

## DESIGN AND DEVELOPMENT OF LOW COST NON CONTACT INFRARED THERMOMETER FOR LOW INCOME COUNTRIES

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**Abstract:** *Temperature is an important vital sign for assessing acutely unwell individuals, and is measured frequently in primary care. However, non-contact measurement of temperature can be challenging in low income countries. This paper will review the current types of infrared thermometer and material cost of production, with the aim of designing and developing non-contact infrared thermometers (NCITs), using available sophisticated and locally sourced materials to build its components. NCIT is built using an infrared thermometer sensor. This is used to actuate desired temperature, the analogy values from the sensor when received is filtered for noise, thereafter passed through an amplifier to make it readable by the microprocessor. The microprocessor collects the amplified analogy signal thereafter uses its internal built analogy to digital module to convert the analogy signal to a digital waveform that can be processed by the microprocessor. A display screen is attached to the microprocessor; this display enables values to be visualized. The NCIT was tested after design to insecure accuracy. The NCIT gave values with significant accuracy when compared to invasive thermometer and other non-invasive thermometer. The NCIT showed capacity to reduce infection rate especially when used within a population. NCIT is a low cost medical device with adequate functionality. Its low cost can be attributed to the choice of materials as most materials used where locally sourced. Its use has the potential to reduce the spread of cross-infection and operational cost as it does not need to be sterilized after each use. It would be available to local health providers to better health care in low income countries.*

**Keywords:** *Temperature, infrared, thermometer, cost effective, non-contact*

### 1. INTRODUCTION

Evaluation of body temperature is one of the oldest known diagnostic methods and is still an important sign of health and disease, both in everyday life and in medical care. Accurate temperature measurement is critically important, particularly in neonates and immune compromised children whom suspicion of infection could result in investigations, treatment and even hospitalization.

Consequently, inaccurate temperature measurement may result in patients remain undiagnosed and untreated, or receiving unnecessary or inappropriate intervention. In health centers and hospitals, nurses are responsible for measuring body temperature accurately and it is important to take into account the kind of thermometer and the sites of the body used for taking the measurement. Pulmonary artery temperature is considered the “gold standard” for measuring core body temperature, as mixed venous blood temperature reflects thermoregulation by the hypothalamus. The distal esophagus and nasopharynx are considered acceptable alternatives to the pulmonary artery catheter and commonly used intra-operatively. However, like the pulmonary artery catheter, these instruments are invasive and thus are generally inappropriate outside the peri-anesthesia, peri-operative and critical care setting. Other invasive methods include rectal and bladder measurement. Clinically, oral and rectal temperatures are the most reliable indicators of core body temperature. Children younger than four years have difficulty keeping an oral thermometer under their tongues, making reliable temperature measurements difficult. At present, rectal thermometer has traditionally been considered the gold standard for temperature measurement in young children because it correlates highly with core body temperature. However, when the core temperature increases or decreases abruptly, rectal temperature changes more slowly and can be substantially different from the core temperature. In addition without proper sterilization techniques, rectal thermometer has the capacity to spread contaminants that are commonly found in stool. Rectal thermometers are very stressful for infants, are time-dependent and require certain level of practice. These characteristics make it an undesirable procedure for infants, health workers and parents. Mercury in glass thermometer was the traditional type of thermometer used to measure body temperature. However, mercury thermometers are gradually being phased out. This is because of concerns regarding the toxic environmental effect of mercury, namely toxicity from the absorption due to breakage and risk of infection. Thus, they are no longer recommended for use in infants and young children. Furthermore, The UK Health and Safety Regulations requires

that mercury containing 2 medical devices should not be used whenever a suitable alternative exists. Electronic thermometers are widely used by healthcare professionals as alternative methods to mercury thermometers. This thermometer is supposedly accurate and very quick to use but they are often complex and quite expensive. Recently, cheaper compact electronic thermometers have been produced and available for use by the public, as well as healthcare professionals. Other types of thermometer available in the market is the chemical phase change thermometers which uses a combination of chemicals that change color in response to variations in temperature. This type of thermometer is either chemical dot thermometers where the chemicals are contained in cells on a plastic stick, or chemical forehead thermometers which consists of a patch of chemicals in a plastic pouch that is placed on the forehead. Chemical dot thermometers are usually designed for single use but reusable types are also available. In recent years, infrared thermometers have been more frequently used. This type of thermometer determines the temperature of infrared emission from a source rather than absorbing heat from the tissue and reaching thermal equilibrium with it. Temperatures can typically be obtained in less than five seconds. Most thermometers of this type measure temperature at the ear drum (Infrared tympanic thermometers) but temporal artery thermometers are now available where temperature is measured on the scalp. Researchers have found a difference of 0.5 C between the tympanic thermometer and the mercury-in-glass thermometer. This study aimed to assess the safety, efficacy/effectiveness and cost-effectiveness of Infrared thermometer for fever detection in a hospital or primary care setting.

## 2. MATERIALS AND METHODOLOGY

Temperature was measured with thermopile. This thermopile was recommended by the manufacture (Hplanar, Technick) for contactless temperature measurement of various applications. It can also be used in medical application for ear and fore head thermometer. The thermopile works by transferring heat radiation emitted by an object into electrical voltage output. The thermopile is a four legged sensor with pin assignment as follows. Pin1=TP<sup>+</sup>, pin2=Ni-RTD, pin3=TP<sup>-</sup>, pin4=GND. The thermopile is operated at a voltage of 5V (DATASHEETLIB). The temperature sensor is a unique design with absorbable area 0.7x0.7mm<sup>2</sup> this makes it suitable to be placed on the circuitry making the final product compact and of unique shape. The thermocouple also has a sensitivity of 0.45+0.08 which makes it to be desired when compared with other sensor available in the market (DATASHEETLIB). It also has an operating temperature between -20 to 100 °C. This is quality makes it suitable to be used to measure extremely low and very high temperature.

### 2.1 ARDUINO PRO MINI

The arduino mini is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers. A six pin header can be connected to an FTDI cable to provide USB power and communication to the board.

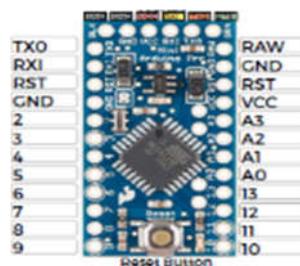


Fig 1: Arduino mini board

### 2.2 OPERATIONAL AMPLIFIER

Filtration and amplification is both done by LM358 which is a dual operational amplifier (LM358). The LM358 consist of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages (NATIONAL SEMICONDUCTOR). Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. LM358 has some unique characteristics such as input bias current and unity gain across frequency that are both temperature compensated. LM358 eliminates the need for dual power supply, power drain suitable for battery operation and compatibility with all form of logic. These makes the use of LM358 very appropriate for the design of thermometer.

**2.3 DISPLAY:** Display used is a Nokia 5110 which is an 84x48 pixels monochrome liquid crystal display (LCD), it is a small display screen with diameter of 1.5. Nokia 5110 is driven by PCD8544 controller chip. This display is made of 84x48 individual pixels, it can be used for graphics, text or bitmaps (ADAFRUIT INDUSTRIES). These displays are inexpensive, easy to use, require only a few digital I/O pins and are fairly low power as well.



Fig 2: Nokia 5110 LCD screen

## 2.4 METHODOLOGY

The NCIT is powered by a 9V direct current (DC) battery as it is relatively cheap and available. This voltage is step-down to 5V that is needed by the entire circuit except the display which is powered by a 3.3V power input. 5V power supply is provided by voltage regulator 7805 while that of 3.3V is supplied by LM117(TEXAS INSTRUMENTS). These output voltages from the voltage regulator is further stabilized by a zener diode. The zener diode serves as a voltage regulator against damage from accidental application of excessive voltage. The thermopile sensor reads physical parameters. The output values from the thermopile is analog in nature and contains noise that can hamper the final result. This noise needs to be filtered out and then amplified. The raw value from the thermopile is connected to an operational amplifier (OPAM). The first amplifier is used to filter out noise. This is achieved by adequately calculating the gain and choose relevant resistor value. The second opam is used to amplify the analogy value this would make it readable by the microprocessor.

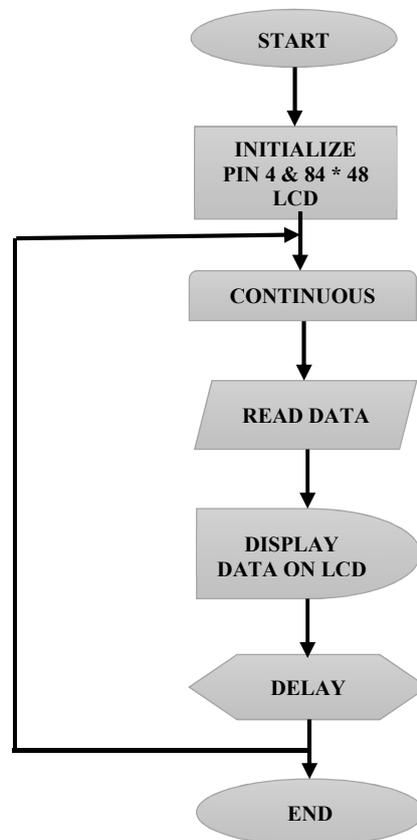


Fig 3: NCIT flow chart.

Output from the amplifier is channeled to microprocessor. The microprocessor accepts the analogy value then after uses its internal analogy to digital module to convert analogy values to digital values. This values are thereafter displayed on the LCD screen.

### 3. RESULTS AND DISCUSSION

Device testing was done by evaluating the efficacy of the prototyped NCIT in its first field testing in order to validate its use in determining the heat radiated from persons by reading the frequency of the heat temperature that is displayed on the LCD screen. The focus of the first phase is centered on the forehead specifically focusing on the mid-forehead as such, Measurements were taken by NCIT at a 1m distance on the forehead. Additional areas were selected based on accessibility and possible presence of viable superficial veins that may allow for better thermal expression. The following locations were measured: eye, lower lip, throatlatch, back of the ear, bridge of nose (side). All measurements were taken using NCIT from a 1m distance as previously utilized. The location in which the measurements were taken remained constant throughout the phase of the data collection; however variables such as changes in natural lighting, ambient temperature, relative humidity, presence of wind, etc. were some of the environmental factors that impact the effects and reading of temperature on the device.



*Fig 4: temperature display on prototyped NCIT*

Figure 4 indicates the temperature value of the person being measured at different locations. The value displayed is normal at 37.2°C. The next phase involves working with a randomly selected group of subjects under simulated conditions with the sensors in order to validate the safety and effectiveness of the thermometer.

### 4. CONCLUSION

#### **4.1 EFFECTIVENESS & COST IMPLICATION.**

As the present work is focused on the design and development of low cost non-contact infrared thermometer based on Arduino mini microprocessor. The non-contact infrared thermometer is more advantageous in its application especially in medical field. In this paper we approached a method in selection of sensor, simplicity, and fast development method. The instrument is quite cost effective, accurate, portable and easy to operate. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced ICs and with the help of growing technology the project has been successfully implemented and evaluated.

#### **4.2 SAFETY**

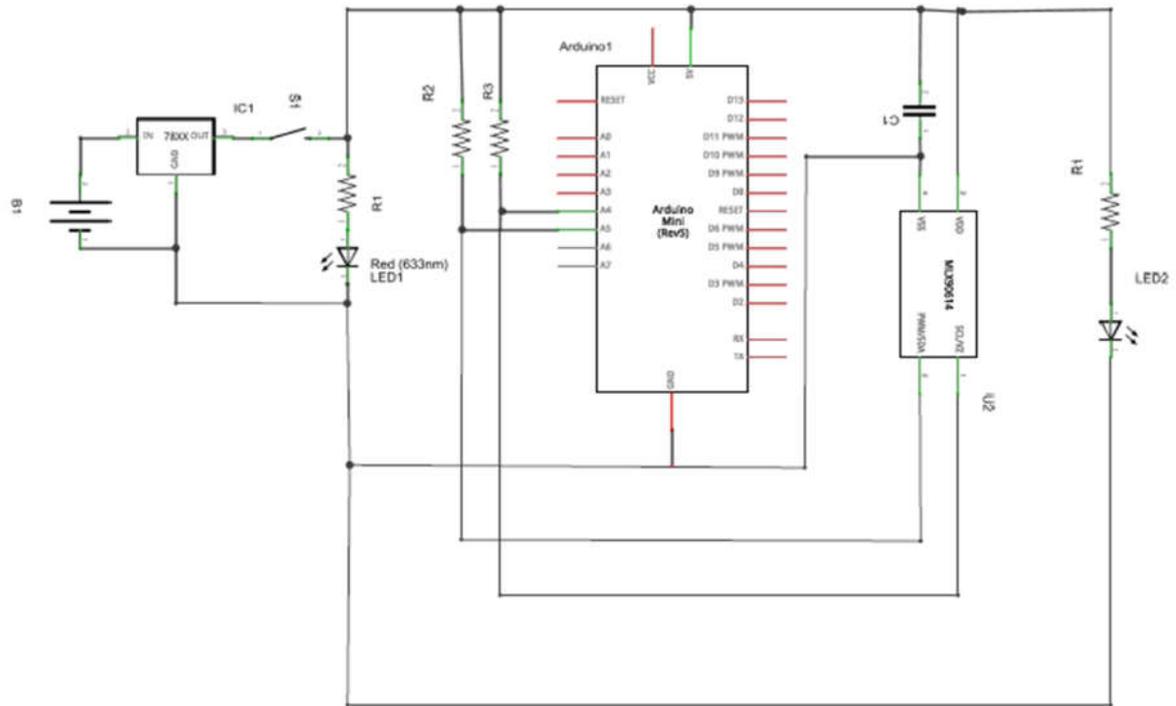
There was no retrievable evidence reporting any adverse events related to the use of the infrared thermometer.

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## APPENDIX



*NCIT Circuit diagram*