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Study and realization of an environmental parameter monitoring system

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Dedication

This project is dedicated to our families, friends, and mentors who have supported us throughout this journey.

To our families, thank you for your unwavering love, encouragement, and understanding. Your constant belief in us has been a source of strength and motivation.

To our friends, thank you for your companionship and the countless moments of joy and relief that helped us navigate through this challenging period.

To our mentors and professors, thank you for your guidance, wisdom, and the invaluable knowledge you have imparted. Your support and constructive feedback have been crucial to our success.

We are profoundly grateful to everyone who has contributed to our journey and made this accomplishment possible.

APPRECIATION

We would first like to thank God Almighty for the will, health, and patience He has given us throughout these long years of study.

We also wish to express our profound gratitude to our supervisor, Mr. KHORISSI NASR EDDINE, for his patience and the time he dedicated to us despite his busy schedule. His selection of this very important topic, along with the extensive information he provided, has been invaluable. Working under his guidance has opened many horizons for future scientific research and innovations.

We sincerely appreciate his sharing of knowledge and pray that God blesses and protects him. We hope he continues to shine always.

We are deeply grateful to our teachers for their efforts throughout our years at the university. Finally, we thank all those who have helped us, directly or indirectly, to accomplish this work.

ABSTRACT

This thesis introduces an environmental monitoring system using Arduino Nano microcontrollers and sensors for temperature, humidity, air quality, and UV radiation. The project aims to provide real-time monitoring of environmental conditions. The system is cost-effective, compact, and suitable for various applications. Experimental results demonstrate its reliability and accuracy, making it a valuable tool for ensuring environmental quality and safety.

RESUME

Cette thèse présente un système de surveillance environnementale utilisant des microcontrôleurs Arduino Nano et des capteurs de température, d'humidité, de qualité de l'air et de rayonnement UV. Le projet vise à fournir une surveillance en temps réel des conditions environnementales. Le système est économique, compact et adapté à diverses applications. Les résultats expérimentaux démontrent sa fiabilité et sa précision, en faisant un outil précieux pour garantir la qualité et la sécurité environnementales.

ملخص

تقدم هذه الأطروحة نظام مراقبة بيئية باستخدام متحكمات أردوينو نانو وأجهزة استشعار لدرجة الحرارة والرطوبة وجودة الهواء والأشعة فوق البنفسجية. يهدف المشروع إلى توفير مراقبة في الوقت الحقيقي للظروف البيئية. النظام فعّال من حيث التكلفة وصغير الحجم ومناسب لمختلف التطبيقات. تظهر النتائج التجريبية موثوقيتها ودقتها، مما يجعلها أداة قيمة لضمان الجودة والسلامة.

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Abbreviations list

I2C	Inter-Integrated Circuit, wiring type
SDA	Serial DATA
SCL	Serial Clock
USB	Universal Serial Bus
PC	Personal computer
LCD	Liquid-Crystal Display
SPI	Serial Peripheral Interface
SD	San Disk
MCU	Micro Controller Unit
CPU	Central Processing Unit
LED	light emitting diode

Symboles :

°C	Temperature in degrees Celsius
°F	Temperature in Fahrenheit
PPM	PARTS PER MILLION
BIT	BINARY DIGIT
MS	MILLISECOND
NH3	NITROGEN AND HYDROGEN INORGANIC CHEMICAL COMPOUND
SNO2	STANNIC OXIDE
CO2	CARBON DIOXIDE
3D	THREE DIMENSION

GENERAL INTRODUCTION

The Importance of addressing environmental challenges necessitates the development of innovative monitoring systems capable of providing real-time insights into ecological dynamics. This thesis introduces a novel environmental monitoring system employing Arduino Nano microcontrollers, a suite of sensors, and an LCD (Liquid Crystal Display) for displaying critical parameters such as temperature, humidity, air quality, and UV radiation. By integrating these components, the system offers a comprehensive solution for monitoring environmental conditions with enhanced accessibility and usability.

1.General overview :

Environmental monitoring plays a pivotal role in assessing the impacts of human activities on ecosystems and public health. However, traditional monitoring systems often suffer from limitations such as high costs, limited scalability, and complex data interpretation. In response to these challenges, the utilization of Arduino Nano microcontrollers, coupled with sensor technology and an LCD display, presents a promising avenue for developing cost-effective and user-friendly monitoring solutions. This thesis explores the potential of such an integrated system to provide accurate, real-time data on environmental parameters, thereby facilitating informed decision-making and proactive environmental management.

2. Problem Position :

Existing environmental monitoring infrastructures frequently encounter obstacles in delivering timely and actionable data to stakeholders. Centralized monitoring stations, characterized by proprietary hardware and cumbersome data collection processes, often fail to capture localized variations in environmental conditions. Furthermore, the lack of user-friendly interfaces impedes the accessibility of monitoring data to non-specialist users. The incorporation of an LCD display within the monitoring system addresses these shortcomings by providing a user-friendly interface for real-time data visualization and interpretation. This enables a broader range of stakeholders, including policymakers, researchers, and community members, to access and comprehend environmental data more effectively.

3. Project Objectives :

The primary objective of this project is to design, implement, and evaluate an Arduino Nano-based environmental monitoring system with an integrated LCD display. The project aims to achieve the following objectives:

- Develop a modular hardware architecture incorporating Arduino Nano microcontrollers, sensor modules, and an LCD display to facilitate seamless integration and user interaction.

- Implement intuitive user interfaces and data visualization techniques on the LCD display to enable real-time monitoring of environmental parameters.
- Evaluate the performance and usability of the monitoring system in diverse environmental settings, assessing its effectiveness in delivering actionable insights to stakeholders.

By accomplishing these objectives, the project seeks to demonstrate the feasibility and efficiency of utilizing Arduino-based platforms with LCD displays for environmental monitoring applications. This endeavor contributes to the advancement of accessible and user-friendly monitoring technologies, fostering greater awareness and engagement in environmental stewardship efforts.

4. Presentation :

For the study of the project, the work was divided into four chapters, the first of which sets out some notions and general information on the parameters of the environment.

The second chapter concerns the sensors and visualization systems in general.

The third chapter is about microcontrollers and arduino and their relationship to each other .and talk about the chosen arduino in this project arduino nano.

in the last chapter contains the algorithmic presentation by a program under the IDE environment of the Arduino and the realization and calibration of the sensors also the simulation of this project with a program called proteus.

CHAPTER 1 : ENVIRONMENTAL PARAMETERS AND THEIR PUBLIC DISPLAY

1.1Introduction :

Environmental parameters are essential elements that determine the conditions in which living beings evolve and interact. Among these parameters, we find in particular the temperature, atmospheric pressure, humidity level, UV level (ultraviolet radiation) and carbon dioxide (CO_2) level. These parameters are all interrelated and can have significant effects on ecosystems, human health, and conservation of ecosystems and mitigating the effects of climate change. Actions to reduce greenhouse gas emissions and promote sustainable use of natural resources are crucial to ensuring a healthy and sustainable environment for future generations.

1.2 History of meteorology:

According to history, the first teacher to teach meteorology to a student may have been Aristotle after he wrote his book on the subject in 450 BC. Several centuries later, the thermometer and barometer were invented, which made it possible to observe the weather for routine reporting. After World War II, weather satellites were launched, and in the 1990s, weather services around the world were modernized. The computer age that began in the 1950s played an important role in the rapid growth of meteorology [1].

1.3 weather stations:

A weather station is a device that collects data related to weather and the environment using many different sensors. Weather stations are also called weather centers, personal weather stations, professional weather stations, home weather stations, and forecasters.

Weather stations include weather tools such as a thermometer to measure temperature, a barometer to measure atmospheric pressure, as well as other sensors to measure rain, wind, humidity, etc. Weather stations range from simple analog technology to digital technology.

Figure 1.1 : analog and digital weather station

1.3.1 An analog weather station:

is a device used to measure and record weather conditions such as temperature, humidity, atmospheric pressure, wind speed and direction, etc., using mechanical instruments rather than digital devices. These stations may include mercury thermometers, dial barometers, cross-section anemometers, and other similar instruments.

Although digital weather stations are more common today due to their accuracy and ease of use, analog stations were once widely used and are sometimes still used in specific applications or by nostalgic weather enthusiasts. They can also be used in remote areas or situations where electricity is not available.

Figure 1.2 : analog weather station

1.3.2 A digital weather station:

is an electronic device that receives and displays weather information digitally, often via a wireless connection to a monitoring device. This type of weather station can display a lot of information, such as current temperature, barometric pressure, accumulated precipitation, and humidity percentages. The information displayed by this system is usually collected by a separate device installed externally and then transmitted via connection or wirelessly to the display device. A digital weather station can also connect to an Internet connection and display information obtained by a separate weather service.

Figure 1.3 : Digital weather station

There are a number of different devices that can function as a digital weather station, although they generally consist of a display device and a means of gathering information about the weather. This display device is generally similar to a portable smartphone or digital tablet and has a screen or display that displays weather information. The type of information provided by a digital weather station depends on the features included by the manufacturer and can be changed based on user input, such as switching between Celsius and Fahrenheit. The price of these devices can vary greatly and additional features are often found on more expensive devices.

A digital weather station typically operates via a connection to a collection device installed outside of a location. This device can be installed outside a house for example or on a barn. The collection device then determines information about local weather, such as temperature, atmospheric or barometric pressure, and humidity, and can even collect rain to produce information about accumulated precipitation. This information is then sent by the collection device to the digital weather station, usually via a cable connection, although wireless devices have become increasingly common and popular. Although this type of digital weather station is very useful, it can usually only provide information about local and immediate weather conditions. There are also Internet weather stations that can be used to receive weather data from a professional weather service, including data on remote locations or forecasts, and then relay that information in a user-friendly format. These devices often include a wireless "dongle" connected to a computer, which establishes an Internet connection to a weather service. This information is then transmitted wirelessly from the dongle to the digital weather station, which is often a small portable device and can receive weather data from a relatively great distance [2].

1.4 Temperature :

is a physical quantity measured using a thermometer and studied in thermometry. In everyday life, it is linked to sensations of cold and heat, coming from the transfer of heat between the human body and its environment. In physics, it is defined in several ways: as an increasing function of the degree of thermal agitation of particles (in kinetic theory of gases), by the balance of heat transfers between several systems or from entropy (in thermodynamics and in statistical physics). Temperature is an important variable in other disciplines: meteorology and climatology, medicine, in chemistry.

Figure 1.4 : thermometer

The most common temperature scale is degrees Celsius, in which water freezes at 0°C and boils at around 100°C under standard pressure conditions. In countries using the Imperial (Anglo-Saxon) system of units, Fahrenheit is used (freezing at 32°F and boiling at 212°F). The unit of the International System of Units, of scientific use and defined from absolute zero, is the kelvin (common name derived from the name of William Thomson, Lord Kelvin) [3].

Meteorological temperature is the temperature that occurs in the different layers of the atmosphere. Meteorological temperature is affected by air density, the relative temperature of air molecules as well as the presence of cold/warm air masses coming from the poles/equator.

Meteorological temperature is measured mainly in the stratosphere and in the troposphere. Weather balloons are generally released at the stratosphere to record the temperature of moving air masses.

1.5 Atmospheric pressure:

is the force exerted at a given point on the Earth's surface by the weight of the air above that point. In short: the air surrounding Earth creates atmospheric pressure, and this pressure is determined by the collective weight of the air molecules. Air molecules at higher altitudes have fewer molecules pressing on them from above and therefore experience lower pressure, while lower molecules experience more force or pressure exerted on them by molecules stacked on top and are more tightly packed together.

When you go up into the mountains or fly high in an airplane, the air is thinner and the pressure is lower. Air pressure at sea level at a temperature of 59°F (15°C) is equal to one atmosphere (Atm), and this is the base reading for determining gauge pressure.

Atmospheric pressure is also called barometric pressure because it is measured using a barometer. A rising barometer indicates increasing atmospheric pressure and a falling barometer indicates decreasing atmospheric pressure.

The standard unit of measurement for barometric pressure is called atmosphere (atm). Compared to the English system of measurement, one atmosphere (atm) is equivalent to 29.9213 inches of mercury (inHg). In millibars (mb) and hectopascal (hPa), the standard pressure at sea level is 1013.25 mb or hPa. Other conversions include:

1 atm = 101,325 pascals (Pa)

1 atm = 1,013.25 hectopascals (hPa)

1 atm = 760 millimeters of mercury (mmHg)

1 atm = 1,013.25 millibars (mbar)

Atmospheric pressure is an indicator of the weather. When a low pressure system enters an area, it usually brings cloudiness, wind and precipitation. High pressure systems generally lead to fine, calm weather [4].

1.6 Humidity:

is a measure of the amount of water vapor present in the air. Relative humidity measures the amount of water in the air relative to the maximum amount of water vapor (humidity). The higher the temperature, the more water vapor the air can contain. It is an integral part of the water cycle, as water vapor is continually generated by evaporation and eliminated by condensation. When the temperature is higher, the air can hold more water vapor, meaning the warmer the climate, the higher the humidity level can be.

Figure 1.5 : Humidity

For example, a densely saturated amount of air may contain 0.9 ounces of water per cubic meter at 86°F, but only 0.2 ounces of water per cubic meter of air at 46°F3.

Colder air cannot handle as much humidity as warmer air. Temperature versus humidity is important, especially since we spend 90% of our time indoors. Take for example a winter day. The outside air could have a relative humidity of 100% at 41°F, and therefore contain 0.2 grams of water. Inside cependant, 41°F serait très inconfortable, alors nous le réchaufferions. Lorsque l'air extérieur est chauffé jusqu'à 73°F à l'intérieur, la quantité absolute amount of water in the air is always the same. But because warmer air can hold more water, the relative humidity drops to 33%.

On the other hand, warm air can handle more humidity than colder air. For example, a hot, humid summer with 80% humidity at 86°F would mean the outside air would contain 0.8 oz/m3 of water. In our homes, a temperature of 86°F would be very uncomfortable and many would use air conditioners to cool it down again. If you cool it below 78.8°F, the relative humidity goes to 100% and the water condenses (the dew point). This is why air conditioning systems often include a dehumidifier. Without them, your house walls would be soaked during the summer.

A relative humidity level of 100% would mean that the air is completely saturated with water vapor. Unable to hold out any longer, it would rain.

1.7 UV radiation levels :

and therefore the index values vary during the day. When reporting UVI, the maximum daily UV level, which occurs during the four-hour period around solar noon, is provided for a given day. . Depending on geographic location and whether daylight saving time is applied, solar noon occurs between noon and 2 p.m. In some countries, sun protection deadlines may also be issued when UV levels are predicted to be 3 or higher. At these levels there is an increased risk of skin damage and protective measures are recommended [5].

Figure 1.6 : UV Radiation danger level

- **UV Index 0-2** means minimal danger from the sun's UV rays for the average person. Most people can stay in the sun for up to one hour during peak sun (10 am to 4 pm) without burning. However, people with very sensitive skin and infants should always be protected from prolonged sun exposure.

- **UV Index 3-5** means low risk of harm from unprotected sun exposure. Fair-skinned people, however, may burn in less than 20 minutes. Wearing a hat with a wide brim and sunglasses will protect your eyes. Always use a broad-spectrum sunscreen with an SPF of at least 30, and wear long-sleeved shirts when outdoors.

- **UV Index 6-**7 means moderate risk of harm from unprotected sun exposure. Fair-skinned people, however, may burn in less than 20 minutes. Wearing a hat with a wide brim and sunglasses will protect your eyes. Always use a broad-spectrum sunscreen with an SPF of at least 30 and wear long-sleeved shirts when outdoors. Remember to protect sensitive areas like the nose and the rims of the ears. Sunscreen prevents sunburn and some of the sun'sdamaging effects on the immune system. Use a lip balm or lip cream containing a sunscreen.

- **UV Index 8-10** means high risk of harm from unprotected sun exposure. Fair-skinned people may burn in less than 10 minutes. Minimize sun exposure during midday hours of 10 am to 4 pm. Protect yourself by liberally applying a broad-spectrum sunscreen of at least SPF 30. Wear protective clothing and sunglasses to protect the eyes. When outside, seek shade. Don't forget that water, sand, pavement, and glass reflect UV rays even under a tree, near a building or beneath a shady umbrella. Wear long-sleeved shirts and trousers made from tightly-woven fabrics. UV rays can pass through the holes and spaces of loosely knit fabrics.

- **UV Index of 11+** means a very high risk of harm from unprotected sun exposure. Fair skinned people may burn in less than 5 minutes. Outdoor workers and vacationers who can receive very intense sun exposure are especially at risk. Minimize sun exposure during midday hours of 10 am to 4 pm. Apply broad-spectrum SPF 30+ sunscreen every 2 hours, more frequently if you are sweating or swimming. Avoid being in the sun as much as possible and wear sunglasses that block out 99-100% of all UV rays (UVA and UVB). Wear a hat with a wide brim which will block roughly 50% of UV radiation from reaching the eyes [6].

1.8 The level of CO2 :

The level of CO2 in the atmosphere is a subject that varies depending on various factors, including human activities, natural cycles and weather conditions. However, in recent decades, atmospheric CO2 levels have increased significantly due to emissions caused by human activity, such as the burning of fossil fuels, deforestation and other industrial processes.

An emission of carbon dioxide is a release of this gas into the earth's atmosphere, whatever the source. Carbon dioxide (CO2) is the second most important greenhouse gas in the atmosphere, after water vapor, with the two contributing 26% and 60%, respectively, to the greenhouse effect.

According to scientific data, atmospheric CO2 levels have exceeded 400 parts per million (ppm) for the first time in modern history, and they continue to rise. This increase is worrying because CO2 is a greenhouse gas that contributes to global warming and climate change. Scientists are closely monitoring these levels and working to find solutions to reduce CO2 emissions and mitigate the effects of climate change.

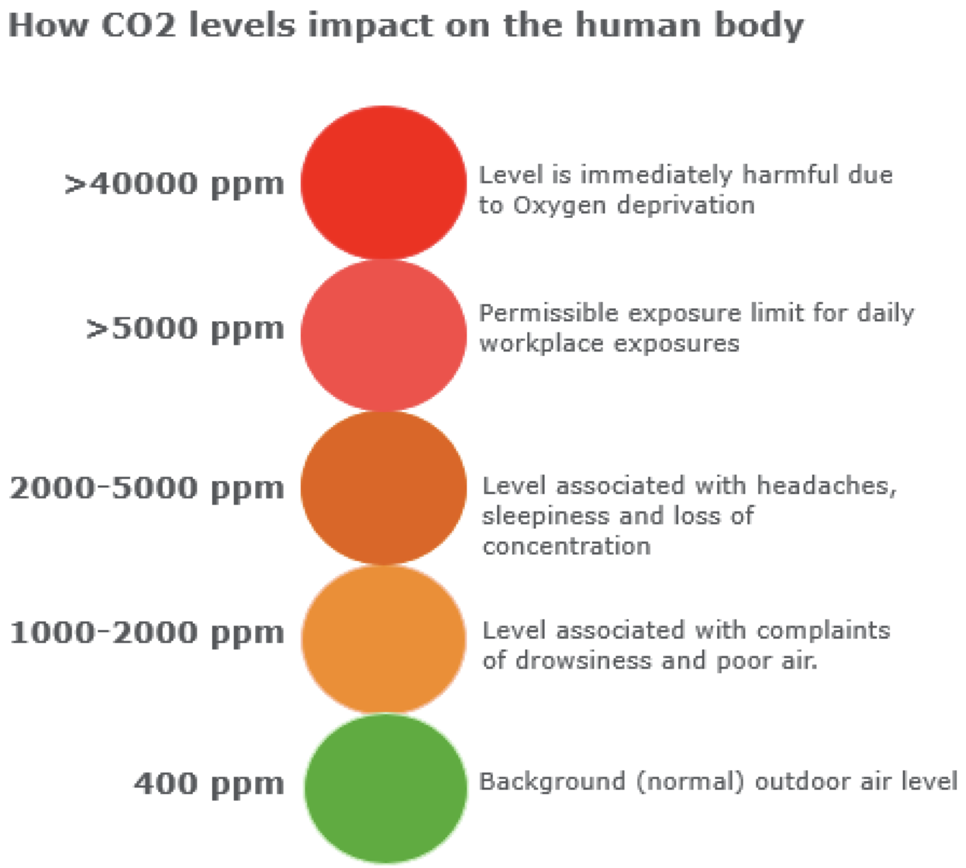


Figure 1.7 : CO2 levels impact in the human body

CO2 emissions into the atmosphere can be of natural origin or of anthropogenic origin, that is to say from human activities. The anthropogenic source has been growing strongly in recent decades. Once emitted, the gas is partly absorbed by natural carbon sinks. This absorption doubled from 1960 to 2010, but half of the CO2 released by human activities accumulates in the atmosphere, so that in November 2020 the concentration of atmospheric CO2 reached 413 ppm (parts per million), while it was around 280 ppm until the industrial revolution. This increase intensifies the greenhouse effect, which causes global warming.

According to the International Energy Agency (IEA), after global emissions stabilized in 2014, 2015 and 2016 thanks to progress in energy skin, emissions then started to rise again, the average concentration global CO2 in the atmosphere reaching new records in 2017 and then in 2018. This increase is partly due to electricity consumption (increased by 4% in 2017), the share of which in overall energy demand is increasing. Thermal power plants running on coal or natural gas, in particular, are seeing their CO2 emissions increase (+2.5% in 2017).

The leading countries by energy-related CO2 emissions in 2022 are China (30.7% of global emissions), the United States (14%), India (7.6%) and Russia (4 .2%); the European Union's share is 7.9%. The highest emitting countries per capita in 2021 are the United Arab Emirates, Australia, Saudi Arabia, Canada, the United States, South Korea, Russia and Taiwan.

The level of CO_2 in the atmosphere varied greatly well before the appearance of humans and industrial society (see History of climate), but never at a rate as rapid as that observed in recent decades, the origin of which anthropogenic is established.

1.9 The need for public display of these parameters :

Public display of temperature, humidity, CO_2 levels, and ultraviolet (UV) radiation levels can be beneficial in raising public awareness of environmental conditions and potential health risks associated with these parameters.

1.9.1 Temperature:

Publicly displaying temperature allows people to plan their activities based on weather conditions, such as dressing appropriately to protect against cold or excessive heat.

Figure 1.8 : public weather screen

1.9.2 Humidity :

Humidity can impact the comfort and well-being of individuals. High levels of humidity can make the air clammy and uncomfortable, while low levels can dry out the airways and skin. Displaying humidity can help people take steps to maintain adequate comfort levels.

1.9.3 The level of CO_2 :

CO_2 is a greenhouse gas and its concentration in the atmosphere is linked to human activities and climate change. High CO_2 levels can also affect indoor air quality, which may have health implications. Publicly displaying CO_2 levels can help raise awareness of these issues and encourage actions to reduce CO_2 emissions.

1.9.4 (UV) radiation levels :

UV rays from the sun can have harmful effects on the skin and eyes, including causing sunburn, premature aging of the skin and cancer of the skin. Displaying UV radiation levels can help people take appropriate precautions when spending time outdoors, such as applying sunscreen and wearing protective clothing.

By providing this information in an accessible and visible way, authorities can help the public make informed decisions to protect their health and well-being, as well as to help preserve the environment.

Atmospheric pressure: Atmospheric pressure is the force exerted by the atmosphere on the earth's surface. It can impact various aspects of daily life, including short-term weather conditions and longer-term weather trends. Displaying air pressure can help people understand impending weather changes, such as the arrival of a storm, and plan accordingly. Additionally, atmospheric pressure can also impact human well-being, with some individuals being sensitive to changes in pressure, which can influence their health.

In summary, public displays of temperature, humidity, CO_2 levels, ultraviolet radiation levels and atmospheric pressure can provide valuable information to help people make informed decisions about their daily activities, their health and general well-being.

CHAPTER 2 : THE SENSORS AND VISUALIZATION SYSTEM

2.1 Introduction :

In this chapter we will conduct an in-depth study of the various components of the device, as well as their operation. We will talk about the different sensors that play an important role in our tool and visualization systems, and we will also present their operating principles, in addition to their limitations in terms of measurement sensitivity. The sensors that will be used are: the ozone gas sensor in its two versions: high concentration and low concentration, air quality sensor, and temperature sensor. The display will be provided in real time, using a real time clock.

2.2 Definiton of Sensor :

A sensor is a device that detects and responds to some type of input from the physical environment. Sensors are typically used to measure various physical phenomena such as temperature, pressure, light, sound, and motion. They convert measured inputs into a signal that can be displayed or processed by other devices. Sensors are essential in a wide range of applications, including automotive, aerospace, industrial automation, and electronics, Therefore, we will provide a detailed explanation of the types of sensors that we will use in this project.

2.3 Temperature sensor :

What is a temperature sensor? A temperature sensor is a device used to measure temperature. This can be air temperature, liquid temperature or the temperature of solid matter.A temperature sensor is a tool that detects and converts the surrounding temperature into an electrical signal. It's commonly used in various settings to monitor and regulate temperature, ensuring equipment and environments remain safe and efficient.

There are different types of temperature sensors available and they each use different technologies and principles to take the temperature measurement [10].

2.3.1Different Types of Temperature Sensor:

2.3.1.1Thermistor: Thermistors come in a very tiny package. They are made up of a glass or epoxy-coated sensing element with two wires for connecting to an electrical circuit. By monitoring the shift in the electric current's resistance, they are able to estimate temperature. Thermistors are frequently inexpensive and come in NTC or PTC varieties [11].

Figure 2.1 :Thermistor NTC

Figure 2.2 : Thermistor PTC

2.3.1.2RTDs:

or Resistance Temperature Detectors work in a similar way to Thermistors and measure ohmic resistance to measure temperature. They are connected to a circuit in a similar way to a thermistor but they have a much wider temperature range and can measure extreme temperatures.

Figure 2.3 : RTD

2.3.1.3Thermocouples :

use two conductors, made up of different metals that are joined at the end to form a junction. When this junction is subjected to heat, a voltage is produced that is directly proportional to the temperature input. They are highly versatile as different metal combinations allow for different measurement ranges; however, they lack the fine accuracy of NTC's and RTD's making them the least precise out of the three types.

2.3.1.4Temperature Probes :

are a very common and diverse type of temperature sensor. They consist of either a thermistor, a thermocouple or RTD sensing element and can be finished with a terminal head. All three types of sensor can be manufactured into a variety of housing types – stock and bespoke. This allows for enhanced utility, that may span .over a multitude of different environments and media that they encounter.

Figure 2.4 : Thermocouple Type K

Figure 2.5 : External Temperature probe

2.3.2 Applications and Fields of Use for Temperature Sensors:

Temperature sensors are used to measure temperature in many different applications and industries. They are all around us; present in both everyday life and .more industrial settings.

Some application examples are:

Industrial Applications – Monitoring various machinery and environments, power .plants, manufacturing

.Scientific and laboratory applications – Science and biotech monitoring

,Medical Applications – Patient monitoring, medical devices, gas analysis thermodilution cardiac catheters, humidifiers, ventilator flow tubes, dialysis fluid .temperature

Cars and Engine – Exhaust gas, inlet air temperature, oil temperature and engine .temperature measurements

Domestic appliances – Kitchen appliances (ovens, kettles etc) as well as white .goods

HVAC applications – Heating ventilation and air conditioning devices either .commercial or domesticated

Transit – Refrigerated vans and lorries . [12]

2.4Humidity Sensor:

A humidity sensor is a device that measures the amount of water vapor present in the air. It detects and measures water vapor by using changes in temperature or electrical currents in the air. The sensor then converts these findings into a corresponding electrical signal [14].

2.4.1 Different Types of Humidity Sensor:

There are three main types of humidity sensor:

2.4.1.1 Capacitive sensors:

They consist of a layer of a dielectric material sensitive to humidity placed between two electrodes, so as to form a capacitor whose capacitance varies according to relative humidity.

They are linear and allow you to measure relative humidity, from zero (0%) to maximum (100%).

These sensors make it possible to give very precise atmospheric measurements. The sectors that use this type of sensors are the industrial sector and the meteorological sector [13].

-Made up of a capacitor whose capacity varies depending on the ambient humidity.

-The capacitor dielectric is a moisture-sensitive material, such as a polymer.

-The higher the humidity, the greater the capacity of the capacitor.

-The change in capacitance is measured and converted into an electrical signal proportional to humidity.

-Advantages: More precise than resistive sensors, less sensitive to contaminants.

-Disadvantages: More expensive than resistive sensors, more sensitive to shock and vibration.

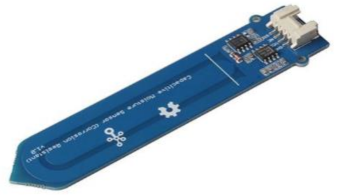


Figure 2.6 : capacitive sensor

2.4.1.2 Resistive sensors:

Figure 2.7 :Resistive Sensor

They measure the variation in the electrical impedance of a hygroscopic medium (it can be a conductive polymer or a salt) using ions. The resistance of this sensitive element varies depending on humidity.

This type of sensor is not very precise for measuring values below 5% relative humidity. However, their advantage is that they are less expensive. If you are not looking for high measurement accuracy, they are therefore interesting.

-Work by absorption of water vapor by a hygroscopic material.

-The higher the humidity, the more water the material absorbs and the lower its electrical resistance.

-The change in resistance is measured and converted into an electrical signal proportional to humidity.

-Advantages: Simple, inexpensive, robust.

-Disadvantages: Less precise than capacitive sensors, sensitive to contaminants.

2.4.1.3 Dew point sensors :

They measure the dew point temperature which is the temperature at which water vapor contained in the air begins to condense, which allows humidity to be deduced.

More complex than the previous ones, these sensors are mainly used for laboratory applications

2.4.1.5 Description of the temperature and Humidity sensor used (DHT11):

A temperature and humidity sensor is included in the DHT11 Temperature & Humidity Sensor.There is a calibrated digital signal output. Using the exclusive digital signal acquisition technique.High-reliability and temperature and humidity sensing technology make it reliable.The long-term stability is excellent. The humidity measurement is resistive-type.The temperature measurement component connects to a highperformance 8-bit microcontroller, offering excellent quality, fast response, and anti-interference. Cost-effectiveness and ability are important [15].

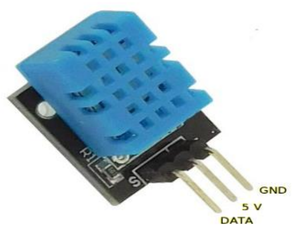


FIGURE 2.8 : DHT11

Parameters		Conditions	Minimum	Average	Maximum
Humidity	Resolution		1%	1%,8Bits	1%
	Repeatability			+-1%	
	Precision	0-50°C		+-4%	
	Measuring range	0°C 25°C 50°C	30% 20% 20%		90% 90% 80%
	Response time		6s	10s	15s
Temperature	Resolution		1°C 8Bit	1°C 8Bit	1°C 8Bit
	Repeatability			+-1°C	
	Precision		+-1°C		+-2°C
	Measuring range		0°C		50°C
	Response time		6s		30s

2.4.1.6 Typical Application :

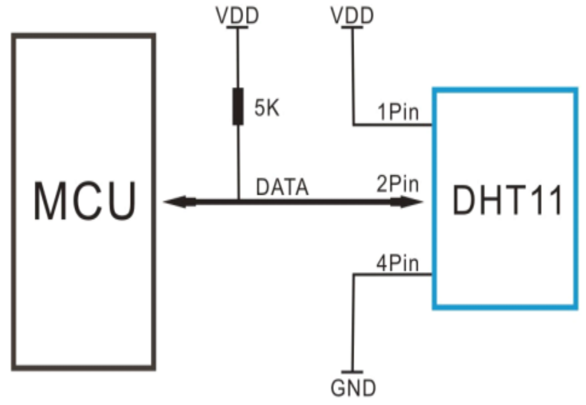


Figure 2.9 : Typical Application

2.4.1.7 Alimentation :

The power source for DHT11 is 3-5.5V DC. Don't send anything when the sensor gets power.
To pass the unstable state, the sensor needs to receive an instruction within a second. One is the one. For power filtering, a 100nF capacitor can be added between VDD and GND .

2.4.1.8 Communication Process: Serial Interface (Single-Wire Two-Way):

Communication and synchronization between MCU and controller are done using a single-bus data format. The DHT11 sensor is there. A 4ms conversation takes place. There are decimal and integral parts in data. A full data transmission is 40bit, and a complete data transmission is 40bit. Higher data bits get sent first by the sensor. Data format: 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit integral T data + 8bit decimal T. Data + 8bit check sum + 8bit data. If the data transmission is correct, the check-sum should be the last 8bit of the data. There are 8 bits integral RH data and 8 bits decimal RH data.

2.4.1.9 Overall Communication Process :

DHT11 changes from the low-power consumption mode to the high-power consumption mode when the start signal is sent. Waiting for the MCU to complete the start signal in running mode. DHT11 sends a message once it's done. The response signal of 40-bit data that include the relative humidity and temperature information was a response signal of 40-bit data that included the relative humidity and temperature information.

Users have the option of collecting data. The DHT11 doesn't have the start signal from the MCU.The MCU won't receive a response signal. Once data is gathered, DHT11 will switch to a low-power mode until the MCU issues a new start signal.

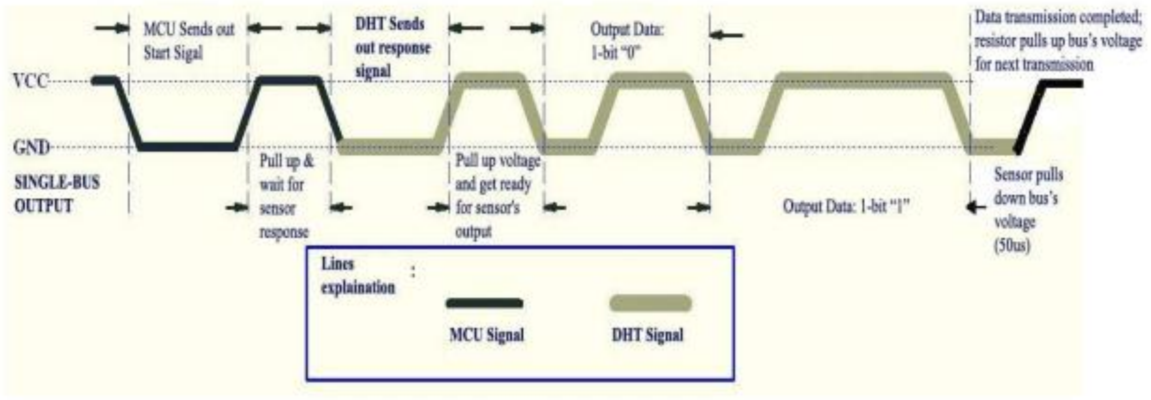


Figure 2.10 : Overall Communication Process

The data single-bus free status is at a high voltage level. When communication between MCU and When the communication between When DHT11 begins, the programme of MCU will set Data Single-bus voltage level from high to low. This process must take at least 18ms to ensure DHT's detection of MCU's signal, then MCU, then this process must take at least 18ms to ensure DHT's detection of MCU's signal, then MCU will pull up the voltage and wait 20-40us for the DHT's response.

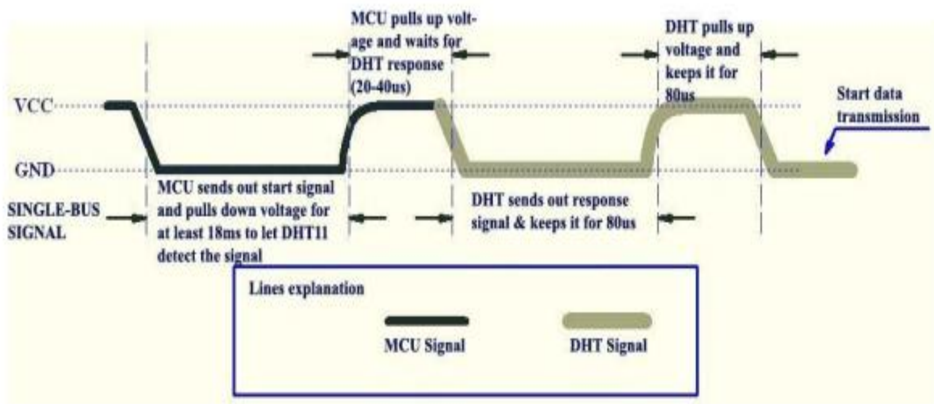


Figure 2.11 : MCU sends start out signal and DHT responses

Upon identifying the start signal, DHT initiates an 80-second low-voltage response signal. Next, in order to give DHT time to prepare for data transmission, the DHT program sets the Data Single-bus voltage level from low to high and maintains it for 80us.

DHT is providing the response signal when DATA Single-Bus is at the low voltage level. DHT prepares for data transfer by pulling up voltage and holding it for 80us after sending out the answer signal. Every bit of data that DHT sends to the MCU starts with a 50us low-voltage signal. Depending on how long the subsequent high-voltage signal is, the data bit is either "0" or "1".

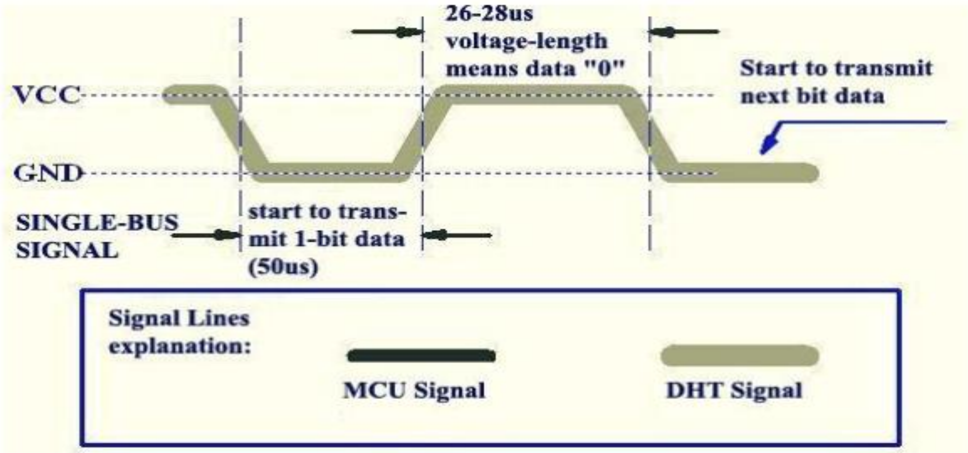


Figure 2.12 : DHT reponse to MCU

2.4.1.10 Electrical Characteristics :

	Conditions	Minimum	Typical	Maximum
Power Supply	DC	3v	5v	5.5v
Current Supply	Measuring	0.5mA		2.5mA
	Average	0.2mA		1mA
	Standby	100uA		150uA
Sampling period	Second	1		

2.5 CO2 SENSOR:

A CO2 sensor is useful for measuring the concentration of carbon dioxide (also called carbon dioxide or CO2) in the air; it indicates when it is appropriate to ventilate a room, whether it is a workplace or a living space in the house.

2.5.1 What is the use of a CO2 sensor?:

In a closed space, the concentration of 600 ppm of carbon dioxide should ideally not be exceeded, the CO2 sensor gives an accurate measurement. Outdoors, the CO2 concentration is around 400 ppm. The red light on a CO2 sensor is triggered from a concentration of 800 ppm.

The CO2 sensor can be used in a closed environment intended for the gathering of several people in order to limit the spread of a virus. The coronavirus, SARS-CoV-2, is transmissible mainly by air - this device is therefore of interest in preventing Covid-19 from spreading. Small particles and droplets are emitted when breathing, some float in the air and can remain for a long time in a closed room.

It is for this reason that the risk of contamination decreases when the room is ventilated regularly and at the right times. A CO2 sensor alerts and reminds you that it is necessary to ventilate the room for everyone's safety. The main places where a CO2 sensor is installed are classrooms, schools, meeting rooms and offices.

2.5.2 The impact of carbon dioxide on health :

Carbon dioxide has a negative impact on our body when its concentration is too high, particularly when many people share the same space. We may notice a loss of concentration and this can have an impact on well-being at work and productivity. Thus, a CO2 sensor is of major interest for our health beyond limiting the transmission of viruses.

2.5.3 The MQ135 air quality sensor:

The MQ135 is a type of air quality sensor commonly used to measure the concentration of various gases in the air, such as ammonia (NH3), nitrogen oxides (NOx), alcohol, benzene, smoke, and carbon dioxide (CO2). It is widely used in air quality monitoring systems due to its sensitivity and wide detection range [17].

The MQ135 sensor has a sensitive layer made of tin dioxide (SnO2), which changes its resistance when exposed to different gas concentrations. The resistance variation is converted to an analog voltage signal, which can be read by a microcontroller or other data acquisition systems [18].

2.5.3.1 Applications and Fields of Use for MQ135 air qualty sensor :

- Indoor air quality monitoring.
- Industrial safety systems.
- Environmental data logging.
- Home automation systems for detecting smoke and harmful gases.

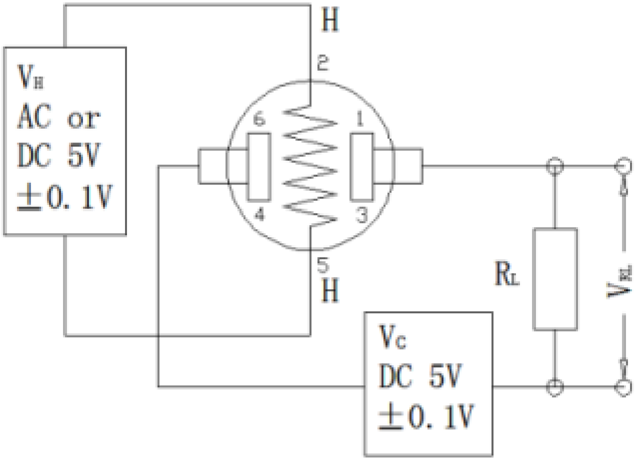


Figure 2.13 : Electrical circuit for MQ135

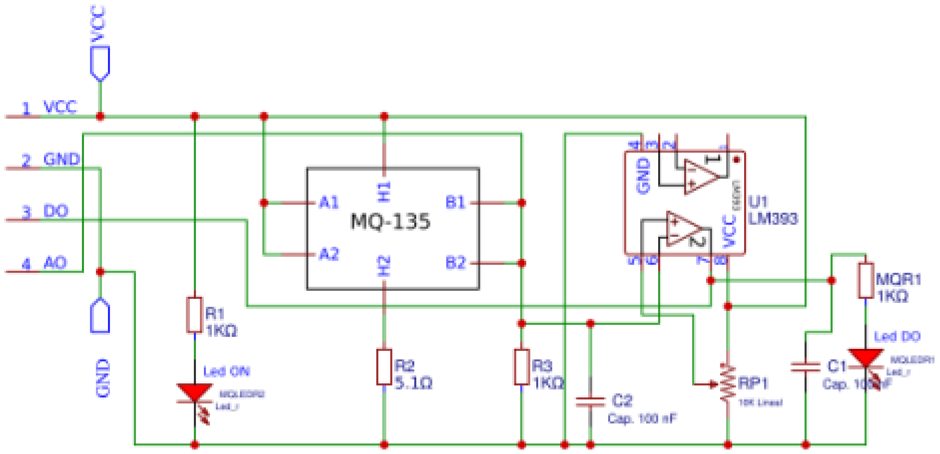


Figure 2.14 : Electonic circuit for the model MQ135

<table>
<tr><td colspan="3">Model</td><td>MQ135</td></tr>
<tr><td colspan="3">Sensor Type</td><td>Semi-Conductor</td></tr>
<tr><td colspan="3">Encapsulation standard</td><td>Bakèlite metal cap</td></tr>
<tr><td colspan="3">Target gas</td><td>ammonia gas, sulfide, benzene

series steam</td></tr>
<tr><td colspan="3">Detection range</td><td>10~1000ppm Ozone</td></tr>
<tr><td rowspan="2">Standard circuit conditions</td><td>Heater Voltage</td><td>VH</td><td>5.0V±0.1V AC or DC</td></tr>
<tr><td>Load resistance</td><td>RL</td><td>Ajustable</td></tr>
</table>

Sensor character under standard test conditions	Heater resistance	RH	29Ω±3Ω (temp ambiante)
	Heater consumption	PH	≤950mW
	Sensitivity	s	Rs(dan l'air) / Rs(in 400ppm H_2)≥5
	Output voltage	Vs	2.0~4.0(in 400ppm H_2)
	Concetration slope	α	≤0.6(R_{400ppm}/R_{100ppm} H_2)
Standard Test conditions	Tem. Humidity		20ºC±2ºC : 55%±5% RH
	Standard test circuit		Vc: 5.0V±0.1V: VH:5.0V±0.1V
	Preheating time		For more than 48hours

2.6 Uv Sensor :

A UV sensor, also called an ultraviolet radiation sensor, is adevice that detects and measures the intensity of ultraviolet (UV) radiation present in the environment.

UV rays are part of the electromagnetic spectrum invisible to the naked eye. They are between X-rays and visible light. The UV sensor does not directly measure the level of exposure to the sun, but rather the intensity of UV radiation coming from different sources, including the sun.

Figure 2.15 :Uv sensor

2.6.1 Different Types of Uv Sensor:

There are several types of UV sensors, but they generally work on a similar principle:

The sensor has a UV-sensitive component, such as a photodiode.When UV radiation reaches the sensitive component, it generates an electric current.

The intensity of the electric current is proportional to the intensity of UV radiation.

This electrical signal is then processed and converted into a digital value indicating the UV index or UV irradiance.

2.6.2 What is the use of a uv sensor? :

Environmental monitoring: to measure the UV index and predict the risks of UV overexposure.

Meteorology: to study the interactions of UV radiation with the atmosphere.

Agriculture: to optimize plant growth based on UV exposure.

Medical field: for phototherapy (therapy using UV light).

Industrial sector: to control drying and curing processes using UV light.

2.6.3 Description of the uv sensor used (GUVA S12SD):

The GUVA-S12SD UV sensor module is employed to measure the intensity of ultraviolet (UV) radiation. This sensor features an analog output that varies according to the UV light intensity, providing a reliable means to quantify UV exposure.

The GUVA-S12SD sensor operates within the UV spectrum range of 200 nm to 370 nm and is designed to convert UV light intensity into an analog voltage signal that corresponds to the amount of received radiation. The sensor boasts high sensitivity and fast response, making it suitable for a variety of applications including scientific research and environmental monitoring [19].

The sensor includes an adaptive circuit that allows for easy integration with various electronic systems, such as microcontrollers (Arduino, Raspberry Pi) and data logging systems. It can be used in diverse applications, including monitoring UV radiation levels in the environment, weather analysis, and preventing UV damage in industrial and agricultural areas.

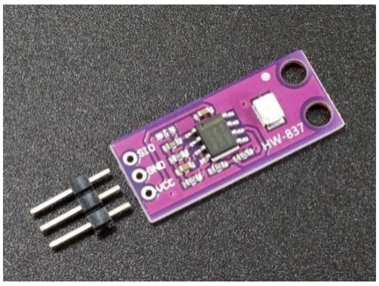


Figure 2.16 : GUVA S12SD sensor

Table : Absolute Maximum Ratings

Item	Symbol	Value	Unit
Forward current	IF	1	mA
Reverse voltage	Vr	5	V
Operating temperature	Top	-30….+85	°C
Storage Temperature	Tst	-40….+95	°C
Soldering Temperature	Tsol	260	°C

2.6.3.1 Electrical Caracteristique (25°C) :

Item	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Dark current	Id	Vr=0.1V	-	-	-	nA
Photo current	I pd	UVA Lamp, 1 Mw/Cm²/1UVI	-	113 26	-	nA
Temperature Coefficient	Itc	UVA Lamp	-	0.08	-	nA
Responsivity	R	λ = 300 nm, VR = 0 V	-	0.14	-	%/°C
Spectral Detection Range	λ	10% of R	240	-	**370**	A/W

2.6.3.2 Responsivity Curve :

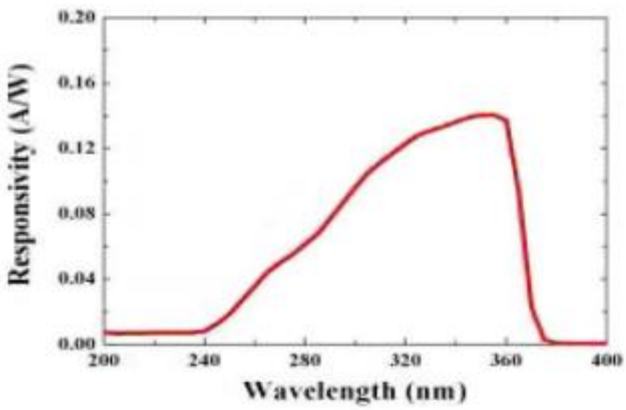
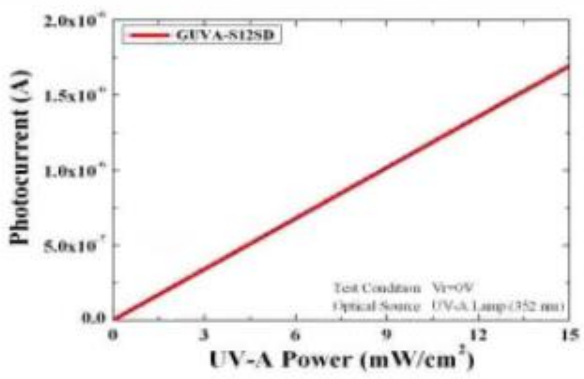
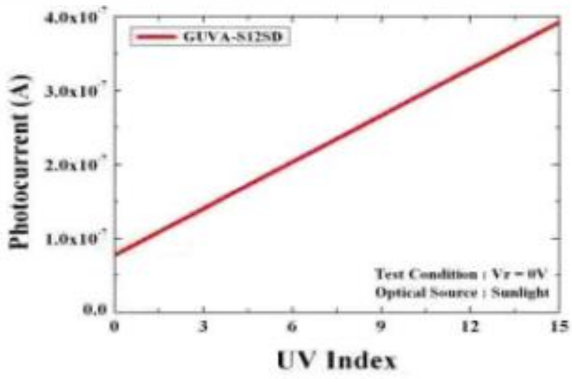


Figure 2.17 Responsivity Curve

2.6.3.3 Photocurrent Along UV power :





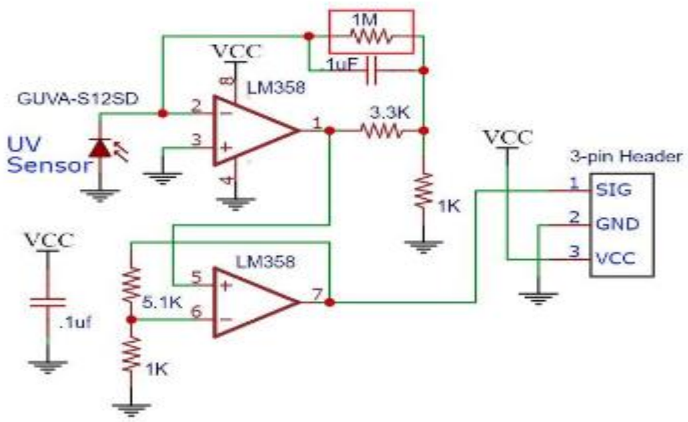


figure 2.18 GUVA S12SD Module Schematic

2.7 high-precision real-time clock (RTC) module:

The DS3231 is a highly accurate real-time clock (RTC) module designed to keep track of time and date with exceptional precision. Unlike typical RTC modules, the DS3231 integrates a temperature-compensated crystal oscillator (TCXO) and a crystal, providing a high degree of accuracy even in varying environmental conditions. This feature makes the DS3231 ideal for applications requiring precise timekeeping [20].

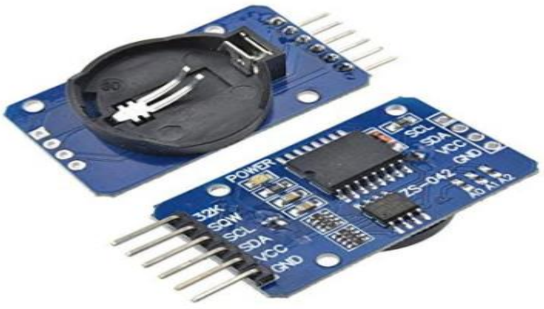


Figure 2.19 : RTC clock Module

2.7.1 Key Features:

High Accuracy: The DS3231 offers an accuracy of ±2 minutes per year due to its integrated TCXO, which compensates for temperature variations that commonly affect the performance of standard crystal oscillators.

Battery Backup: The module includes a battery backup input, enabling it to retain time information even when the main power source is disconnected. This ensures continuous timekeeping during power outages.

I2C Interface: It communicates with microcontrollers, such as Arduino, via the I2C interface, simplifying the connection and programming process.

Built-in Temperature Sensor: The DS3231 includes a built-in temperature sensor, which can be used for monitoring and compensating for temperature fluctuations, enhancing its accuracy [21].

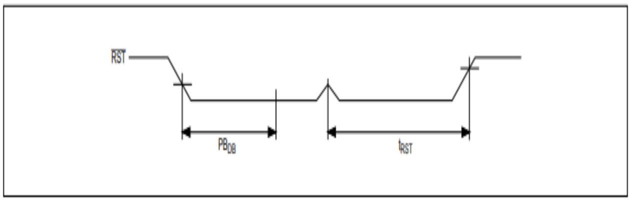
2.7.2 Electrical Charactersitics :

VCC = 2.3V to 5.5V, VCC = Active Supply (see Table 1), TA = TMIN to TMAX, unless otherwise noted.) (Typical values are at VCC = 3.3V, VBAT = 3.0V, and TA = +25°C

Parametr	Symbol	Conditions	Min Typ MAX	Units
Active Supply Current	**Icca**	Vcc=3.63v Vcc=5.5V	200 300	µA
Standby Supply Current	ICCS	Vcc=3.63V Vcc=5.5V	110 170	µA
Temperature Conversion Current	ICCSCONV	Vcc=3.63V Vcc=5V	575 650	µA
Power-Fail Voltage	VPF		2.45 2.575 2.70	V
Logic 0 Output, 32kHz, INT/SQW, SDA	VOL	IoL=3mA IoL=1mA	0.4	V

Logic 0 Output, RST	VOL	Ouput high impedance	0.4	V
Output Leakage Current 32kHz, INT/SQW, SDA	ILO		-1 0 +1	µA
input Leakage SCL	ILi		-1 +1	µA
RST Pin I/O Leakage	IOL	RST high impedance (Note 6)	-200 +10	µA

Pushbutton Reset Timing:



Typical Operating circuit :

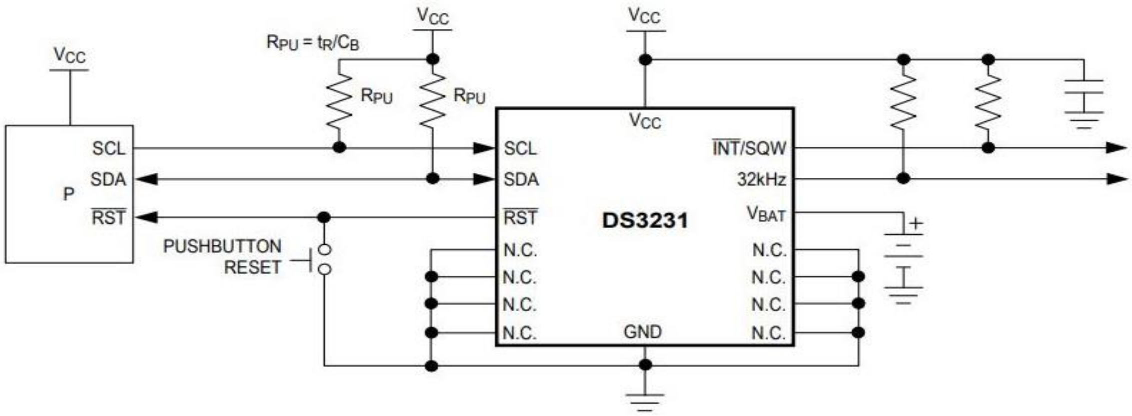


Figure 2.20 : Typical Operating circuit for RTC clock DS3231

2.8 Visualization Systems:

A visualization system is a tool that allows you to present information visually. It is a broad term that encompasses a variety of technologies and applications.

2.8.1 Different Types of Visualization Systems :

2.8.1.1. Digital display systems:

Description: Large format electronic displays presenting varied information dynamically.

Examples: Digital advertising panels in public places, information screens in airports, stadiums and shopping centers.

Figure 2.21 : Digital Display System

2.8.1.2 Information systems for travelers:

Description: Provide real-time transportation, traffic and weather data.

Examples: Displays in train stations and airports indicating timetables and delays, road signs providing traffic information, mobile applications for navigation.

Figure 2.22 : information Display system

2.8.1.3 Environmental data display systems:

Description: Present live information about the environment such as air quality, temperature or pollution.

Examples: City air quality monitoring stations, offshore weather buoys, mobile apps displaying environmental conditions.

Figure 2.23 : outdoor led environmental data display board

2.8.1.4 Video walls and screen mosaics:

Description: Assemblies of multiple video displays creating a single large image or multi-source display.

Examples: Art installations and interactive exhibitions, control rooms and monitoring centers, broadcasting live events in public spaces

.

Figure 2.24 : mosaic wall

2.8.1.5 Holographic Display Systems (Emerging):

Description: Technology projecting 3D images suspended in air for more immersive viewing.

Examples: Entertainment and marketing applications, scientific and medical data visualization, industrial training and simulation.

figure 2.25 :holographic display system

CHAPTER 3 : ARDUINO AND MICROCONTROLLERS

3.1 Introduction :

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

Sometimes referred to as an embedded controller or microcontroller unit (MCU), microcontrollers are found in vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances, among other devices. They are essentially simple miniature personal computers (PCs) designed to control small features of a larger component, without a complex front-end operating system (OS).

Figure 3.1 : microcontroller

3.2 How does microcontrollers work :

A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor. The temporary information that the microcontroller receives is stored in its data memory, where the processor accesses it and uses instructions stored in its program memory to decipher and apply the incoming data. It then uses its I/O peripherals to communicate and enact the appropriate action.

Microcontrollers are used in a wide array of systems and devices. Devices often utilize multiple microcontrollers that work together within the device to handle their respective tasks. [7]

For example, a car might have many microcontrollers that control various individual systems within, such as the anti-lock braking system, traction control, fuel injection or suspension control. All the microcontrollers communicate with each other to inform the correct actions. Some might communicate with a more complex central computer within the car, and others might only communicate with other microcontrollers. They send and receive data using their I/O peripherals and process that data to perform their designated tasks.

3.3 What are the elements of a microcontroller :

The core elements of a microcontroller are:

- The processor (CPU) -- A processor can be thought of as the brain of the device. It processes and responds to various instructions that direct the microcontroller's function. This involves performing basic arithmetic, logic and I/O operations. It also performs data transfer operations, which communicate commands to other components in the larger embedded system.
- Memory -- A microcontroller's memory is used to store the data that the processor receives and uses to respond to instructions that it's been programmed to carry out. A microcontroller has two main memory types:
  1. Program memory, which stores long-term information about the instructions that the CPU carries out. Program memory is non-volatile memory, meaning it holds information over time without needing a power source.
  2. Data memory, which is required for temporary data storage while the instructions are being executed. Data memory is volatile, meaning the data it holds is temporary and is only maintained if the device is connected to a power source.
- I/O peripherals -- The input and output devices are the interface for the processor to the outside world. The input ports receive information and send it to the processor in the form of binary data. The processor receives that data and sends the necessary instructions to output devices that execute tasks external to the microcontroller.

While the processor, memory and I/O peripherals are the defining elements of the microprocessor, there are other elements that are frequently included. The term *I/O peripherals* itself simply refers to supporting components that interface with the memory and processor. There are many supporting components that can be classified as peripherals. Having some manifestation of an I/O peripheral is elemental to a microprocessor, because they are the mechanism through which the processor is applied.

Other supporting elements of a microcontroller include:

- Analog to Digital Converter (ADC) -- An ADC is a circuit that converts analog signals to digital signals. It allows the processor at the center of the microcontroller to interface with external analog devices, such as sensors.
- Digital to Analog Converter (DAC) -- A DAC performs the inverse function of an ADC and allows the processor at the center of the microcontroller to communicate its outgoing signals to external analog components.
- System bus -- The system bus is the connective wire that links all components of the microcontroller together.
- Serial port -- The serial port is one example of an I/O port that allows the microcontroller to connect to external components. It has a similar function to a USB or a parallel port but differs in the way it exchanges bits.

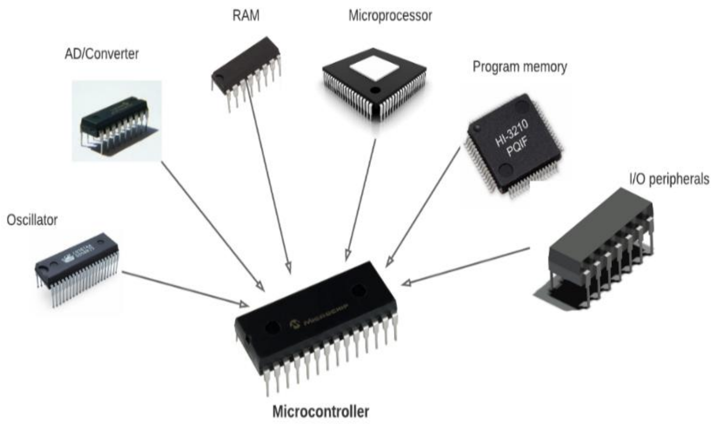


Figure 3.2 : the elements of a microcontroller

3.4 Microcontroller Uses :

Lots of devices make use of microcontrollers. Some examples:

- Burglar alarms incorporate a microcontroller chip which is connected to the keypad, display and sensor/contact inputs. Microcontrollers are generally self-contained chips with the ALU (Arithmetic Logic Unit), memory and I/O all contained within one integrated circuit.
- Older automatic washing machines used a cam switch for sequencing the operations during a wash cycle. This was quite a complex switch and was mounted on the end of the shaft of the knob you used to select a wash program. Newer machines use a microcontroller to sequence operations. Other appliances, such as microwave ovens and dishwashers, may incorporate a microcontroller.

- TVs use microcontrollers to handle the selection of channels and read the state of buttons on the TV.
- Microcontrollers are used for engine control and the display of information on the dashboard (fascia) of vehicles.
- Digital cameras use microcontrollers to handle input from buttons and control image capture and display.

3.5 Arduino and microcontrollers :

Arduino board was designed in the Ivrea Interaction Design Institute intended for students without a background in electronics and programming concepts. This board started altering to adapt to new requirements and challenges, separating its presence from simple 8-bit boards to products for IoT (Internet of Things) applications, 3D printing, wearable, and embedded surroundings. All boards are entirely open-source, allowing users to build them separately and finally adapt them to their exact needs.

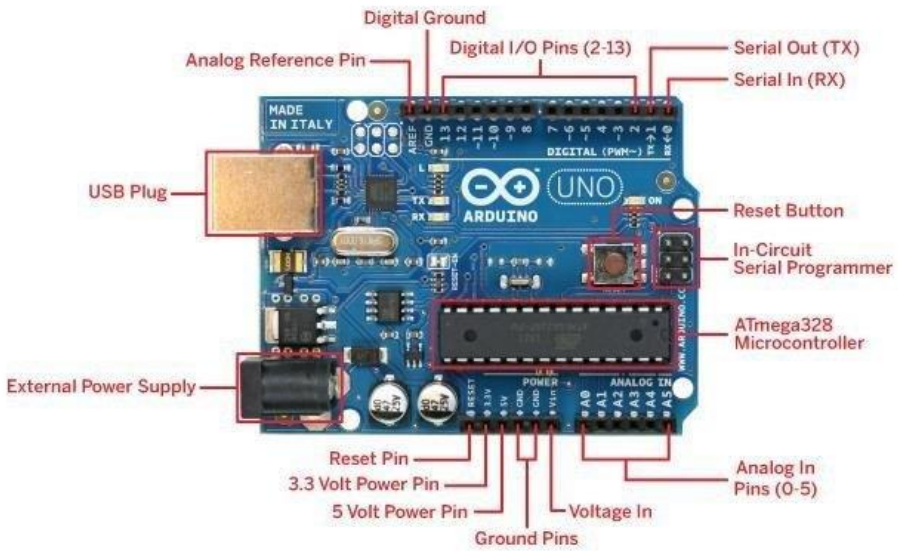


Figure 3.3 : Arduino-uno-microcontroller

Over the years the different types of Arduino boards have been used to build thousands of projects, from daily objects to compound scientific instruments. An international community of designers, artists, students, programmers, hobbyists, and experts has gotten together around this open-source stage, their donations have added up to an unbelievable amount of available knowledge that can be of immense help to beginners and specialists alike. This article discusses an overview of **different types of Arduino boards** and their comparison.

3.6 What are the Types of Arduino Boards:

Arduino board is an open-source platform used to make electronics projects. It consists of both a microcontroller and a part of the software or Integrated Development Environment (IDE) that runs on your PC, used to write & upload computer code to the physical board. The platform of an Arduino has become very famous with designers or students just starting out with electronics, and for an excellent cause. [8]

Figure :Types of Arduino Boards

Unlike most earlier programmable circuit boards, the Arduino does not require a separate part of hardware in order to program a new code onto the board you can just use a USB cable. As well, the Arduino IDE uses a basic version of C++, making it simpler to learn the program. At last, the Arduino board offers a typical form factor that breaks out the functions of the microcontroller into a more available package.

3.7 Different Types Of Arduino Boards :

The list of Arduino boards includes the following such as

- Arduino Uno
- Arduino Nano
- Arduino Micro
- Arduino Due
- LilyPad Arduino Board
- Arduino Bluetooth
- Arduino Diecimila
- RedBoard Arduino Board
- Arduino Mega (R3) Board
- Arduino Leonardo Board
- Arduino Robot
- Arduino Esplora
- Arduino Pro Mic
- Arduino Ethernet

- Arduino Zero
- Fastest Arduino Board

3.8 What is Arduino Nano:

Arduino Nano is a small, compatible open-source electronic development board based on an 8-bit AVR microcontroller. Two versions of this board are available, one is based on ATmega328p, and the other on Atmega168.

Arduino Nano can perform some functions similar to other boards available in the market, however, it is smaller in size and is a right match for projects requiring less memory space and fewer GPIO pins to connect with.

This unit features 14 digital pins which you can use to connect with external components, while 6 analog pins of 10-bit resolution each, 2 reset pins, and 6 power pins are integrated on the board.

Like other Arduino boards, the operating voltage of this device is 5V, while input voltage ranges between 6V to 20V while the recommended input voltage ranges from 7V to 12V.The clock frequency of this unit is 16MHz which is used to generate a clock of a certain frequency using constant voltage.

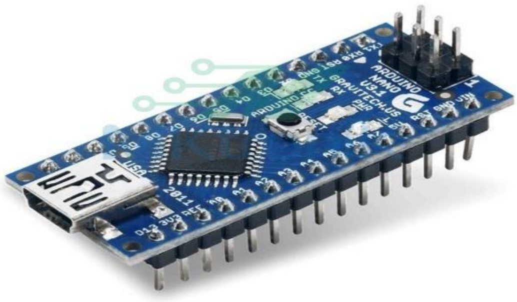


Figure 3.4 : Arduino nano

The board supports a USB interface and it uses a mini USB port, unlike most Arduino boards that use the standard USB port. And there is no DC power jack included in this unit i.e. you cannot power the board from an external power supply. Plus, this device is bread-board friendly in nature means you can connect this unit with breadboards and make a range of electronic projects.

The flash memory is used to store the program and the flash memory of Atmega168 is 16KB (of which 2KB is used for the Bootloader) and the flash memory of Atmega328 is 32KB.Similarly, the EEPROM is 512KB and 1KB, and SRAM is 1KB and 2KB for Atmega168 and Atmega328 respectively.The Nano board is almost similar to the UNO board with the former smaller in size with no DC power jack.

3.9 Arduino Nano Pin Description :

In this section, we'll cover the Arduino Nano Pinout, we will discuss pin description of each pin integrated on the board.

Digital Pins: There are 14 digital pins on board which is used to connect external component.
Analog Pins: 6 analog pins on board that is used to measure voltage in a range from 0 to 5V.
LED: The unit comes with a built-in LED connected to pin 13 on the board.
VIN: This is an input voltage to the Arduino board when using an external power source (6-12V).
3.3V: It is a minimum voltage produced by the voltage regulator on the board.
5V: Regulated power supply used to power up the controller and other components on board.
AREF: It is an Analog Reference that is applied to the unit as a reference voltage from an external power supply.
GND: Two ground pins are available on the board.
Reset: Two reset pins are integrated on the board. These pins are used to reset the controller internally through software.
External Interrupts: Pin 2 and 3 are used to trigger external interrupts. These pins are used in case of emergency.
USART: The board supports USART serial communication that carries two pins i.e. Rx which is used for receiving the serial data and Tx which is a transmission pin used to transmit serial data.
I2C: The unit comes with an I2C communication protocol where two pins SDA and SCL are used to support this communication. SDA is a serial data line that carries the data while SCL is a serial clock line used for data synchronization between the devices on the I2C bus. The Wire Library of Arduino Software can be accessed to use the I2C bus.
SPI: The device also supports SPI (serial peripheral interface) communication protocol where four pins (SS, MISO, MOSI, SCK) are used for this communication. This protocol is used to transfer data between the microcontroller and other peripheral devices.

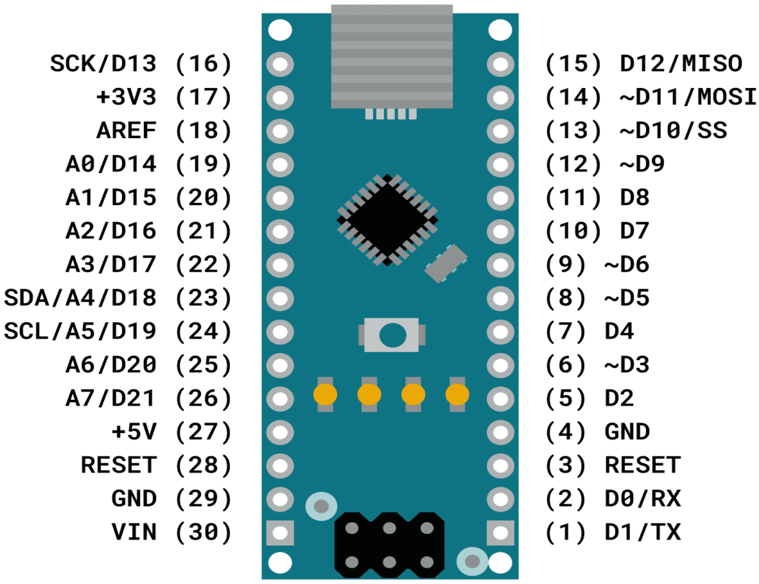


Figure 3.5 : Arduino nano pinout

3.10 How to Program Arduino Nano :

All Arduino boards can be programmed using Arduino IDE (Integrated Development Environment) Software – An official software introduced by Arduino. cc. All you need is a code to burn into the board to make it work as per the instructions fed into the board.

Plus, the board features a built-in Bootloader which sets you free from getting an external burner to burn the Arduino program. The unit supports a USB interface with a mini USB port. The USB cable is used to connect the board with the computer.

3.11 Arduino Nano Applications :

The best thing about Arduino boards is they can work as a stand-alone project or as a part of other electronic projects. You can interface Arduino Nano with other Arduino boards and Raspberry Pi boards. No technical expertise is required to use Arduino boards and anyone with little to no technical knowledge can make amazing projects with these units.

The following are the main applications of Arduino Nano Board.

- Medical Instruments
- GSM Based Projects
- Embedded Systems
- Arduino Metal Detector

- Industrial Automation
- Android Applications
- Virtual Reality Applications
- Real-Time Face Detection
- Automation and Robotics

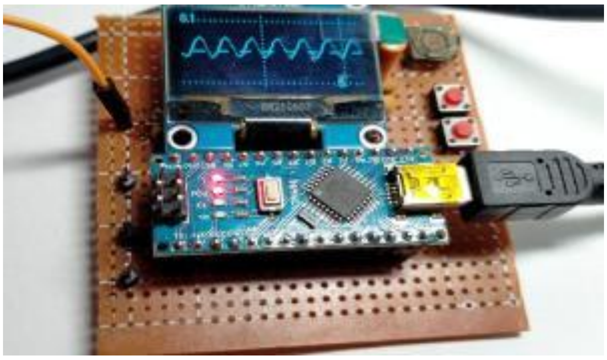


Figure 3.6 : arduino nano based projects with sources codes

3.12 Arduino IDE :

Arduino IDE (Integrated Development Environment) is a software platform used for programming Arduino microcontrollers. It provides a convenient interface for writing, compiling, and uploading code to Arduino boards. The IDE is open-source and cross-platform, making it compatible with various operating systems like Windows, macOS, and Linux. [9]

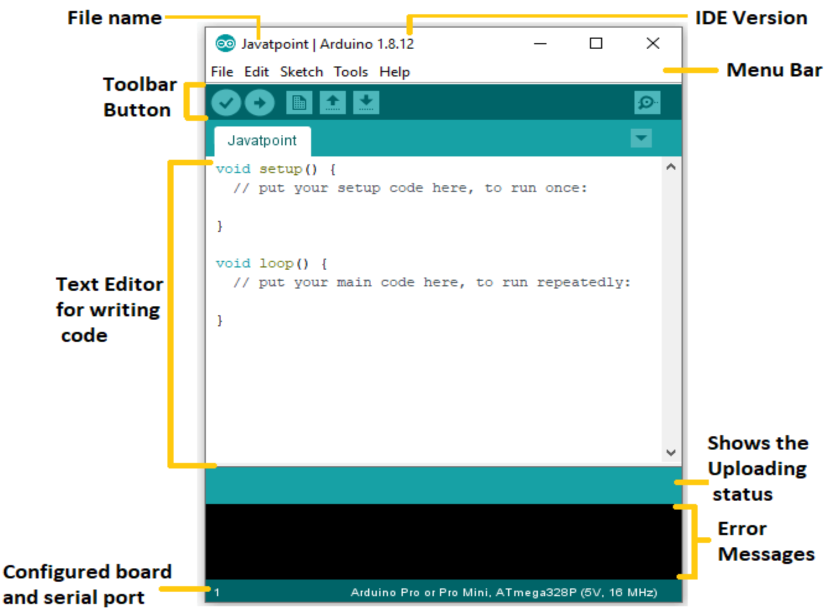


Figure 3.7 : Arduino ide

3.12.1 Key features of Arduino IDE include:

3.12.1.1. Code Editor:

- The code editor in Arduino IDE provides syntax highlighting, auto-indentation, and auto-completion features to assist you in writing code efficiently.

- It supports the Arduino programming language, which is a simplified version of C/C++ with added libraries and functions specific to Arduino boards.

3.12.1.2. Compiler:

- The heart of the Arduino IDE is the compiler, which translates the human-readable code written in the Arduino programming language into machine-readable instructions (binary code) that the microcontroller can execute.

- When you click the "Upload" button in the IDE, the compiler compiles your code and generates a firmware file (usually with a .hex extension) ready to be uploaded to the Arduino board.

3.12.1.3.Uploader:

- Arduino IDE comes with a built-in uploader tool that communicates with the Arduino board via a USB connection (or other supported interfaces) to transfer the compiled firmware.

- Once the firmware file is generated, the uploader tool sends it to the Arduino board's microcontroller memory, allowing the code to run on the board.

3.12.1.4. Library Manager:

- Arduino IDE features a Library Manager, which is an easy way to browse, install, and manage libraries (collections of pre-written code) for various sensors, actuators, displays, communication protocols, and other components.

- The Library Manager connects to the Arduino Library Repository, where you can find thousands of libraries contributed by the Arduino community and third-party developers.

3.12.1.5. Serial Monitor :

- The Serial Monitor is a tool integrated into Arduino IDE that allows you to communicate with your Arduino board over a serial connection.

- It displays the data sent by the Arduino board via the Serial.print() or Serial.println() functions in your code, enabling you to monitor sensor readings, debug issues, and interact with your projects in real-time.

- You can also use the Serial Monitor to send commands or data from the IDE to the Arduino board, facilitating bidirectional communication.

Overall, Arduino IDE provides a user-friendly and accessible environment for both beginners and experienced developers to prototype, program, and deploy projects using Arduino microcontrollers. Its simplicity and extensive documentation make it a popular choice for DIY enthusiasts, educators, and professionals working in the field of embedded systems and electronics.

CHAPTER 4 : REALIZATION AND TEST

4.1 Introduction :

This chapter focuses on the practical implementation of the system, detailing the steps necessary to fully realize the project. It begins with programming the Arduino board and designing the circuit board. We will also explore the calibration of sensors and the assembly and testing of components. This will allow us to evaluate the system's response to ozone, smoke, alcohol, temperature, and humidity. Additionally, we will provide a description of the Proteus software used in the process.

4.2 The Logiciel Proteus :

Proteus is a software suite used for electronic design automation (EDA). It allows users to create schematics, simulate circuits, and design printed circuit boards (PCBs). Proteus is widely used for designing and testing electronic circuits, offering tools for virtual testing of microcontroller code alongside the hardware design.

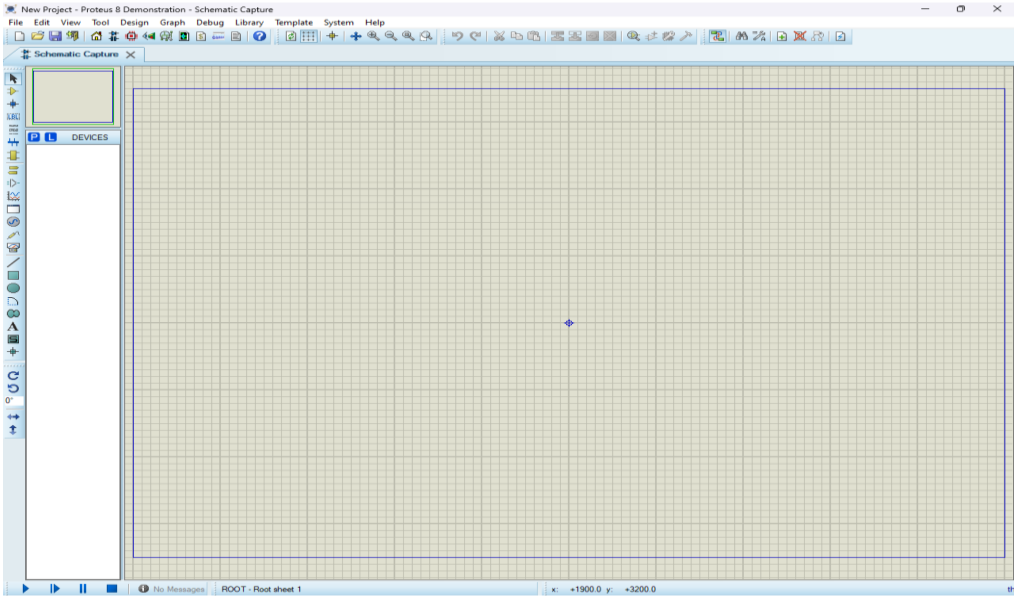


Figure 4.1: Proteus window

This picture shows the window that meets you when you start drawing and simulating. Which contains all the necessary supplies on the right, left and top to simulate any device or electronic project you want to try or implement.

4.3 Project design and simulation :

Simulation involves creating a virtual model of a system or process to study its behavior under various conditions. It is a method used to analyze the performance, predict outcomes, and optimize the design without physically building the system. Simulations can be used in various fields such as engineering, computer science, and physics, and they often employ software tools to create detailed and accurate models. The primary goals of simulation are to:

1. Understand the system's behavior.
2. Identify potential issues or improvements.
3. Test different scenarios and design choices without the risk or cost of real-world trials.

Here we show the simulation we did for our project which consists of an Arduino Nano , an air quality sensor (MQ135), a temperature and humidity sensor(DHT11), an ozone sensor (GUVA -s12sd), and an RTC (real time clock) time calculator.

We also added a pull-up resistor because the DHT 11 sensor here does not have it, On the contrary, we have the resistor integrated with the sensor in our project.

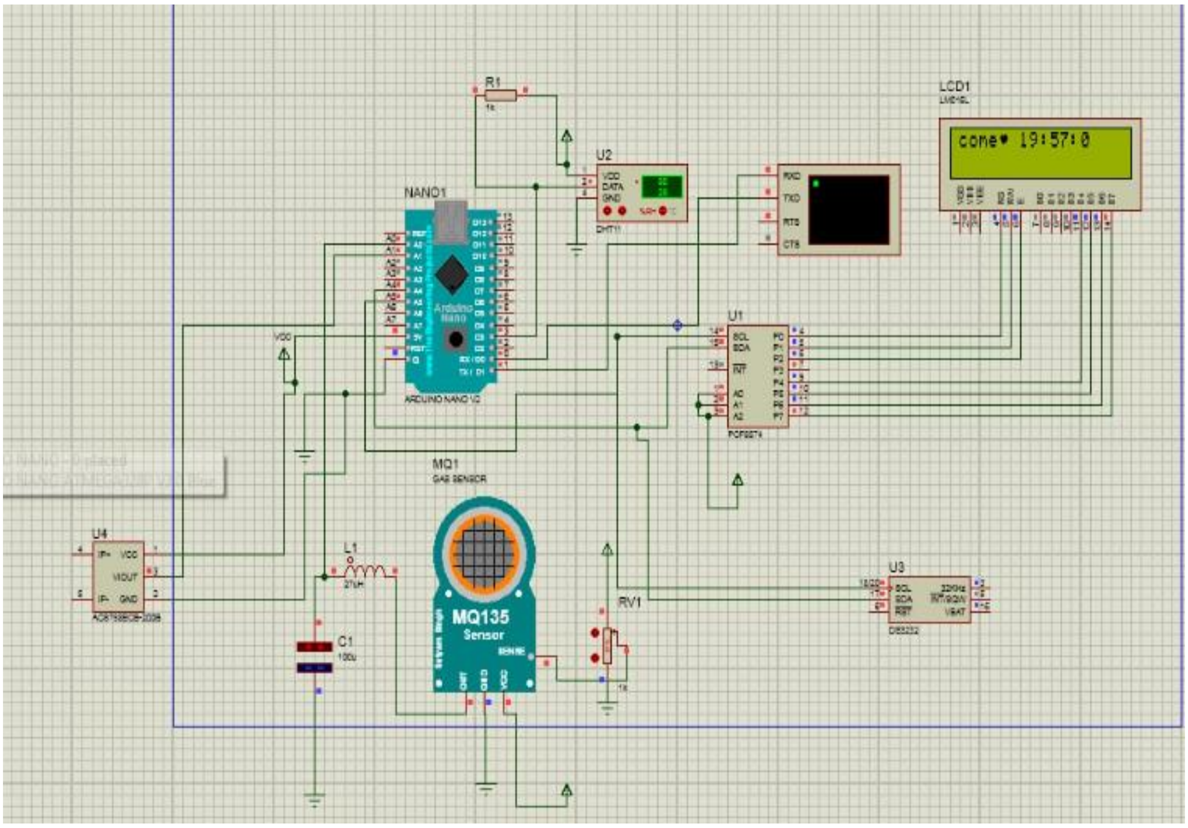


Figure 4.2 : Electrical diagram of the device produced by Proteus software

4.4 Calibration of sensors :

Sensor calibration is an essential step to guarantee accuracy, reliability and validity of the measurements taken. It makes it possible to eliminate manufacturing deviations, to compensate environmental influences, correct deviations and validate the performance of sensors.

4.4.1 Calibration of MQ 135 sensor :

To calibrate the MQ135 sensor, we connected the MQ135 sensor and an LCD screen (16.2) to our Arduino board. Then we uploaded the sketch below in the Arduino :

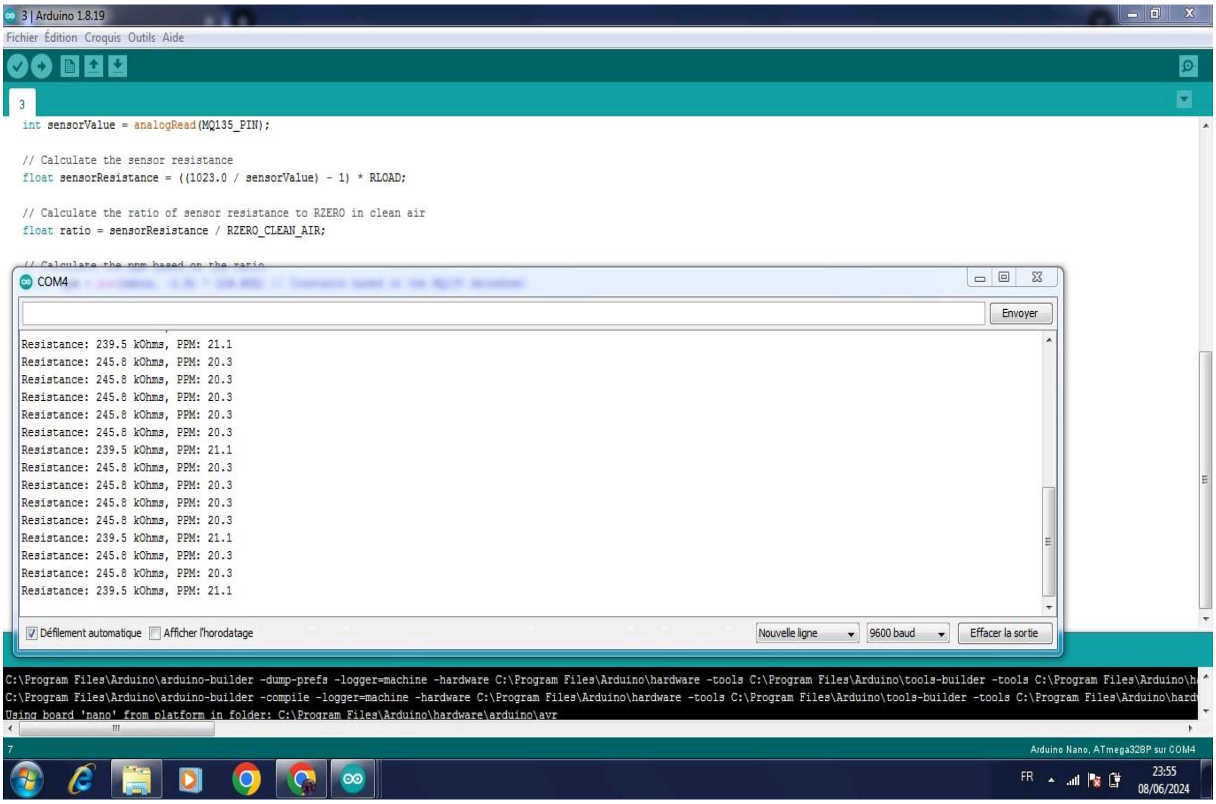


Figure 4.3: Display of R0 values on the serial monitor

This drawing initializes the LCD display and MQ135 sensor configuration. Thus, it performs calibration by calculating a value and storing it Primary resistance reference (R0) of the sensor. Once the calibration is completed, we display the R0 value on the LCD screen as shown in Figure 4.3. Calibration of the MQ135 in free air gave a reference resistance of R0 Equals 254 ohms. Using this calibration method, we obtain an accurate value of the resistance The initial (R0) of the MQ135 sensor, which is necessary to correctly interpret the receiver.

4.4.2 Calibration of Temperature and humidity Sensor DHT11 :

To calibrate the DHT11 sensor, its measurements are compared with those of a temperature thermometer reference. Before using the DHT11 sensor, it is essential to download the program Corresponding Arduino, as shown in Figure IIII.3. This program will allow communicate with the sensor and retrieve the measurements it takes. The measurements will be displayed in the serial monitor of the Arduino IDE.

First of all, we ensure that the DHT11 sensor and the reference thermometer are placed in the same stable environment representative of the desired measurement range. Then we verifies that the reference thermometer is calibrated and accurate. We leave the DHT11 sensors and the reference thermometer acclimatize to the environment for a period of time in order to obtain stable measurements. Then, we read and record the values provided by the DHT11 sensor and the reference thermometer. We compare the values measured by the two devices for temperature and we note the differences between the measurements of the DHT11 sensor and those of the reference thermometer. It was found that the values of the DHT11 sensor are different significantly from those of the reference thermometer, then we applied a -2° adjustment factor to correct DHT11 measurements.

Figure 4.4 : Displaying temperature and humidity measurements on the IDE serial monitor.

4.5 Operation of the device:

In this section, we will explain how the device works:

4.5.1 Display of measurements obtained by the sensors :

Once the data has been acquired by the Arduino from the sensors, it is ready to be displayed. To display the data on the LCD Since we have a lot of data to display, we organize the screen using coordinates Selector to place different elements (text, fonts, colors) using display controls. Thus ensuring real-time visualization for everyone data shown on the screen. Figure 4.5 and Figure 4.6 shows the device reception page which contains the date and time and Figure 4.7, Figure 4.8, Figure 4.9 and Figure 4.10 shows the measurement of the air quality ,temperature,humidity, index uv inside the room. Here we see a percentage below half, which indicates that the air is somewhat good measured values of sensors (image taken while the device is running).

Figure 4.5 : Time by RTC model

Figure 4.6 : Date by RTC model

Figure 4.7 : Air quality values by THE MQ135

Figure 4.8 : Temperature value by DHT11

Figure 4.9: Humidity Value by DHT11

Figure 4.10 : UV index by GUVA s12-sd

4.5.2 Display the information provided by the device and its function :

Here we see in Figure 4.11 the temperature and humidity sent by the sensor, the value of the gas that determines its quality (0-20%: Excellent air quality , 21-40%: Good air quality 41-60%: Moderate air quality ,61-80%: Poor air quality ,81-100%: Very poor air quality) , and the ultraviolet index of ozone, and we conclude that the device works successfully and without problems.

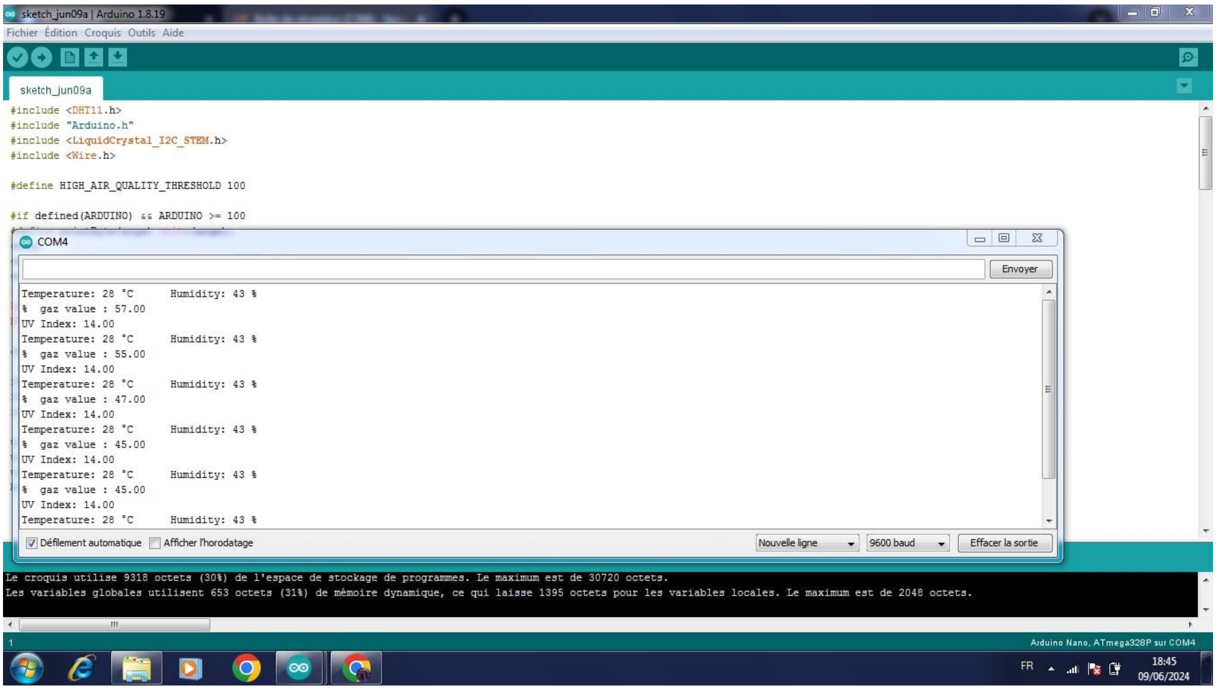


Figure 4.11: environment parameter sent by the sensor

4.6 Conclusion :

This chapter demonstrated the practical aspects of creating the device, highlighting the different stages, the challenges encountered and the solutions put in place the results obtained demonstrate the effectiveness and reliability of this instrument, as well as our ability to design and implement it. This information will be valuable for the scientific community interested in similar projects and will pave the way for new opportunities for research and innovation in the field.

General Conclusion :

In conclusion, this thesis detailed the development and implementation of a multi-sensor device , using an Arduino NANO and sensors such as the MQ135, DHT11 and UV ozone sensor GUVA s12-sd . Each phase of the project was crucial to the device's successful operation.

The work conducted provided a solid understanding of sensor operating principles and the calibration techniques required to achieve accurate and reliable measurements. The circuit simulation using Proteus software enhanced the layout of components and ensured the system's proper functioning.

The final device was capable of real-time ozone measurements and monitoring environmental parameters such as air quality, temperature, and humidity, enabling further analysis. This project allowed for the application of theoretical knowledge acquired during studies to create a functional device. It also opens new avenues for research and improvement in gas monitoring, with possibilities for device expansion, exploration of new sensors, and integration of advanced technologies.

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APPENDIX

Arduino program:

```
#include <DHT11.h>

#include "Arduino.h"

#include <LiquidCrystal_I2C_STEM.h>

#include <Wire.h>


#define HIGH_AIR_QUALITY_THRESHOLD 100


#if defined(ARDUINO) && ARDUINO >= 100

#define printByte(args) write(args);

#else

#define printByte(args) print(args, BYTE);

#endif


LiquidCrystal_I2C_STEM lcd(0x27, 20, 4);

DHT11 dht11(2);


char daysOfTheWeek[7][12] = {"Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday",
"Saturday"};


float sensor = A0;

float gas_value;

int UVPIN = A1; // Define the analog pin for the UV sensor


uint8_t clock[8] = {0x0, 0xe, 0x15, 0x17, 0x11, 0xe, 0x0};

uint8_t sad[8] = {0x3C, 0x42, 0xA5, 0x91, 0x91, 0xA5, 0x42, 0x3C};

uint8_t heart[8] = {0x0, 0xa, 0x1f, 0x1f, 0xe, 0x4, 0x0};

byte drop[8] = {

  B00100,

  B00100,

  B01110,

  B01110,

  B11111,
```

```
  B11111,
  B11111,
  B01110,
};

byte sun[8] = {
  B00100,
  B10101,
  B01110,
  B11111,
  B01110,
  B10101,
  B00100,
  B00000,
};

byte smile[8] = {
  0b00000,
  0b00000,
  0b01010,
  0b00000,
  0b10001,
  0b01110,
  0b00000,
  0b00000
};

void setup() {
  Serial.begin(9600);
  lcd.init();       // initialize the lcd
  lcd.backlight();  // Set backlight on
  lcd.clear();
  lcd.createChar(3, clock);
```

```
  lcd.createChar(0, drop); // Custom character for drop (humidity)
  lcd.createChar(2, smile);
  lcd.createChar(4, sad);
  lcd.createChar(5, heart);
  lcd.createChar(1, sun);  // Custom character for sun (temperature)

  pinMode(sensor, INPUT);
  pinMode(UVPIN, INPUT);
}

void loop() {
  gas_value = analogRead(sensor);
  int temperature = 0;
  int humidity = 0; // Attempt to read the temperature and humidity values from the DHT11 sensor.
  int result = dht11.readTemperatureHumidity(temperature, humidity);
  if (result == 0) {
    Serial.print("Temperature: ");
    Serial.print(temperature);
    Serial.print(" °C\tHumidity: ");
    Serial.print(humidity);
    Serial.println(" %");
  } else {
    // Print error message based on the error code.
    Serial.println(DHT11::getErrorString(result));
  }

  Serial.print(F("%  gaz value : "));
  Serial.println(gas_value);

  // Read UV index from UV sensor
  int uvValue = analogRead(UVPIN);
  float uvIndex = map(uvValue, 0, 1023, 0, 15); // Adjust the mapping according to your UV sensor
  Serial.print(F("UV Index: "));
```

```
Serial.println(uvIndex);

// Print welcome message
lcd.clear();
lcd.setCursor(0, 0);
lcd.printByte(5);
lcd.print("Welcome");
lcd.printByte(5);
delay(3000);

unsigned long startTime = millis(); // Get the start time in milliseconds
while (millis() - startTime < 7000) { // Continue looping for 5 seconds
  lcd.scrollDisplayLeft();
  delay(800); // Adjust the delay to control the scroll speed
}

delay(3000);
lcd.clear();

// Print air quality
lcd.setCursor(0, 2); // Set cursor to first column of third row
lcd.print(F("Air Quality:"));
if (gas_value > HIGH_AIR_QUALITY_THRESHOLD) {
  lcd.printByte(4); // Custom character for sad emoji
} else {
  lcd.printByte(2); // Custom character for happy emoji
}
lcd.print(F(" "));
lcd.print(gas_value);
delay(3000);
lcd.clear();

// Print temperature
```

```
  lcd.setCursor(0, 2); // Set cursor to first column of third row
  lcd.print(F("Temperature: "));
  lcd.printByte(1); // Custom character for sun (temperature)
  lcd.print(temperature);
  lcd.print((char)223); // Print the degree symbol (°)
  lcd.print("C");       // Print the "C" character for Celsius
  delay(3000);
  lcd.clear();

  // Print humidity
  lcd.setCursor(0, 3); // Set cursor to first column of fourth row
  lcd.print(F("Humidity: "));
  lcd.printByte(0); // Custom character for drop (humidity)
  lcd.print(humidity);
  lcd.print(F("%"));
  delay(3000);
  lcd.clear();

  // Print UV index
  lcd.setCursor(0, 3); // Set cursor to first column of fourth row
  lcd.print(F("UV Index: "));
  lcd.print(uvIndex);
  delay(3000);
  lcd.clear();
}
```

MQ135 sensor program:

```
#define MQ135PIN A0  // Analog pin where the MQ135 is connected


void setup() {
  Serial.begin(9600);
  Serial.println("MQ135 Sensor Reading");
```

```
}

void loop() {
  int airQuality = analogRead(MQ135PIN);

  Serial.print("Air Quality: ");
  Serial.println(airQuality);

  delay(1000);  // Wait 1 second between readings
}
```

DHT 11 sensor Program :

```
#include "DHT.h"

#define DHTPIN 2     // Pin where the DHT11 is connected
#define DHTTYPE DHT11   // Define the type of sensor used, DHT11

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(9600);
  Serial.println("DHT11 Sensor Reading");
  dht.begin();
}
void loop() {
  // Wait a few seconds between measurements.
  delay(2000);  // Reading temperature or humidity takes about 250 milliseconds!
  float humidity = dht.readHumidity(); // Read temperature as Celsius
  float temperature = dht.readTemperature();  // Read temperature as Fahrenheit
  float fahrenheit = dht.readTemperature(true);  // Check if any reads failed and exit early (to try again).
  if (isnan(humidity) || isnan(temperature) || isnan(fahrenheit)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
```

```
 }
Serial.print("Humidity: ");
 Serial.print(humidity);
 Serial.print(" %\t");
 Serial.print("Temperature: ");
 Serial.print(temperature);
 Serial.print(" *C ");
 Serial.print(fahrenheit);
 Serial.println(" *F");
```

Uv sensor program :

```
#define UVPIN A0  // Analog pin where the UV sensor is connected
void setup() {
 Serial.begin(9600);
 Serial.println("UV Sensor Reading");
}
void loop() {
 int uvLevel = analogRead(UVPIN);
 float voltage = uvLevel * (5.0 / 1023.0); // Convert the analog value to voltage
Serial.print("UV Level: ");
 Serial.print(uvLevel);
 Serial.print("\tVoltage: ");
 Serial.println(voltage);

 delay(1000);  // Wait 1 second between readings
}
```

RTC module Program :

```
#include <Wire.h>
#include <RTClib.h>
RTC_DS3231 rtc;
void setup() {
 Serial.begin(9600);
```

```
  if (!rtc.begin()) {
    Serial.println("Couldn't find RTC");
    while (1);
  }
  if (rtc.lostPower()) {
    Serial.println("RTC lost power, setting the time!");
  Serial.begin(9600);
  Serial.println("UV Sensor Reading");
}
void loop() {
  int uvLevel = analogRead(UVPIN);
  float voltage = uvLevel * (5.0 / 1023.0); // Convert the analog value to voltage

  Serial.print("UV Level: ");
  Serial.print(uvLevel);
  Serial.print("\tVoltage: ");
  Serial.println(voltage);

  delay(1000);  // Wait 1 second between readings
}
```