The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

Design Remote Thermometer Measurement Electronic Devices

Halo akram Albarazange
Department of Computer Technical Engineering, Al-Qalam University College, Kirkuk 36001, Iraq, halonamiq71@gmail.com

Abstract
Fever is a common symptom of many infections, e.g., in the ongoing COVID-19 pandemic, keeping monitoring devices such as thermometers in constant demand. Recent technological advancements have made infrared (IR) thermometers the choice for contactless screening of multiple individuals. Yet, even so, the measurement accuracy of such thermometers is affected by many factors including the distance from the volunteers' forehead, To realize the human body temperature fast and non-contact measurement, an infrared thermometer is designed. The infrared human body temperature sensor is mainly used to convert the human body's infrared into a voltage signal, an operational amplifier to amplify the signal, a filter circuit to filter the signal, the analog signal into a digital signal by the A/D conversion circuit, data processing by the MCU, LCD display reporting body temperature, we also found ways to program compensation methods for the final assembled digital IR thermometer to provide more accurate readings and measurements.

Keywords: Remote Thermometer, Measurement, Electronic Devices.

INTRODUCTION

1.1 Thermometer

A thermometer comes from the Greek word, thermos, meaning "hot" and metron, "measure". It is a device that measures temperature or temperature gradient using a variety of differentprinciples. A thermometer has two important elements: the temperature sensor (e.g. the bulb on amercury-in-glass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer).
Thermometers measure temperature, by using materials that change in some way when they are heated or cooled. In a mercury or alcohol thermometer, the liquid expands as it is heated and contracts when it is cooled, so the length of the liquid column is longer or shorter depending on the temperature.
Modern thermometers are calibrated in standard temperature units such as Fahrenheit (used in the United States) or Celsius (used in Canada) and Kelvin (used mostly by scientists).

1.2 Temperature

While an individual thermometer can measure degrees of hotness, the readings on two thermometers cannot be compared unless they conform to an agreed scale. There is today an absolute thermodynamic temperature scale. Internationally agreed temperature scales are designed to approximate this closely, based on fixed points and interpolating thermometers. The most recent official temperature scale is the International Temperature Scale of 1990. It extends from 0.65 K (−272.5 °C; −458.5 °F) to approximately 1,358 K (1,085 °C; 1,985 °F).

1.3 Development

Various authors have credited the invention of the thermometer to Cornelis Drebbel, Robert Fludd, Galileo Galilei, and Santorio Santorio. The thermometer was not a single invention, however, but a development. Philo of Byzantium and Hero of Alexandria knew of the principle that certain substances, notably air, expand and contract and described a demonstration in whicha closed tube partially filled with air had its end in a container of water.
The expansion and contraction of the air caused the position of the water/air interface to move along the tube. Such a mechanism was later used to show the hotness and coldness of the air witha tube in which the water level is controlled by the expansion and contraction of the gas. These devices were developed by several European scientists in the 16th and 17th centuries, notably Galileo Galilei. As a result, devices were shown to produce this effect reliably, and the term thermoscope was adopted because it reflected the changes in sensible heat (the concept of temperature was yet to arise). The difference between a thermoscope and a thermometer is that the latter has a scale.
Though Galileo is often said to be the inventor of the thermometer, what he produced were thermoscopes. The first clear diagram of a thermoscope was published in 1617 by Giuseppe Biancani: the first showing a scale and thus constituting a thermometer was by Robert Fludd in 1638. This was a vertical tube, closed by a bulb of air at the top, with the lower end opening into a vessel of water. The water level in the tube is controlled by the expansion and contraction ofthe air, so it is what we would now call an air thermometer.
The first person to put a scale on a thermoscope is variously said to be Francesco Sagredo or

The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

Santorio Santorioin about 1611 to 1613.

Figure 1: Galileo Thermometer 24 degrees

The word thermometer (in its French form) first appeared in 1624 in La Récréation Mathématique by J. Leurechon, who describes one with a scale of 8 degrees. The above instruments suffered from the disadvantage that they were also barometers, i.e. sensitive to air pressure. In about 1654 Ferdinando II de Medici, Grand Duke of Tuscany, made sealed tubes part-filled with alcohol, with a bulb and stem; the first modern-style 4 thermometer, dependent on the expansion of a liquid, and independent of air pressure. Many other scientists experimented with various liquids and designs of thermometers. However, each inventor and each thermometer were unique—there was no standard scale.

In 1665 Christiaan Huygens suggested using the melting and boiling points of water as standards, and in 1694 Carlo Renaldini proposed using them as fixed points on a universal scale. In 1701 Isaac Newton proposed a scale of 12 degrees between the melting point of ice and body temperature.

Finally, in 1724, Daniel Gabriel Fahrenheit produced a temperature scale that now (slightly adjusted) bears his name.

He could do this because he manufactured thermometers, using mercury (which has a high coefficient of expansion) for the first time and the quality of his production could provide a finer scale and greater reproducibility, leading to its general adoption. In 1742 Anders Celsius proposed a scale with zero at the boiling point and 100 degrees at the freezing point of water, though the scale which now bears his name has them the other way around.

In 1866 Sir Thomas Clifford Allbutt invented the clinical thermometer that produced a body temperature reading in five minutes as opposed to twenty.

In 1999 Dr. Francesco Pompei of the Exergen Corporation introduced the world's first temporal artery thermometer, a non-invasive temperature sensor that scans the forehead in about two seconds and provides a medically accurate body temperature.

Old thermometers were all non-registering thermometers. That is, the thermometer did not hold the temperature after it was moved to a place with a different temperature.

Determining the temperature of a pot of hot liquid required the user to leave the thermometer in the hot liquid until after reading it. If the non-registering thermometer was removed from the hot liquid, then the temperature indicated on the thermometer would immediately begin changing to reflect the temperature of its new conditions (in this case, the air temperature).

Registering thermometers are designed to hold the temperature indefinitely so that the thermometer can be removed and read at a later time or in a more convenient place.

The first registering thermometer was designed and built by James Six in 1782, and the design, known as Six's thermometer is still in wide use today.

Mechanical registering thermometers hold either the highest or lowest temperature recorded until manually re-set, e.g., by shaking down a mercury-in-glass thermometer, or 5 until an even more extreme temperature is experienced.

Electronic registering thermometers may be designed to remember the highest or lowest temperature or to remember whatever temperature was present at a specified point in time.

The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

Thermometers increasingly use electronic means to provide a digital display or input to acomputer.

1.4 Physical Principles of Thermometer

Thermometers may be described as empirical or absolute. Absolute thermometers are calibrated numerically by the thermodynamic absolute temperature scale.
Empirical thermometers are not in general necessarily in exact agreement with absolute thermometers as to their numerical scale readings, but to qualify as thermometers at all they must agree with absolute thermometers and with each other in the following way: given any two bodies isolated in their separate respective thermodynamic equilibrium states,
all thermometers agree as to which of the two has the higher temperature, or that the two have equal temperatures.
For any two empirical thermometers, this does not require that the relation between their numerical scale readings be linear, but it does require that relation to be strictly monotonic.
This is a fundamental characteristic of temperature and thermometers.
As it is customarily stated in textbooks, taken alone, the so-called "zeroth law of thermodynamics" fails to deliver this information, but the statement of the zeroth law of thermodynamics by James Serrin in 1977, though rather mathematically abstract, is more informative for thermometry: "Zeroth Law – There exists a topological line which serves as a coordinate manifold of material behavior.
The points of the manifold are called 'hotness levels', and called the 'universal hotness manifold'.
To this information there needs to be added a sense of greater hotness; this sense can be had, independently of calorimetry, thermodynamics, and properties of particular materials, from Wien's displacement law of thermal radiation: the temperature of a bath of thermal radiation is proportional, by a universal constant, to the frequency of the maximum of its frequency spectrum; this frequency is always positive but can have values that tend to zero. Another way of identifying hotter as opposed to colder conditions is supplied by Planck's principle, that when a process of isochoric 6 adiabatic work is the sole means of change of internal energy of a closed system,
the final state of the system is never colder than the initial state; except for phase changes with latent heat, it is hotter than the initial state. There are several principles on which empirical thermometers are built, as listed in the section of this article entitled "Primary and secondary thermometers".
Several such principles are essentially based on the constitutive relation between the state of a suitably selected particular material and its temperature. Only some materials are suitable for this purpose, and they may be considered "thermometric materials". Radiometric thermometry, in contrast, can be only very slightly dependent on the constitutive relations of materials.
In a sense then, radiometric thermometry might be thought of as "universal".

This is because it rests mainly on a universality character of thermodynamic equilibrium, that it has the universal property of producing blackbody radiation.

1.5 Primary and secondary thermometers

Thermometers can be divided into two separate groups according to the level of knowledge about the physical basis of the underlying thermodynamic laws and quantities.

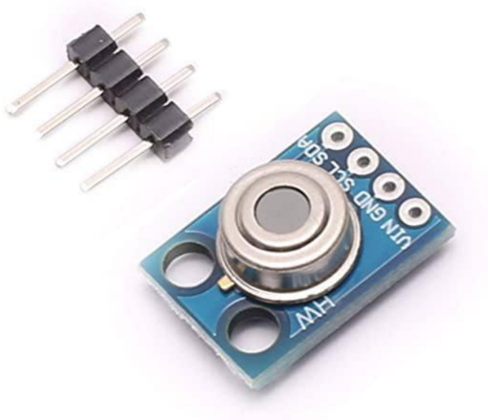
The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

For **primary thermometers,** the measured property of matter is known so well that temperature can be calculated without any unknown quantities. Examples of these are thermometers based on the equation of state of a gas, on the velocity of sound in a gas, on the thermal noise (see Johnson–Nyquist noise), voltage or current of an electrical resistor, on blackbody radiation, and the angular anisotropy of gamma-ray emission of certain radioactive nuclei in a magnetic field. Primary thermometers are relatively complex.
Secondary thermometers are most widely used because of their convenience. Also, they are often much more sensitive than primary ones. For secondary thermometers knowledge of the measured property is not sufficient to allow direct calculation of temperature. They have to be calibrated against a primary thermometer at least at one temperature or several fixed temperatures. Such fixed points, for example, triple points and superconducting transitions, occurreproducibly at the same temperature.

Temperature Sensor : MLX90614
The MLX90614 is an InfraRed thermometer for non-contact temperature measurements. Both the IR-sensitive thermopile detector chip and the signal conditioning ASSP are integrated intothe same TO-39 can. Thanks to its low noise amplifier, 17-bit ADC, and powerful DSP unit, high accuracy, and resolution of the thermometer are achieved. The thermometer comes factory calibrated with a digital PWM and SMBus (System Management Bus) output. As a standard, the 10-bit PWM is configured to continuously transmit the measured temperature in the range of -20…120 C, with an output resolution of 0.14 C. The factory default POR setting is SMBus. Figure 2: typical application schematics. The MLX90614 is built from 2 chips developed and manufactured by Melexis:
*The Infra-Red thermopile detector MLX81101
*The signal conditioning ASSP MLX90302, is specially designed to process the output of an IR sensor.
The device is available in an industry-standard TO-39 package.
the low noise amplifier, high-resolution 17-bit ADC, and powerful DSP unit of MLX90302 high accuracy and resolution of the thermometer are achieved. The calculated object and ambient temperatures are available in the RAM of MLX90302 with a resolution of 0.01°C.
They are accessible by 2 wire serial SMBus compatible protocol (0.02°C resolution) or via the 10-bit PWM (Pulse Width Modulated) output of the device.
As a standard, the MLX90614 is calibrated for an object emissivity of 1. It can be easily customized by the customer for any other emissivity in the range of 0.1. 1.0 without the need for recalibration with a black body.
The 10-bit PWM is a standard configured to transmit continuously the measured object temperature for an object temperature range of -20°C…120°C with an output resolution of0.14°C, and -70°C. 380°C for the object temperature.

The PWM can be easily customized for virtually any range desired by the customer by changing the content of 2 EEPROM cells. This does not affect the factory calibration of the device.

Figure 3: sensor (MLX90302)



3.1 Microcontroller

the microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on-chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general-purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys, and other embedded systems.
By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed-signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems. Some microcontrollers may use four-bit words and operate at clock rate frequencies as low as 4 kHz, for low power consumption(single-digit million-watts or microwatts).
They will generally have the ability to retain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just Nano-watts, making many of them well suited for long-lasting battery applications. Other microcontrollers may serve performance-critical roles, where they may need to act more like a digital signal processor (DSP), with higher clock speeds and power consumption.

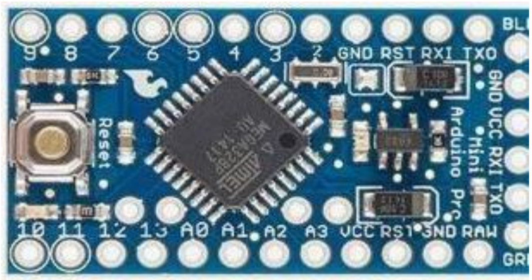
3.2 The Arduino Pro

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 onboard resonator, a reset button, and holes for mounting pin headers. A six-pin header can be connected to an FTDI cable or Sparkfun breakout board to provide USB power and communication to the board.

The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

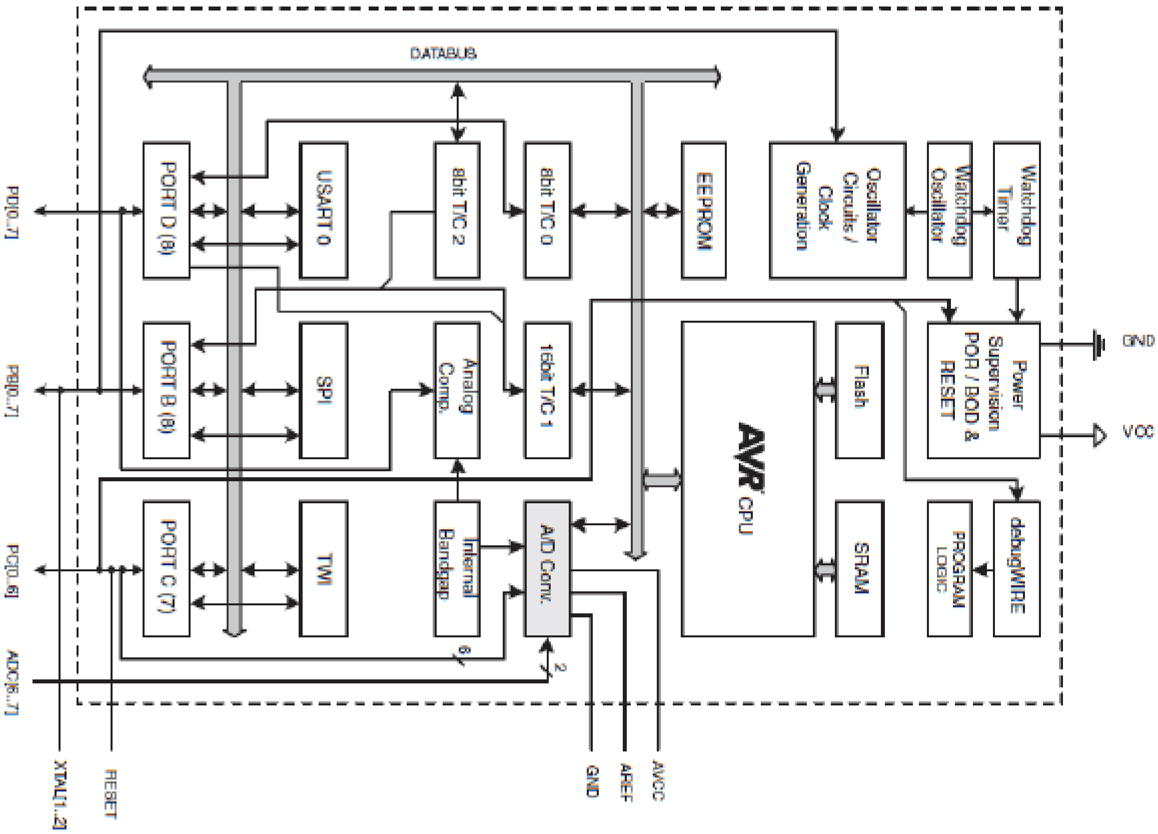
The Arduino Pro Mini is intended for semi-permanent installation in objects or exhibitions. The board comes without pre-mounted headers, allowing the use of various types of connectors or direct soldering of wires. The pin layout is compatible with the Arduino Mini.

Figure 4: The Arduino Pro (ATmega328)



3.3 Block diagram

Figure 5: block diagram of microcontroller board



OLED Display SSD1306

SSD1306 is a single-chip CMOS OLED/PLED driver with a controller for an organic / polymer light-emitting diode dot-matrix graphic display system. It consists of 128 segments and 64commons. This IC is designed for Common Cathode type OLED panels.

The SSD1306 embeds with contrast control, display RAM, and oscillator, which reduces the number of external components and power consumption. It has 256-step brightness control.

It is suitable for many compact portable applications, such as Smartwatch, real-time image display of cameras on smart cars, Battery management devices, etc.

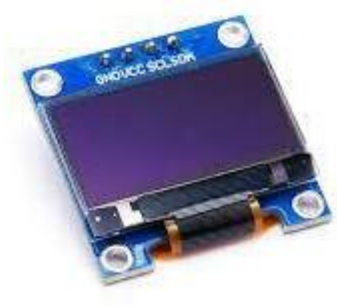


Figure 6: OLED Display SSD1306

- **Features**
  - For OLED-SSD1306, a more elaborate and beautiful screen than LCD, with more functions
  - High contrast, thus supporting clear display With no need for a backlight
  - Working voltage: 2.7V - 5.5V; PCB size: 2.8 x 3.2cm
  - Standard double-sided printed circuit board, 1.16mm thick, with an elegant layout, 3-mm holesat two corners for easy fixing
  - Low power consumption: 0.04W during normal operation

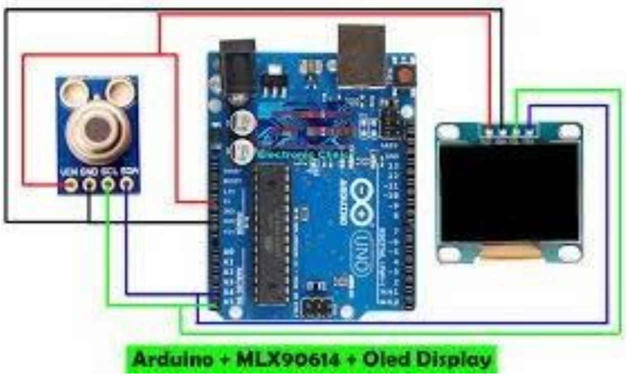


Figure 7: Connection between the parts

PEERIAN JOURNALS
The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

4.1 Diagram

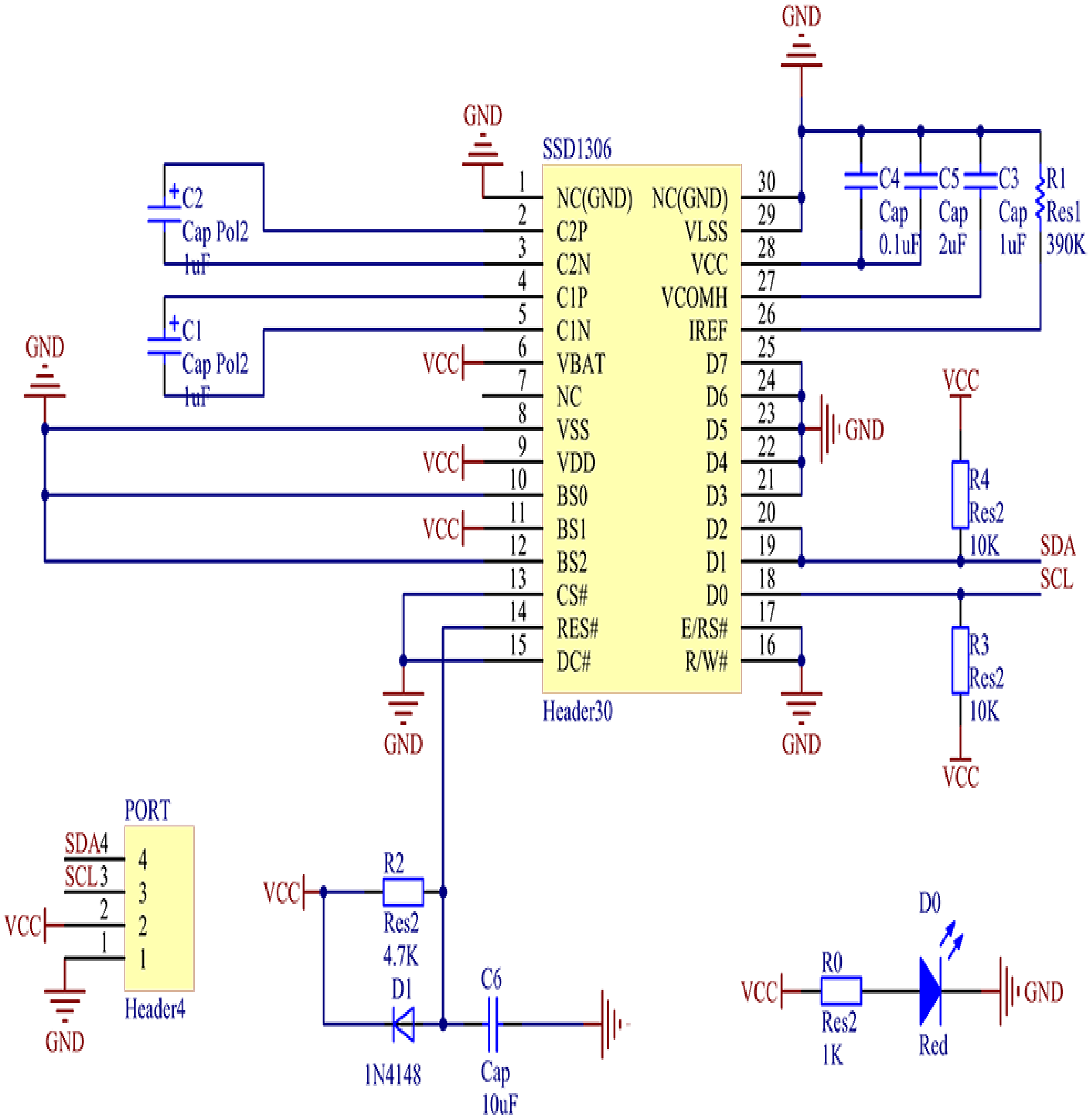


Figure 7 : Diagram of OLED

The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

How The Thermometer Works And The Steps Of The Process Of Making It

Theoretical Realities With Thermal Temperature Measurement

The recipes used to estimate infrared temperature are ancient, well-established, and well documented. While it is unlikely that any IRT clients would use the recipes, knowledge of them will pique interest in the interdependency of particular variables and help to clarify previous material. Below are the major equations:

1. Kirchoff's Law When an article is in warm harmony, the measure of assimilation will rise tothe measure of emanation.
2. Stephan Boltzmann Law The more sweltering an item turns into the more infrared energy itradiates.
3. Wien's Removal Law The frequency at which the greatest measure of energy is discharged gets more limited as the temperature increments.
4. Planck's Condition Depicts the connection between unearthly emissivity, temperature, andbrilliant energy.

Infrared Thermometer Plan And Development

An essential infrared thermometer (IRT) plan, includes a focal point to gather the energy transmitted by the objective, an identifier to change the energy over to an electrical sign,

An emissivity acclimation to coordinate with the IR in temperature test alignment to the radiating attributes of the article being estimated, and an encompassing temperature remuneration circuit to guarantee that temperature varieties inside the infrared temperature sensor, because of surrounding changes, are not moved to the last yield.

For a long time, most monetarily accessible IRTs followed this idea. They were amazingly restricted in application, and everything considered didn't gauge agreeably, by and large, however, they were truly strong and were satisfactory for the norms of the time.

The advanced IR temperature sensor is established on this idea, however, is all the more innovatively modern to extend the extent of its application.

5.1 Hardware Requierments

Arduino Pro Mini
MLX90614 Infrared Temperature Sensor
OLED Display – SSD1306
Laser Diode
Power Supply/ 9v BatteryPush-
button
Connecting wires

The Peerian Journal
Open Access | Peer Reviewed
Volume 27, February, 2024
ISSN (E): 2788-0303
Website: www.peerianjournal.com
Email: editor@peerianjournal.com

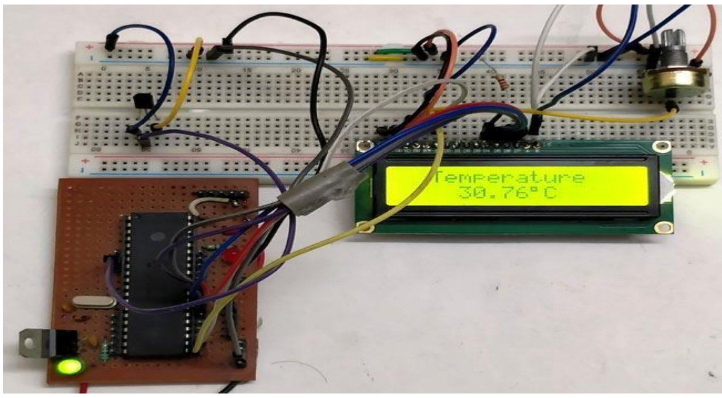


Figure 8: Testing of the circuit on the breadboard

5.2 How an Infrared Thermometer Works

Albeit not apparent to the natural eye, all items transmit infrared light beams and the focus fluctuates relying on temperature.

By distinguishing the IR beams, we can see the temperature range. The MLX90614 thermometer sensor works utilizing this guideline. MLX90614 is an infrared detecting gadget with an exceptionally low commotion speaker and a 17-piece ADC. It empowers high exactness and goalfor the thermometer.

The best part about the MLX90614 is it comes adjusted with a computerized SMBus from the manufacturing plant.

This implies that it will give a yield with a high goal of 0.02°C and can constantly move the deliberate temperature in the scope of - 20 to 120°C.

Like noticeable light, infrared energy can be engaged, reflected, and assimilated. Handheld IR thermometers utilize a focal point to center the infrared energy from an article onto a sensor that actions it, ordinarily a thermopile.

The sensor ingests infrared radiation and converts it to an electrical sign, with more serious radiation making a more grounded signal.

The IR thermometer measures this sign to convey a temperature readout. Like noticeable light, it is additionally conceivable to center, reflect, or ingest infrared light. Infrared thermometers utilize a focal point to shine the infrared light produced from the article onto a finder known as a thermopile.

The thermopile is only thermocouples associated in arrangement or equal. At the point when the infrared radiation falls on the thermopile surface, it gets retained and changes over into heat.

Voltage yield is delivered to the occurrence of infrared energy. The identifier utilizes this yield to decide the temperature, which gets shown on the screen.

Codes

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

Adafruit has provided us a Library to easily read data from the MLX90614. Like always we begin the program by adding the required library files.

Volume 27, February, 2024 ISSN (E): 2788-0303
Website: www.peerianjournal.com Email: editor@peerianjournal.com

Here the Wire library (in-built) is used to communicate using the I2C protocol and the SparkFunML90614 library is used for communicating with the sensor.
The SPI, GFX, and SSD1306 libraries are used for communicating with the 4-wire SPI protocol to the OLED display module. 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 work with the I2C protocol as well, but we can’t use them here since the I2C pins are already occupied by the thermometer sensor.
Here in Iraq the most followed unit for temperature is Celsius (degree C) hence we have set the unit with TEMP_C we can also change this to TEMP_F if we need the values to be in Fahrenheit(F).
Finally, we initialize the OLED display and clear its display. Inside the loop function, we read the value of temperature from the sensor and convert it into a String to be displayed in the OLED display

Conclusion

While IR thermometers offer a convenient way to measure any object's surface temperature, it is crucial to select the right type of device for your application to ensure accuracy in temperature readings.
There are infrared thermometers specially made for long-range measurements. Likewise, there are IR thermometers explicitly built for reading high temperatures from a limited distance but with better accuracy.

Reference

1. Jing Zhang, Development of a Non-contact Infrared Thermometer, (AER)volume 153 pp 308-312(AETR 2017)
2. Microcontroller: Internals, Instructions, Programming, and Interfacing - Subrata Ghoshal.
3. Microcontroller & Embedded Systems- Mazidi, M. A
4. R.P. Benedict (1984) Fundamentals of Temperature, Pressure, and Flow Measurements, 3rd ed, ISBN 0-471-89383-8 page 4 R.P. Benedict (1984) Fundamentals of Temperature, Pressure, and Flow Measurements, 3rd ed, ISBN 0-471-89383-8 page 6
5. Aw J, The non-contact handheld cutaneous infra-red thermometer for fever screening during the COVID-19 global emergency, External Link Disclaimer J Hosp Infect 2020 104(4):451
6. Datasheet of MLX90614 https://www.melexis.com/en/product/MLX90614/D
7. 7.https://create.arduino.cc/projecthub/Aswinth_mkr/contactless-smart-thermometer-using-arduin o-mlx90615- ir-9b3772
8. Mach, E. (1900). Die Principien der Wärmelehre. Historisch-kritisch entwickelt, Johann
9. Ambrosius Barth, Leipzig, section 22, pages 56-57. English translation edited by McGuinness,
10. B. (1986), Principles of the Theory of Heat, Historically and Critically Elucidated, D. Reidel
11. Publishing, Dordrecht, ISBN 90-277-2206-4, section 5, pp. 48–49, section 22, pages 60–61.
12. Temperature Sensors (PDF). Silicon Labs. 2016. Retrieved 2017-01-03.
13. Rogalski, A. "History of infrared detectors." Opto-Electronics Review 20.3 (2012): 279-308.