A

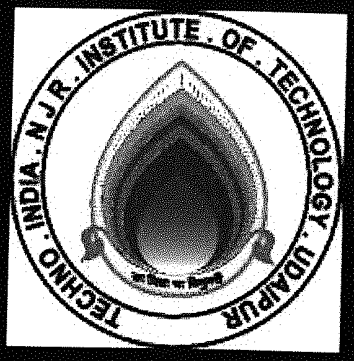
MAJOR PROJECT REPORT

on

Non-Contact Infrared Thermometer

Submitted in partial fulfilment of the requirements of the degree of

BACHELOR OF TECHNOLOGY



Under Guidance of

Mr. Yogendra Solanki
Ass. Professor
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Submitted by

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

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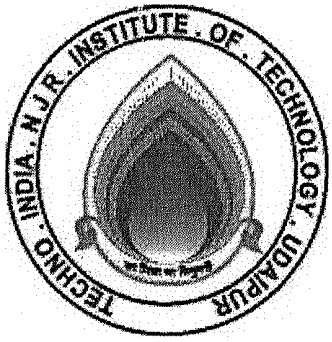

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Department of Electronics and Communication Engineering

Techno India NJR Institute of Technology, Udaipur

Certificate

This is to certify that this Major Project report entitled **Non-Contact Infrared Thermometer** by **Aayushi Gahlot, Shrinath Vaishnav** have completed the work under my supervision and guidance, hence approved for submission in partial fulfilment for the award of degree of Bachelor of Technology in Electronics and Communication to the Department of Electronics and Communication Engineering, Techno India NJR Institute of Technology, Udaipur during academic session 2017-2021.

Mr. Yogendra Solanki	Mr. Pradeep Chhawcharia
Ass. Professor	Head of Department
Dept. of E.C.E, TINJRIT, Udaipur	Dept. of E.C.E TINJRIT, Udaipur
Date.....	Date.....

Department of Electronics and Communication Engineering
Techno India NJR Institute of Technology, Udaipur

Examiner certificate

This is to certify that the following students

Aayushi Gahlot

Shrinath Vaishnav

of final year B.Tech. (Electronics & Communication Engineering), were examined for the project work entitled

Non-Contact Infrared Thermometer

during the academic year 2017 – 2021 at Techno India NJR Institute of Technology, Udaipur

Remarks:

Date:

Signature
(Internal Examiner)

Signature
(External Examiner)

PREFACE

In present situations, social distancing is the most important fact. Furthermore, the fact is COVID-19 patient's first symptom is body temperature is high. The reason why, measuring body temperature is most important, but needs to maintain social distancing. While traditional thermometers can't make sure of social distancing, where our developed contactless thermometer can achieve temperature on display by using Arduino unoR3 as the main control device as well as MLX90614 as the infrared (IR) thermometer sensor. As a result, compared with the traditional thermometer, it shows strong points such as convenient reading, wide range of temperature measurement, and accuracy where temperature output is displayed digitally. Besides, it would be used everywhere because of its easy-handling

ACKNOWLEDGMENT

We take this opportunity to record our sincere thanks to all who helped us to successfully complete this work. Firstly, we are grateful to our **supervisor Mr. Yogendra Singh Solanki** for his invaluable guidance and constant encouragement, support and most importantly for giving us the opportunity to carry out this work.

We would like to express our deepest sense of gratitude and humble regards to our

Head of Department Mr. Pradeep Chhawcharia for giving invariable encouragement in our endeavours and providing necessary facility for the same. Also, a sincere thanks to all faculty members of ECE, TINJRIT for their help in the project directly or indirectly.

Finally, we would like to thank my friends for their support and discussions that have proved very valuable for us. We are indebted to our parents for providing constant support, love and encouragement. We thank them for the sacrifices they made so that we could grow up in a learning environment. They have always stood by us in everything we have done, providing constant support, encouragement and love

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LIST OF ACRONYMS

ACRONYM	FULL FORM
OLED	organic light-emitting diode
ADC	Analog-to-digital converter
GND	Ground
PWM	Pulse-width modulation
SCL	Serial Clock
SPI	Serial Peripheral Interface
I2C	Inter-Integrated Circuit.
SDA	Artificial Neural Network

ABSTRACT

An integrated sensors platform for non-contact temperature monitoring is proposed in this work. The adopted solution, based on the combined integration of an infrared thermometer and a capacitive humidity sensor, is able to provide a fast and accurate tool for remotely sensing both ambient and body temperature in the framework of pandemic situations, such as COVID-19, thus avoiding any direct contact with people.

The information related to IR radiation ,the working of sensors with Arduino and full details on the design of the proposed platform are provided in the work .

Chapter 1 - INTRODUCTION

1.1 Overview

Since the outbreak of Covid-19, infrared thermometers are being used as a screening tool to scan the people at Airports, Railway Stations, and other crowded establishments. These scans are being used to **identify potential patients of Covid-19**. The **Government made it compulsory** to scan everyone before entering the office, school, or any other crowded place.

When debugging an electronics circuit or testing a new hardware design, often times I tend to check if the components on the board are getting hot abnormally by touching them. And if something is messed up (which usually is in the first try) these components could get as hot as 80°C or more burning not only the component but also my finger along with it. After burning my fingers for more times than I could remember I decided to build my own **Temperature Gun.**

hence it can not only be used to measure component temperatures but can also be used for measuring body temperature, surface temperature, Heat ventilation and much more. Of course, these thermal guns are readily available in the market from renowned manufacturers like Fluke etc. But they are not light on your pockets so we will build it **pocket friendly.**

- **Materials Required:**

    1. Arduino Pro Mini
    2. MLX90614 Infrared Temperature Sensor
    3. OLED Display – SSD1306
    4. Laser Diode
    5. 9V Battery

6. Push button
7. Battery Clip
8. Connecting wires
9. 3D Modelling Software
10. 3D Printer

1.2 Process Description

1. Implementation of Arduino MLX90614 Thermometer Circuit Diagram on breadboard.
2. Testing the Circuit.
3. Find and debugging circuit faults
4. Designing the casing for temperature gun on 3D software.
5. Print the casing for temperature gun model.
6. Programming for Arduino MLX90614 Infrared Thermometer.
7. Final testing and debugging.

Chapter 2 - MLX90614 TEMPRATURE SENSOR

2.1 Overview

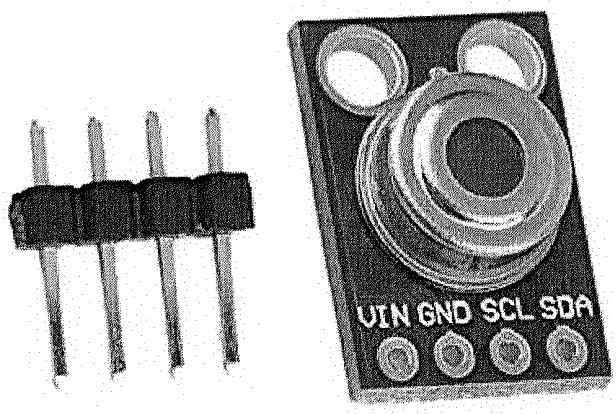


Fig 2.1 MLX90614 Temperature Sensor

1 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.

2 MLX90614 is a temperature measurement device works on infrared radiations. It is the best option for such applications where we cannot easily reach to measure temperature because it provides non-contact measurement of temperature.

3 It has an amplifier of squat noise, Analog to Digital (ADC) converter of 17- bits and potent DSP component, all these components provide the elevated exactness and high degree of this thermometer.

4 During its fabrication, it is mounted with the 10-bit Pulse width modulation (PWM) which constantly sends out the calculated temperature in the assortment of -20 to 120 °C by providing yield resolution of 0.14 °C.

5 It consists of two boards (chips) one is infrared radiation detector and other is ASSP which is a signal conditioner, it is for the processing of infrared sensor output. It is available in TO-39 enclosing.

6 The pinout of Pulse width Modulation can also be used as a thermal type of relay, which provides us less expensive completion in temperature observant applications such as boiling and freezing.

7 This device has two input supply choices one is 5V and other is the 3V battery. We can supply 5 volts by exterior supply.

8 An optical filter (long-wave pass) that cuts off the visible and near infra-red radiant flux is integrated in the package to provide sunlight immunity.

2.2 Working Principle

MLX90614 sensor is manufactured by Me lexis Microelectronics Integrated system, it has two devices embedded in it, one is the infrared thermopile detector (sensing unit) and the other is a signal conditioning DSP device (computational unit). It works based on **Stefan-Boltzmann's law.**

Stefan-Boltzmann law- states that all objects emit IR energy and the intensity of this energy will be directly proportional to the temperature of that object.

2.1.1 IR Sensor

There are a number of reasons why you should consider choosing infrared technology for your temperature reading needs. When shopping for a thermometer to add to your stable of equipment, consider purchasing a quality infrared thermometer for some of the following reasons.

1. Accuracy. Obviously, you need to be confident that you are getting an accurate reading from your thermometer when you put it to use, and infrared models have a great reputation for accuracy. The technology used in these products is simple yet advanced, and you should be able to rely on the information that you receive - provided that the thermometer is used in the right way.

2. Safety. One of the great things about being able to check on temperature remotely is that you don't actually need to touch the object in question. If you are trying to take the temperature of a particularly hot item, you won't need to place your hand, or even another piece of equipment, onto the hot surface. Just by aiming your IR thermometer at the object you wish to measure; you can get all of the information you need without putting yourself at risk.

3. Contamination prevention. Another benefit to the remote measuring system is avoidance of contamination. This is particularly important within the food service world, but it applies in other applications as well. Since you don't need to touch the item that you are measure, you won't need to worry about contaminating that product with the probe of a thermometer. Rather than having to make sure that all of your temperature measuring equipment is properly sterilized prior to each use, you can simply point the IR gun at the item being measured and forget any worries about contamination problems.

4. Durability. You want an Infrared Thermometer that is tough enough to stand up to the demands of the jobsite, workshop or just being bounced around in your toolbox.

There are certainly more than three advantages to using infrared, but the three listed above are some of the most important. Additionally, the cost of this technology has come down in recent years, meaning you can access this great method of temperature measurement for a significantly lower cost than it would have required just a few short years ago.

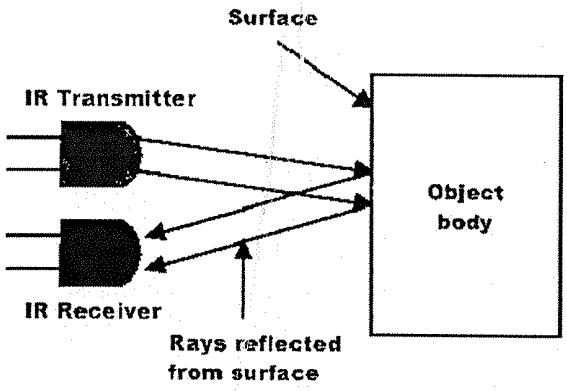


Fig 2.2 IR sensor working

IR sensor consists of an **IR LED and a Photodiode**, this pair is generally called **IR pair** or **Photocoupler**. IR sensors work on the principle in which IR LED emits IR radiation and Photodiode sense that IR radiation. Photodiode resistance changes according to the amount of IR radiation falling on it, hence the voltage drop across it also changes, and by using the voltage comparator we can sense the voltage change and generate the output accordingly.

The working principle of infrared sensor MLX90614 is to transform the infrared radiation signal collected from objects and bodies into electrical signals, send the electrical signal into converter after noise amplification processing by amplifier, then the electrical signal is converted to digital signals and store the processed signals

into the internal memory, finally send the signals into the SCM control system for further processing.

MLX90614 infrared temperature sensor uses the SPI bus, when connected to the microcontroller, SCL termination microcontroller serial input port RXD, serial output pulse signals of sensor are provided by the microcontroller, it is used to transmit temperature information, SDA serial output port TXD is used to provide temperature information for the microcontroller, in the specific operation, the microcontroller transfer data through the serial port mode 0.

Table 2.1 Pin Functions

Pin Name	Function
VSS	Ground. The metal can is also connected to this pin
SCL	Serial clock input for 2 wire communications protocol. 5.7V Zener is available at this pin for connection of external bipolar transistor to MLX90614A to supply the device from external 8 -16V source
PWM / SDA	Digital input / output. In normal mode the measured object temperature is available at this pin Pulse Width Modulated.
VDD	External supply voltage.

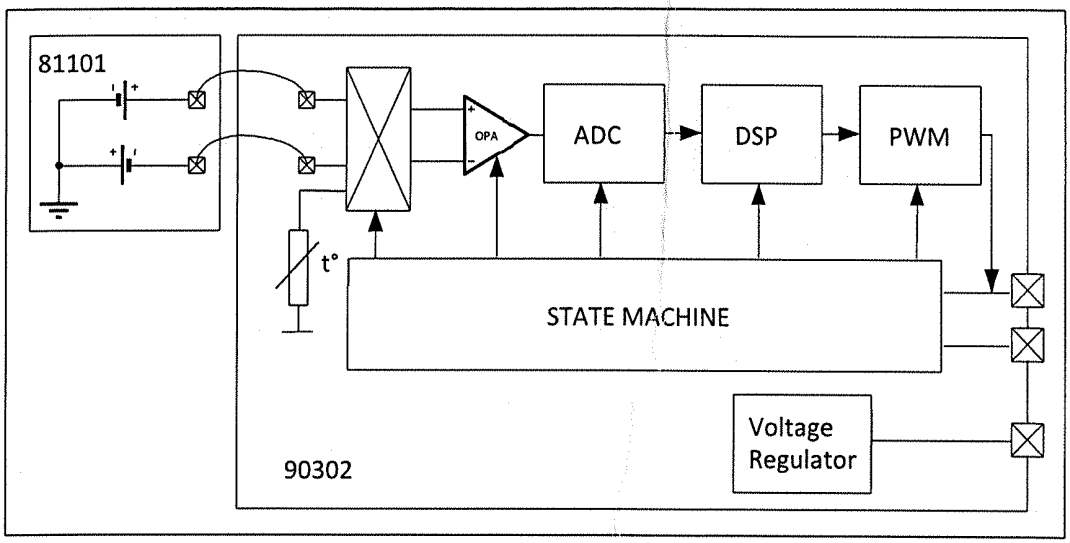


Fig 2.3 Block Diagram

2.2.2 Block Description

Amplifier: A low noise low offset amplifier with programmable gain is implemented for amplification of the IR sensor voltage. With a carefully designed input modulator and balanced input impedance, an offset as low as 0.5µV is achieved.

Supply regulator and POR: The module can operate from 2 different supplies: VDD= 5V => MLX90614Axx VDD=3.3V => MLX90614Bxx (battery or regulated supply) Refer to "Applications information" section for information about adopting higher voltage supplies.

The Power On Reset (POR) is connected to Vdd supply. The on-chip POR circuit provides an active (high) level of the POR signal when the Vdd voltage rises above approximately 0.5V and holds the entire MLX90614xxx in reset until the Vdd is higher than the specified POR threshold VPOR (note that this level is different for MLX90614Axx and MLX90614Bxx). During the time POR is active, the POR signal is available as an open drain (active high) at the PWM/SDA pin. After the MLX90614xxx

exits the POR condition, the function programmed in EEPROM takes precedence for that pin.

EEPROM: A limited number of addresses in the EEPROM memory can be changed by the customer. The whole EEPROM can be read via SMBus interface.

The addresses Tomax, Tomin and Ta range are for customer dependent object and ambient temperature ranges.

RAM: It is not possible to write into the RAM memory. It can only be read and only a limited number of RAM registers are of interest to the customer.

2.3 Features

These are some features of MLX90614.

1. It is accessible in lesser size and less costly.
2. It can be effortlessly incorporated.
3. It is obtainable in large no of temperature range such as -40 to 125 °C is used for temperature instruments and -70 to 380 °C for measurement of the different object's temperature.
4. It delivers high exactness on different temperature choices such as 0 to 50 °C.
5. It has a resolution value of 0.02°C.
6. It works on 3v and 5V temperature range.
7. It exists in single and twice over varieties.
8. For the evaluation of temperature on consistent basis System Management Bus Control Pulse Width Modulation.
9. It can transform for such devices which works on 8 to 16V temperature.
10. This module also has a mode for energy saving.
11. It is offered in different suites according to the working atmosphere and applications.

12. It can easily adaptable from one state to another.

2.4 Applications and Examples

1. High precision non-contact temperature measurements.
2. Thermal Comfort sensor for Mobile Air Conditioning control system.
3. Temperature sensing element for residential, commercial and industrial building air conditioning.
4. Windshield defogging.
5. Automotive blind angle detection.
6. Industrial temperature control of moving parts.
7. Temperature control in printers and copiers.
8. Home appliances with temperature control.
9. Healthcare.
10. Livestock monitoring.
11. Movement detection.
12. Multiple zone temperature control – up to 100 sensors can be read via common 2 wires.
13. Thermal relay/alert.
14. Body temperature measurement.

Chapter 3 - ARDUINO PRO MINI

3.1 Overview

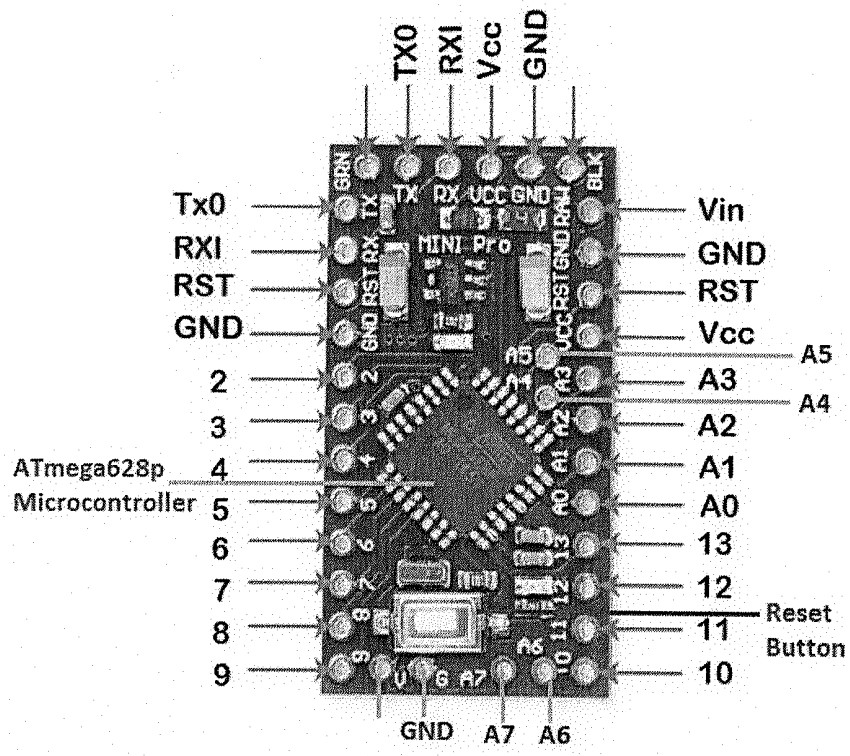


Fig 3.1 Pin Diagram

ARDUINO PRO MINI board is one of the application boards. Since it is an application board, it does not have an in-built programmer. USB port and other connectors are also removed. Because once it is placed in an application, programmer and connectors are basically useless.

The Arduino Pro Mini 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, an on-board resonator, a reset button, and holes for mounting pin headers. A six-pin header can be connected to an FTDI cable or Spark fun breakout board to provide USB power and communication to the board.

The Arduino Pro Mini is intended for semi-permanent installation in objects or exhibitions. The board comes without pre-mounted headers, allowing the use of various types of connectors or direct soldering of wires. The pin layout is compatible with the Arduino Mini. There are two version of the Pro Mini. One runs at 3.3V and 8 MHz, the other at 5V and 16 MHz The Arduino Pro Mini was designed and is manufactured by Spark Fun Electronics

3.2 Technical Specifications

Table 3.1 ARDUINO PRO MINI Pinout Configuration

PIN GROUP	PIN NAME	DESCRIPTION
POWER SOURCE	VCC, GND, and RAW	VCC - Connected to +5V or +3.3V GND – Connected to GROUND RAW – Connected to Unregulated power supply 5+V to +12V
COMMUNICATION INTERFACE	UART Interface (RXD, TXD) SPI Interface (MOSI, MISO, SCK, SS) TWI Interface (SDA, SCL)	UART (Universal Asynchronous Receiver Transmitter) Interface can be used to program PRO MINI SPI (Serial Peripheral Interface) Interface ban be used to program PRO MINI TWI (Two Wire Interface) Interface can be used to connect peripherals.

INPUT OUTPUT PINS	PD0 to PD7 (8 pins of PORTD) PB0 to PB5 (6 pins of PORTB) PC0 to PC6 (7 pins of PORTC) ADC6 and ADC7(2 additional pins)	Although these 23 pins have many functions, they can be considered as data I/O pins.
ANALOG to DIGITAL CONVERTER	ADC0, ADC1, ADC2, ADC7	These channels can be used to input Analog signals. There are of 10-bit resolution.
PWM	OC0A, OC0B, OC1A, OC1B, OC2A, OC2B	These six channels can provide PWM (Pulse Width Modulation) outputs. They are of 8-bit resolution.
RESET	RESET	Resets the controller.
EXTERNAL INTERRUPTS	T0 and T1	These two pins are specially designed hardware interrupts.
ANALOG COMPARATOR	AIN0 and AIN1	These two pins are connected to an internal comparator.

Table 3.2 Technical Specifications

Microcontroller	ATmega328 *
Board Power Supply	3.35 -12 V (3.3V model) or 5 - 12 V (5V model)
Circuit Operating Voltage	3.3V or 5V (depending on model)
Digital I/O Pins	14
PWM Pins	6
UART	1
SPI	1
I2C	1
Analog Input Pins	6
External Interrupts	2
DC Current per I/O Pin	40 mA
Flash Memory	32KB of which 2 KB used by bootloader *
SRAM	2 KB *
EEPROM	1 KB *
Clock Speed	8 MHz (3.3V versions) or 16 MHz (5V versions)

1. **Arduino Pro Mini** is a compact, small-sized & application-type microcontroller board, developed by Arduino. cc and comes with an **Atmega328** microcontroller incorporated on the board.

2. This board comes with **14 Digital I/O Pins**, out of which **6 pins** are used for providing **PWM output**.

3. Arduino Pro Mini Pinout also consists of **8 Analog Pins**.

4. The size of Arduino Pro Mini is 1/6th of the size of Arduino Uno, so it's quite small as compared to Arduino UNO.

5. Depending on operating voltage, Arduino Pro Mini is of two types:

    - Operating Voltage: 5.0V, Crystal Oscillator: 16MHz, Voltage Regulator: KB33.
    - Operating Voltage: 3.3V, Crystal Oscillator: 8MHz, Voltage Regulator: KB50.

6. To reduce the size, the USB port & built-in programmer are removed from Arduino Pro Mini, so after uploading code you can simply place it in your application (that's why also termed as application-type).

7. Official Arduino Software called Arduino IDE (Integrated development environment) is used to write & upload programming code. The code we write to program this board is normally called a sketch.

8. Arduino Pro Mini also has a Reset Button and a small LED connected to PIN 13.

3.2.1 Arduino Pro Mini Power Pins

The Arduino Pro Mini can be powered with an FTDI cable or breakout board connected to its six-pin header, or with a regulated 3.3V or 5V supply (depending on the model) on the Vcc pin. There is a voltage regulator on board so it can accept

voltage up to 12VDC. If you're supplying unregulated power to the board, be sure to connect to the "RAW" pin on not VCC.
The power pins are as follows:

1. **Vcc:** Arduino Pro Mini Pinout consists of 2 Vcc Pins. It gives the regulated voltage i.e. 5V or 3.3V depending on the type of the board.
2. **GND:** There are 3 GND (ground) pins incorporated on the board.
3. **RAW:** This pin is used for supplying raw voltage to the board. You can power connect an external power supply ranging from 5V to 12 V.
4. **Reset:** Pro Mini board comes with 2 Reset Pins, which comes in handy if the board hangs up in the middle of the running program, making this pin LOW will reset the board.

3.2.2 Programming Header Pins

Programming Header: FTDI six-pin programmer is connected with these pins and is used to upload programming code on the Pro Mini board.

3.2.3 Arduino Pro Mini I/O Pins

1. **Digital Pins:** Arduino Pro Mini has 14 Digital I/O Pins in total labelled from 0 to 13, where Pin 0 is RX1 and Pin 1 is TX0.
2. **Analog Pins:** It has 8 analog pins labelled from A0 to A7. These pins are used to input analog signals and come with a total resolution of 10bit.

3.2.4 Arduino Pro Mini Communication Pins

1. Arduino Pro Mini supports 3 Communication Protocols for the transmission of data with other peripherals i.e., sensors, registers etc. and are named as:

- Serial Protocol.
- I2C Protocol.
- SPI Protocol.

2. **TXD & RXD Pins:** These pins are used for serial communication. TXD represents the transmission of serial data while RXD is used for receiving the data. Code is also uploaded through Serial Protocol.
3. **SPI Pins:** Four pins 10(SS), 11(MOSI), 12(MISO), and 13(SCK) are used for communicating through SPI Protocol.
4. **I2C Pins:** Two Pins (A4 and A5) are used for developing I2C communication. A4 is known as serial data line (SDA) which holds the data and A5 shows serial clock line (SCL) which provides data synchronization clock.

Other Pinouts

1. **PWM.** There are 6 digital pins labelled as 3,5,6,9,10, and 11 available on the board that provide PWM (pulse width modulation).
2. **External Interrupts.** There are two external interrupts available called T0(at Pin 4) and T1(at Pin 5). They are also known as hardware interrupts.

3.2.5 Memory Structure

The Memory structure of the Pro Mini is similar to Arduino UNO. The memory structure is shown below:

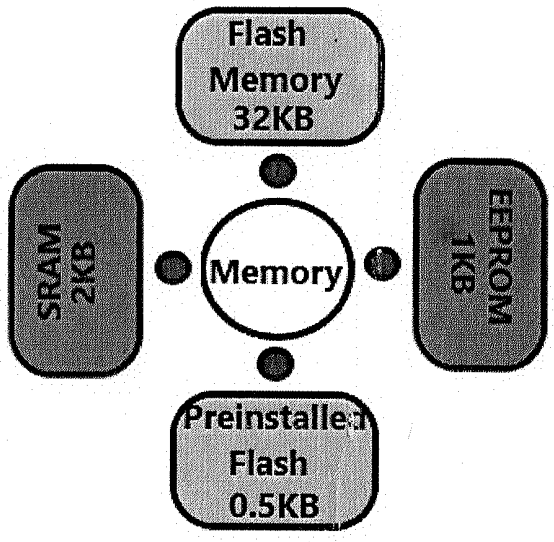


Fig 3.2 Memory Structure

3.3 Programming in ARDUINO PRO MINI

Using PRO MINI is similar to any other development board. All you need to do is program the controller and provide the appropriate peripheral to get system running. We will discuss the programming of PRO MINI in step by step below.

1. First you need to get a programmer. As mentioned earlier, the PRO MINI does not have an inbuilt programmer, so you cannot connect PRO MINI directly to PC to program it. Choose either UART or SPI programmer. Preferable UART programmer.
2. Download and install ARDUINO IDE software.
3. Open the code or sketch written in the Arduino software.

4. Select the port and the type of board.
   The ATmega328p microcontroller is used in the Arduino Pro Mini. So, we will select the Processor as ATmega328p. Click on '**Tools**' and select **Processor**.
5. List the functions to be performed by PRO MINI.
6. Write the functions as program in IDE. Remember the program is written in 'C' language.
7. No separate burner is required to burn the code. You can directly burn the code in the IDE software and transfer it to the board.
8. Connect the programmer and establish a communication between IDE and PRO MINI.
9. Burn the program to PRO MINI through IDE.
10. Disconnect the programmer. Provide the power and attach the necessary peripherals. After reset, the control executes the program and provides the desired output.

3.4 Applications

Case1: Where system is permanent installation. In permanent applications, the board only needs to be programmed once, and that is all. In those cases, features provided like USB programmer, I/O connectors and other supporting hardware is useless. The PRO MINI is specifically designed for those systems. This board has only basic hardware just enough for those applications.

Case2: For convenience. This board is one of the smallest boards of ARDUINO. With its comfort size, it can be used in mobile applications.

Case3: With basic hardware the cost of board is considerable lesser.

Case4: With 32Kbytes memory, the PRO MINI can accommodate most application programs.

Pros:

1. This pro-mini is particularly designed so that you can permanently embed it in your project.
2. Due to its favourable form factor, its power consumption is very low.
3. It can be put into a portable device due to its smaller size.
4. It is very light in weight.
5. Slower speed allows better controllability.
6. Cost-effective.

Cons:

1. It does not have any USB port and other connectors.
2. It does not have an inbuilt programmer.

Chapter 4 LASER DIODE

4.1 Overview

Laser Diode is another popular diode for its kind. This is an optical diode which emits light but with stimulated process. The
name **LASER** implies **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

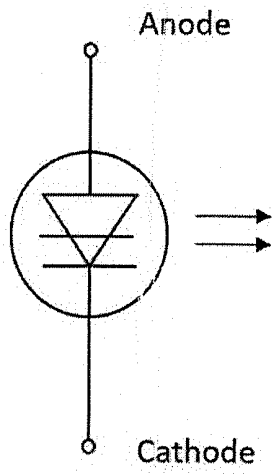


Fig 4-1 Laser diode symbol

4.2 Working Principle

4.2.1 Stimulated Emission and Population Inversion

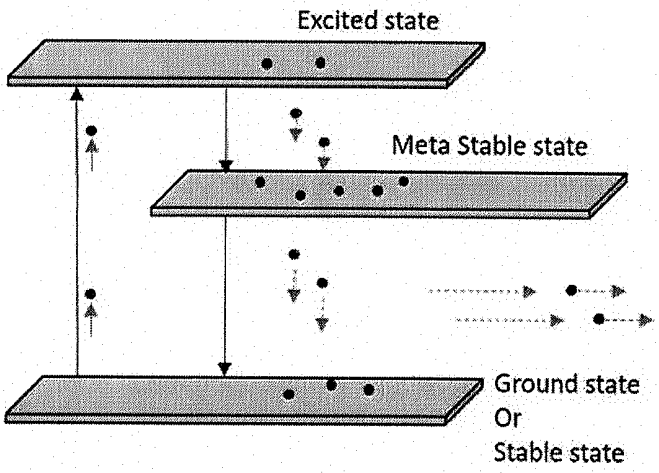
This is a PN junction diode whose action starts when a light ray is incident on it. With a light ray, when photons get incident on an atom, the atom gets excited and it reaches an upper level which can be termed as a **Higher Energy Level.**

The atom when shifts from the higher energy level to a **Lower Energy Level**, it releases **two photons** which are **similar in characteristics** to the incident photon and are in **equal phase** to it. This process is called as **Stimulated Emission**. An atom can generally stay in this excited state for **10^{-8} secs** of time.

So, the above process sets the principle for laser diode.

Whenever a photon is incident on an atom, that atom is excited from a lower energy state to a higher energy state and two photons are released in this process. Actually, an atom can generally stay at this excited state for **10^{-8}** secs of time. So, in order to achieve amplification, during this excited process, the atom is made to be placed in another state called **Meta Stable State** which is below the higher energy level and above the lower energy level.

An atom can stay in this Meta stable state for **10^{-3}** secs. While the atom gets to the lower state from this, two photons are released. If more number of atoms are there in the excited state, prior to the photons striking the atoms, then we have the **Lasing Effect.**



Population Inversion in Laser diode

Fig 4.2 Population Inversion in Laser Diode

In this process, we have two terms to understand. Having more number of atoms at Meta Stable state than the lower energy state or ground state is called as Population inversion. Then energy that lets the atoms to send from a lower energy state to a higher energy state to achieve the population inversion, is called as Pumping. This is Optical pumping.

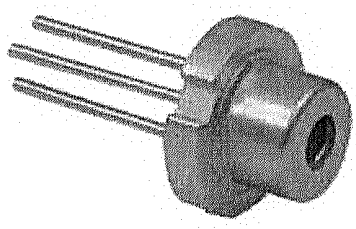


Fig 4.3 Laser Diode

4.3 Advantages

There are many advantages of Laser diode such as –

- Power used by laser diodes is much less
- Higher ON/OFF switching speed
- More Compact
- Less expensive
- They are cheaper than laser generators
- Less chances of providing electrical shocks

Chapter -5 SSD1306 OLED DISPLAY

5.1 Overview

- OLED is organic light emitting diode that emits light in response to an electric current. OLED display works with no backlight so it can display deep black levels. It is small in size and light in weight than Liquid Crystal Displays
- 128x64 OLED display is simple dot matrix graphic display. It has 128 columns and 64 rows which make it display of total 128x64 = 8192 pixels. By just turning on/off these pixel's led we can display graphical image of any shape on it.

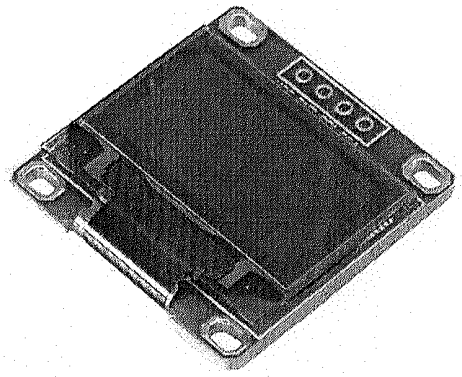


Fig 5.1 OLED Display

OLED displays driven by SSD1306 driver IC. SSD1306 is a CMOS OLED driver with controller for OLED dot-matrix graphic display system. Due to use of SSD1306 driver, number of external components required and power consumption has reduced.

- OLED display is used for displaying text, images and various patterns. It is also suitable for mobile phone sub-display, MP3 player, calculators etc.

- OLED display has 256 steps for brightness control.
- OLED display also available with different resolution like 128x32, 128x64. OLED display in above image has resolution of 128x64 pixels.

5.2 Technical Specifications

Table 5.1 OLED Pin Configuration

Pin No:	Pin Name:	Description
1	Ground (Gnd)	Connected to the ground of the circuit
2	Supply (Vdd,Vcc,5V)	Can be powered by either 3.3V or 5V
3	SCK (D0,SCL,CLK)	The display supports both IIC and SPI, for which clock is supplied through this pin
4	SDA (D1,MOSI)	This is the data pin of the both, it can either be used for IIC or for SPI
5	RES(RST,RESET)	When held to ground momentarily this pin resets the module
6	DC (A0)	This is command pin, can either be used for SPI or for IIC
7	Chip Select (CS)	Normally held low, used only when more than one SPI device is connected to MCU

5.2.1 Features

1. Monochrome 7-pin SSD1306 0.96" OLED display.

2. 128×64pixel resolution with 160° viewing angle.
3. Supply voltage 3V – 5V (supports both 5V and 3.31v logic devices).
4. Uses SSD1306 for interfacing hence can communicate through SPI or IIC.
5. Multiple SPI or IIC devices are supported
6. Can be easily interfaced with Arduino (Library available).
7. Supports decent graphics of bitmap images.
8. Available in different colours and sizes as discussed below.

How to use OLED display module:

As discussed above, there are many types of OLED displays available in the market the most popular one is the **Monochrome 7-pin SSD1306 0.96" OLED display** which we are discussing here. This display can support both IIC and SPI communication. When you receive the module from the factory it will be in 4-wire SPI mode by default and it is the fastest of all available modes. However, you can re-solder the resistors in different positions to make it work in 3-Wire SPI and IIC protocol also.

Once you have settled on which protocol to use you should jump into the datasheet (given below) to know how to communicate with. The IC supports both 3.3V and 5V logic devices so hardware should not be a problem. If you are planning to interface with Arduino, then all the hard work is already pulled over by the Arduino community by providing you ready-made library. Make sure you have made the connections correctly and used the correct library and you are all set to go.

5.3 Applications

1. Used in consumer electronics.

2. Used for Smartwatch, mobile phone, and MP3 displays.
3. Small level gaming displays.
4. Wide range of viewing angle enable to be used in low light.

5.4 Advantages and Disadvantages

Advantage

1. No need for a backlight.
2. Display is very thin and light weight.
3. View angles are better than LCDs.
4. Brightness and contrast are great.
5. High speed and low response time.
6. Deep black colour.

Disadvantage

1. Costly technology
2. Short lifecycle
3. OLEDs are more likely to burn-in.
4. Water damage

Chapter 6 INTEGRATION AND WORKING

6.1 Working Principle

All bodies with a temperature above 0 °K radiate infrared energy. Infrared radiation is the portion of the electromagnetic spectrum which lies between visible light and radio waves. The wavelength range of infrared radiation lies between 0.7 µm and1000 µm. In practice however, within this broad range only wavelengths between 0.7 and 20 µm are suitable for measuring temperatures. The amount of energy emitted from a surface is proportional to the fourth power of the temperature of the surface.

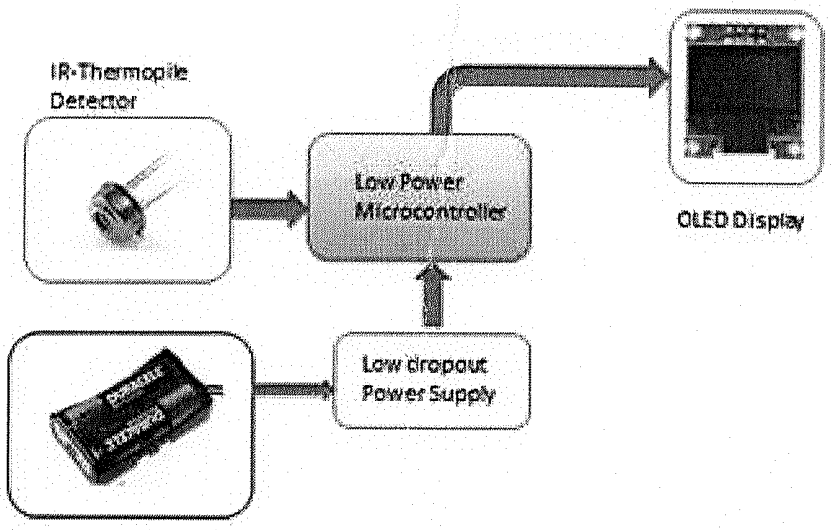


Figure 6.1 System Block Diagram

6.2 Field of View

One question that is not directly answered by the datasheet is the measuring distance between the sensor and the object. The value of this distance is given by the term **Field of View (FOV)**, for our sensor the field of view is about 80°.You can think of the sensing range to be in a conical shape from the point of sensor as show above. So, as we go far from the measuring object the sensing area increase by two

folds. Meaning for every 1cm we move away from the object the sensing area grows by 2cm. In our thermal gun **we have placed a laser diode on top of the sensor** to know where the sensing area of the sensor is currently pointing at. I found that the values were reliable if the gun is pointed at 2cm away from the object and the accuracy goes down as we move away.

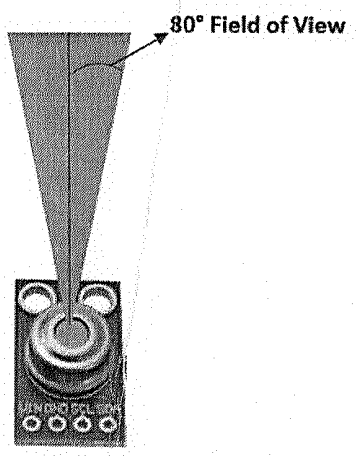


Figure 6.2 Field of View

6.3 Connections

The entire circuit is powered by the 9V battery through a push button. When the push button is pressed the 9V battery is connected to the RAW pin of Arduino which is then regulated to 5V using the on-board voltage regulator. This 5V is then used to power the OLED module, Sensor and Laser diode.

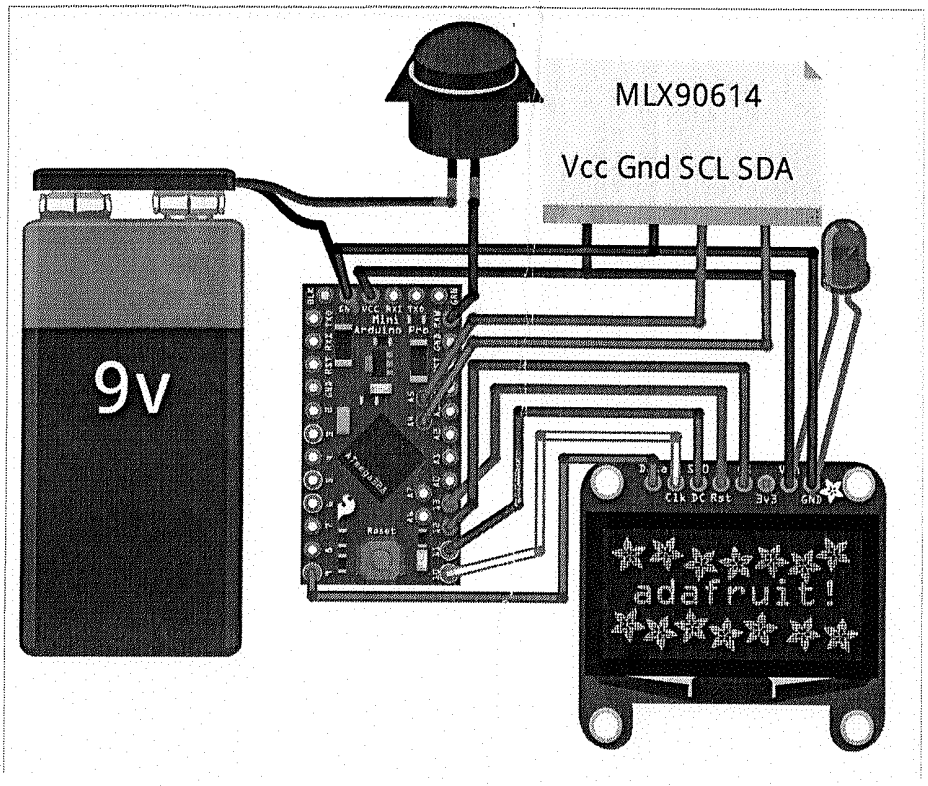


Figure 6.3 Circuit Diagram

Chapter 7 DESIGNING THE CASING FOR TEMPRATURE GUN

7.1 Overview

In 3D computer graphics, 3D modelling is the process of developing a mathematical coordinate-based representation of any surface of an object (inanimate or living) in three dimensions via specialized software by manipulating edges, vertices, and polygons in a simulated 3D space.

Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created manually, algorithmically (procedural modelling), or by scanning. Their surfaces may be further defined with texture mapping.

The term 3D printing or three-dimensional printing is a form of additive manufacturing technology where a three-dimensional object is created from successive layers material. Objects can be created without the need for complex expensive molds or assembly with multiple parts. 3D printing allows ideas to be prototyped and tested without having to go through a production process.

In recent years, there has been an upsurge in the number of companies offering personalized 3D printed models of objects that have been scanned, designed in CAD software, and then printed to the customer's requirements. 3D models can be purchased from online marketplaces and printed by individuals or companies using commercially available 3D printers, enabling the home-production of objects such as spare parts and even medical equipment.

Almost all 3D models can be divided into two categories:**Solid** – These models define the volume of the object they represent (like a rock). Solid models are mostly

used for engineering and medical simulations, and are usually built with constructive solid geometry

Shell or boundary – These models represent the surface, i.e. the boundary of the object, not its volume (like an infinitesimally thin eggshell). Almost all visual models used in games and film are shell models.

7.2 3D Modelling Process

1. Polygonal modelling – Points in 3D space, called vertices, are connected by line segments to form a polygon mesh. The vast majority of 3D models today are built as textured polygonal models, because they are flexible and because computers can render them so quickly. However, polygons are planar and can only approximate curved surfaces use many polygons.

2. Curve modelling – Surfaces are defined by curves, which are influenced by weighted control points. The curve follows (but does not necessarily interpolate) the points. Increasing the weight for a point will pull the curve closer to that point. Curve types include nonuniform rational B-spline (NURBS), splines, patches, and geometric primitives

3. Digital sculpting – Still a fairly new method of modelling, 3D sculpting has become very popular in the few years it has been around. [citation needed] There are currently three types of digital sculpting: Displacement, which is the most widely used among applications at this moment, uses a dense model (often generated by subdivision surfaces of a polygon control mesh) and stores new locations for the vertex positions through use of an image map that stores the adjusted locations. Volumetric, loosely based on voxels, has similar capabilities as displacement but does not suffer from polygon stretching when there are not enough polygons in a region to achieve a deformation. Dynamic tessellation, which is similar to voxel, divides the surface using triangulation to maintain a smooth surface and allow finer details. These methods allow for very artistic exploration as the model will have a new topology created over it once the models

form and possibly details have been sculpted. The new mesh will usually have the original high resolution mesh information transferred into displacement data or normal map data if for a game engine.

7.2.1 Need of casing

To make the project more practically usable we have 3D modelled and printed our outer casing for our thermal gun. The design involves two parts, one is the top part which acts as the body of the gun housing the Arduino controller, OLED, Sensor and the Laser diode. The other is the bottom part which acts as a handle of the gun housing the battery and push button. The Push button here acts as the trigger. The model looks like below image.

7.2.2 Model File Description:

Model resolutions are optimized for polygon efficiency (in 3DS MAX the mesh smooth function can be used to increase mesh resolution if necessary). - All colours can be easily modified. - No part-name confusion when importing several models into a scene. - No cleaning up necessary, just drop model into your scene and start rendering. - No special plugin needed to open scene. - HDRI background & lights scene we have used is not included, it's just the model with materials applies.

Table 7.1 Casing Specification

Geometry	**Polygonal quads/tris**
Polygons	3,344
Vertices	3,371
Textures	Yes
Rigged	No
Animated	No

respectively. The OLED was then mounted in the printed part using screws while the sensor and Laser diode was mounted using hot glue. The power pins (Raw, Gnd) were then slid down through a wire for the handle part which consists of the push button and battery. This wire was then connected to the battery though the push button.

Chapter 8 – PROGRAMMING FOR ARDUINO MLX90614 THERMOMETER

The Program for Arduino should read the temperature value from the MLX90614 and display it on the OLED display.

8.1 Programming for Arduino and MLX90614 for display on OLED

Like always we begin the program by **adding the required library files**. Here the Wire library (in-built) is used to communicate using I2C protocol and the SparkFunML90614 library is used to for communicating with the sensor. The SPI, GFX and SSD1306 libraries are used for communicating with 4-wire SPI protocol to the OLED display module.

```
#include <Wire.h>

#include <SparkFunMLX90614.h>

#include <SPI.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>
```

We then **define the pins of the OLED display** to which we have made the connection. Since the module works with SPI we have used the SPI pins of the Arduino. There are OLED displays that works with I2C protocol as well, but we can't use them here since the I2C pins are already occupied by the thermometer sensor.

```
#define OLED_MOSI  9

#define OLED_CLK  10
```

```
#define OLED_DC   11

#define OLED_CS   12

#define OLED_RESET 13

Adafruit_SSD1306 display(OLED_MOSI, OLED_CLK, OLED_DC, OLED_RESET,
OLED_CS);
```

Inside the **void setup ()** function, we initialize serial monitor for debugging and also the IR temperature sensor using the object term that we created earlier. Here in India the most followed unit for temperature is Celsius (degree C) hence we have set the unit of the with TEMP_C you can also change this to TEMP_F if you need the values to be in Fahrenheit (F). Finally we initialize the OLED display and clear its display. Also the screen of OLED is rotated by 180 degree for easier mounting option in the casing.

```
void setup ()

{

 Serial.begin(9600);

 therm.begin();

 therm.setUnit(TEMP_C);


 display.begin(SSD1306_SWITCHCAPVCC);

 display.clearDisplay();
```

```
  display.setRotation(2);

}
```

Inside the *loop* function, we read the value of temperature from the sensor and convert it into String to be displayed in the OLED display. We have also printed the value on the serial monitor for debugging purpose. We have also incremented a variable called runner which is produce a small animation on the screen every time the value of the temperature sensor is updated successfully, this will help us know if the reading is stuck for some reason.

```
if (therm.read()) // On success, read() will return 1, on fail 0.

{

  temperature = String(therm.object(), 2);

  Serial.print("Object: ");

  Serial.print(temperature); Serial.println("C");

  display.clearDisplay();

  runner++;

  delay(5);

}
```

8.2 Testing

Once the Arduino code is ready we can upload it to our hardware using an external TTL programmer or FTDI board since the pro mini does not have one on-board. Then simply press the push button to trigger the thermal gun and you will notice the laser beam falling on the object and the temperature of the object being displayed on the OLED screen as shown below. Here I have used it to measure the temperature of a component as pointed by the laser beam.

```
/**********************************
Code for Arduino MLX90614 Contactless thermometer
MLX90614 I2C connection
OLED 4-wire SPI connection
Dated: 7-6-2019
Code by: Aswint Raj
**********************************/

#include <Wire.h>
#include <SparkFunMLX90614.h>

#include <SPI.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

// If using software SPI (the default case):
#define OLED_MOSI  9
#define OLED_CLK   10
#define OLED_DC    11
#define OLED_CS    12
#define OLED_RESET 13
```

```
Adafruit_SSD1306 display(OLED_MOSI, OLED_CLK, OLED_DC, OLED_RESET,
OLED_CS);

IRTherm therm;

void setup()
{
 Serial.begin(9600);
 therm.begin();
 therm.setUnit(TEMP_C);

  display.begin(SSD1306_SWITCHCAPVCC);
  display.clearDisplay();
  display.setRotation(2);


}

String temperature;
char runner;

void loop()
{
 if (therm.read()) // On success, read() will return 1, on fail 0.
 {
  temperature = String(therm.object(), 2);
  Serial.print("Object: ");
  Serial.print(temperature); Serial.println("C");
  display.clearDisplay();
  runner++;
  delay(5);
 }

 display.setTextSize(2);
 display.setTextColor(WHITE);
```

```
        display.setCursor(display.width()/4,display.height()/12);

        if (therm.object()>=100)
        display.setCursor(display.width()/4,display.height()/12);

        display.println(temperature);

        display.drawLine(display.width()/runner,display.height() - display.height()/2.5,
    display.width()/runner+1, display.height() - display.height()/2.5, WHITE);

        display.setCursor(0,display.height()-display.height()/4);
        display.setTextSize(1);
        display.println("   Arduino Thermlgun");
        display.setCursor(display.width()- display.width()/4,display.height()/12);
        display.println("deg C");
        display.display();

      if (runner>20)
      runner=0;
    }
```

Chapter 9 RESULT

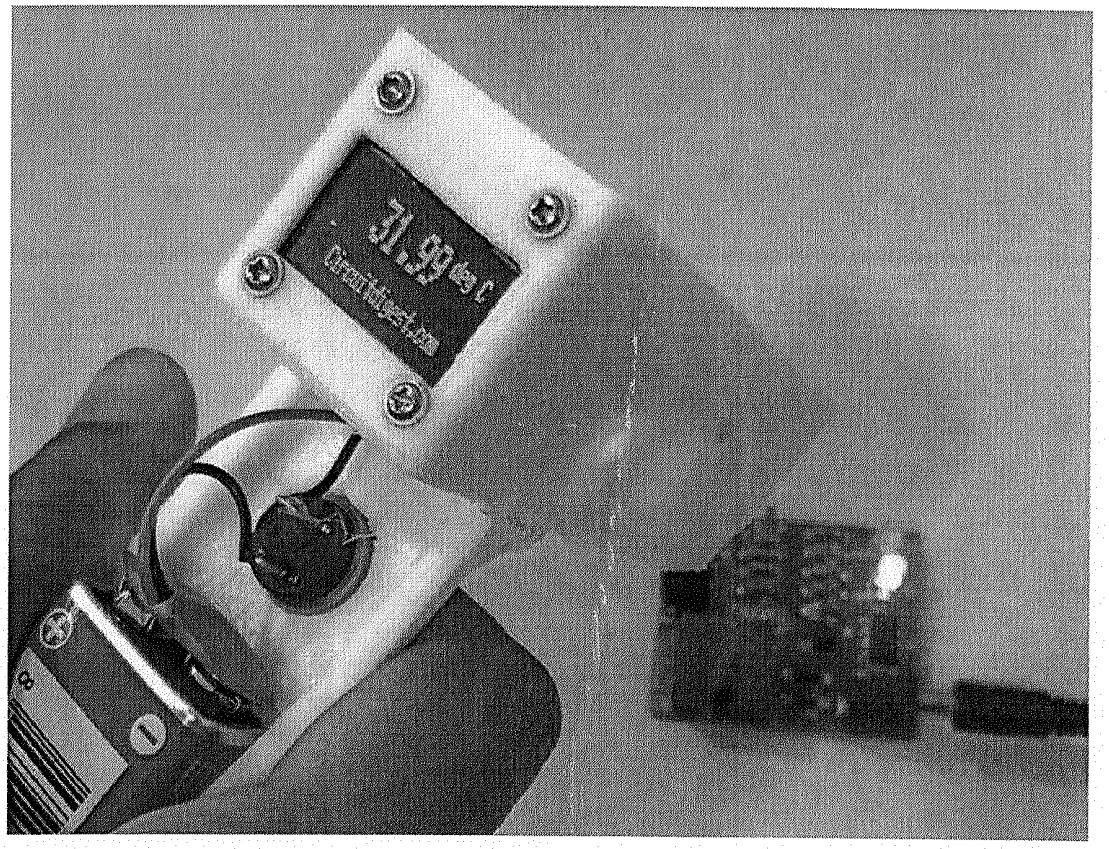


Fig 9.1 IR Thermometer using Arduino and MLX90614 Infrared Temperature Sensor

Refrence

[1] Introduction to MLX90614. https://www.theengineeringprojects.com/2019/05/introduction-of-mlx90614.html

[2] Arduino Pro MINI. https://www.arduino.cc/en/pmwiki.php?n=Main/ArduinoBoardProMini

[3] OLED https://components101.com/displays/oled-display-ssd1306

[4] Arduino IDE https://www.arduino.cc/en/Guide/Environment

[5] https://ieeexplore.ieee.org/document/9299586