9
	Ear	36.5	-
	Armpit	36.7	36.8
2nd Person	Forehead	35.5	-
	Oral	36.8	37
	Ear	36.6	-
	Armpit	36.7	36.9
3rd Person	Forehead	35.4	-
	Oral	36.7	36.9
	Ear	36.5	-
	Armpit	36.6	36.8
4th Person	Forehead	34.5	-
	Oral	36.7	36.9
	Ear	36.4	-
	Armpit	36.6	36.8

Discussion

From table 1 shown above, it is observed that the temperature values of different regions of the body are different although, with slight differences. For all the four persons considered, Oral temperature is the closest to the normal body temperature (37^0C). As observed from table 1, it is inconvenient to measure the Forehead and Ear regions using mercury-in-glass thermometer. It is also observed that the results of the constructed NCFIT are almost the same with that of mercury-in-glass thermometer with minute deviations between the two recorded temperature values. With the displayed results in Table 1, the difference between the temperature readings for the two thermometers ranges from 0^0C to 0.2^0C. With further improvements in constructed NCFIT, the accuracy will also improve.

8. Packaging

The device is housed in a plastic casing for proper compacting. The internal packaging of the designed system is shown in fig.3 while fig. 4 indicates the constructed Non-contact Infrared Forehead Thermometer.

Figure 3: Internal Packaging of the circuit board

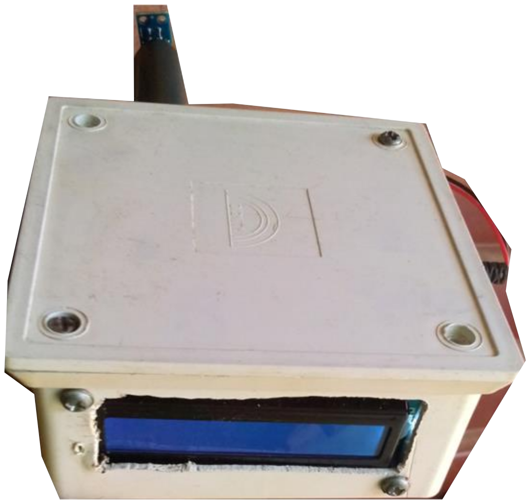

Figure 4: Constructed Non-Contact Forehead Infrared Thermometer

9. Conclusion

The main aim of this project work is to design and develop a Non-Contact Forehead Infrared Thermometer NCFIT, this has been achieved. The designed NCFIT has been tested and performed satisfactorily. The use of precision temperature sensor and microcontroller to perform computations eliminates errors thereby enhancing the device accuracy, increase flexibility and programmability. Hazards associated with mercury-in-glass thermometer is eliminated. NCFIT not only have fast response but also strong, convenient to use, reliable, portable, no parallax issue and cost effective. The beauty of NCFIT is that it measures adults, children and infants temperatures conveniently. NCFIT is applicable not only in medical but also in daily life, research laboratories, industries as well as in any applications that require accurate measurement of temperature. Lastly, as the whole world is witnessing Covid-19 pandemic, NCFIT is preferred to mercury-in-glass thermometer and contact digital thermometer in measuring body temperature as it prevents the risk of spreading contagious deadly diseases such as Corona Virus, the Flu, etc.

References

Abayomi – Alli, A., E.J. Etuk, P.I. Ezomo, F.A. Izilein A.Y. Akingboye and K.B. Erameh. A Microcontroller-Based Digital Thermometer with TIMER (Digithermo). IJCSI International Journal of computer Science. ISSN (Print): 1694-0814) ISSN (Online) 1694-0784.

Abubakar, M. A., Adepoju, T.M., Yusuf, M.A., Abdulhamid M., Muhammad A.S. and Shehu, B. A. (2017). Design and Implementation of a Microcontroller-Based Digital Thermometer. International Conference of Science, Engineering & Environmental Technology (ICONSEET), 2(17): 132-140, 2017 ISSN0794-9650.

Anuj Shaw (2013). A Practical Approach of Designing Infrared Controlled Thermometer. International Journal of Computer Science & Engineering Technology (IJCSET).

Benjamin, O. A., Aaron O. O., and Donaldson E.O. (2016). Design and Implementation of a Digital Thermometer with Clock Global Journal of Engineering Research. body temperature measurements by mothers and physicians using mercury- in-glass, digital mercury and infrared tympanic membrane thermometers in healthy newborn babies. TheTurkish Journal of Pediatrics.

Gang J., Xiangyu Z., Wenqiang F., Yunxue L., and Penfei H. (2015). Design of Non-Contact Infrared Thermometer Based on the Sensor of MLX90614. The Open Automation and Control System Journal.

Guangh L. (2016). Design of A Non-Contact Infrared Thermometer. International Journal on Smart Sensing and Intelligent Systems.

Hadgu G. and Rajalakshmi M. (2016). Is There Significant Difference between Digital and Glass Mercury Thermometer? Hindawi Publishing Corporation, Advances in Nursing. Article ID: 3474503. http: //dxidio.org|10.1155|2016|3474503 Implementation of Digital Alarm Clock with Thermometer, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 3(2): 7651-7653.

Jing Z. (2017). Development of a Non-Contact Infrared Thermometer. Advances in Engineering Research (AER).

Jose, B. M., Aminu C. T. Anand, M., Arjun, S and Aswathy, R., (2014). Design and Karamanoglu A.Y. and Korkmaz F.D (2015).Evidences and practice recommendations for the measurement of non-invasive body temperature in the emergency department, International Refereed Journal of Nursing Researchers 2015.

Madam Sin L.T., Junainah S., and Datin D.B., (2012). Health Technology Assessment Section, Medical Development Division, Ministry of Health, Malaysia D. Ng, J. Lam and K. Chow, (2002), “Childhood fever revisited”. Hong Kong Medical Journal, Article 39.

Mahammad D. V., Tanveer K.A., Punyasheshudu D., Ramamurthy B. (2016). Design and Development of Digital Proximity Type IR Thermometer Based on Arduino unoR3. International Journal of Innovative Research in Science, Engineering and Technology.

Megha S. P., Khayati M.K., Snehal V.P., Nayan J.P., Vishesh I., and P., Panchisilla M. D. (2014). A Comparative Study of Accuracy of Non- Contact Infrared Thermometer and Axillary Digital Thermometry in neonates. GUJARAT MEDICAL JOURNAL.

Nakitende I., Namujwiga T., Kellet J., Opio M., and Lumala A. (2018). Patient reported Symptoms, body temperature and hospital mortality: an observational study in a low resource healthcare environment. 111:691-7.

Oge C, Inci Y., Mehmet C., Ayse K., Murat Y., Ergun K. and Gulten Secmeer (2008). Comparing body temperature measurements by mothers and physicians using mercury-in-glass, digital mercury and infrared tympanic membrane thermometers in healthy newborn babies.The Turkish Journal of Pediatrics.

Rahman N., Kasem F.B., Islam M.R., Sultana R., and Matin A. Comparison Between Mercury and Liquid Crystal Forehead Thermometers for Measurement of Body Temperature. 14421-Article Text-52422-1-10-20130403.pdf

Stand Alone Microcontroller Circuit, (2015). http://www.arduino.cc|en|Main|Standalone.html

The free dictionary (2015). www.thefreedictionary.com http://arduino.cc/en/Main/Arduino_BoardUno mlx90614datasheet.