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Sector: Renewable Energy Specialization : Renewable Energy in Electrotechnics
Presented by:

Miss. Djihad Benchaa and Miss. Zekizki Oum Kalthoum **Theme:**

Study, design and management of a smart home

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In front of the jury:

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Finally, we also thank all our families and individuals who directly or indirectly assisted us in writing this work.

Dedication

Praise be to Allah, Lord of all worlds.

At first, all praise be to Allah for his help, with love and gratitude.

With a great pride, I dedicate the fruit of my efforts first to my self, then to all inhabitants in my heart.

To my pride in life, my support, the symbol of giving and sacrifice, my father.

To my eternal and first supporter, my pure angel, to my dear mother where Allah placed paradise under her feet.

To those whom Allah has said about: "We will strengthen your arm through your brother"; my brothers and sisters, the symbol of loyalty and sacrifice, each by name, and their children, may Allah protect them.

To the companions of the first and last step, the companions of the journey, who were my support in all my stumbles.

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Finally, to the one who said, "I am for it, and achieved it".

Djihad Benchaa

Dedication

All praise is due to Allah, first and foremost, for His countless blessings and guidance that enabled me to achieve this milestone.

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Zekizki Oum Kalthoum

Abstract

Smart homes provide significant conveniences for users, offering a high level of luxury through the use of modern technology and techniques to enhance comfort, security, and safety. However, the smart home typically requires a constant connection to the internet and electricity. Moreover, most applications are available in foreign languages, which deprives remote houses, distant work sites, as well as people with special needs and the elderly from the benefits of smart homes. Therefore, the main objective of this work was to solve these problems by creating a home control system that combines automated control and an application we programmed. This system allows controlling of interior and exterior lighting, opening/closing doors, issuing gas, smoke, and fire alerts, and opening windows as a precautionary measure. In case of rain, the windows will be closed automatically to prevent water leakage in to the house. Additionally, it includes automatic control of water consumption and storage. The developed smart home prototype features a smart camera that reacts to any movement, directing its elf towards the movement and dis playing the video on a phone and a computer with zoom, recording, lighting, and other features. Furthermore, the smartphone application allows remote control using buttons or voice commands in Arabic, English, and other languages upon request, thereby integrating deprived cases and persons with special needs into the smart home technology. Notably, the designed and realized smart home operates on clean, renewable photovoltaic energy. In addition, it has a system against water and energy waste, which makes it contribute to water, energy, food and health security.

Keywords: Smart homes, automatic control, photovoltaic energy, Arduino, Android application.

الخلاصة

توفر المنازل الذكية تسهيلات كبيرة للمستخدمين، مما يضفي على حياتهم مستوى عالٍ من الرفاهية بفضل استخدام التكنولوجيا الحديثة لتحسين الراحة، الأمن، والسلامة. ومع ذلك، يتطلب تشغيل المنازل الذكية اتصالًا دائمًا بالإنترنت والكهرباء، بالإضافة إلى أن معظم التطبيقات المتاحة تقدم بلغات أجنبية، مما يحرم البيوت النائية، وورش العمل البعيدة، وكبار السن، وذوي الاحتياجات الخاصة من فوائد هذه التقنية.لذا، كان الهدف الأساسي من هذا العمل هو إيجاد حلول لهذه المشكلات من خلال تصميم نظام تحكم منزلي يجمع بين التحكم الآلي وتطبيق ذكي تم برمجته خصيصًا. يتيح هذا النظام التحكم في الإضاءة الداخلية والخارجية، فتح وغلق الأبواب، وإطلاق تنبيهات للغاز، الدخان، والحرائق، بالإضافة إلى فتح النوافذ تلقائيًا كإجراء وقائي، وغلقها في حالة هطول الأمطار لتجنب تسرب المياه. كما يوفر النظام التحكم الآلي في استهلاك المياه وتخزينها. يتضمن النموذج الأولي كاميرا ذكية تتفاعل مع الحركة وتوجه نفسها نحو المصدر، مع عرض الفيديو على الهاتف والحاسوب، وإمكانية التكبير، التسجيل، والإضاءة. كما يدعم تطبيق الهاتف الذكي التحكم عن بُعد باستخدام الأزرار أو الأوامر الصوتية باللغتين العربية والإنجليزية، مع إمكانية إضافة لغات أخرى حسب الطلب، مما يتيح دمج الفئات المحرومة وذوي الاحتياجات الخاصة في تكنولوجيا المنازل الذكية .
الجدير بالذكر أن المنزل الذكي يعمل بالطاقة الشمسية النظيفة والمتجددة، ويحتوي على نظام يحد من إهدار المياه والطاقة، مما يجعله مساهمًا في تعزيز الأمن المائي، الطاقوي، الغذائي، والصحي.

الكلمات المفتاحية :المنازل الذكية، التحكم الآلي، الطاقة الشمسية، أردوينو، تطبيق أندرويد.

Résumé

Les maisons intelligentes offrent de grandes facilités aux utilisateurs et ajoutent un haut niveau de confort à leur vie en exploitant la technologie et les techniques modernes pour améliorer le confort, la sécurité et la sûreté. Cependant, une maison intelligente nécessite toujours une connexion Internet et une alimentation électrique constante, et la plupart des applications sont disponibles en langues étrangères, ce qui exclue les maisons éloignées, les ateliers isolés, ainsi que les malveillants et les personnes âgées de l'exploitation des avantages des maisons intelligentes. Par conséquent, l'objectif principal de ce travail est de résoudre ces problèmes en créant un système de contrôle domestique combinant le contrôle automatique et le contrôle via une application que nous avons programmée. Cette application permet de contrôler l'éclairage intérieur et extérieur, d'ouvrir/fermer les portes, de lancer des alertes en cas de fuite de gaz, de fumée ou d'incendie, et d'ouvrir la fenêtre comme mesure préventive. En cas de pluie, la fenêtre se ferme automatiquement pour éviter les infiltrations d'eau dans la maison. Le système offre également un contrôle automatique de la consommation et du stockage de l'eau. Le prototype de la maison intelligente que nous avons réalisé comprend une caméra intelligente qui réagit à tout mouvement, se dirige vers celui-ci, et affiche la vidéo sur le téléphone et l'ordinateur avec la possibilité de zoomer, d'enregistrer et d'éclairer, avec autres fonctionnalités. En outre, l'application pour smartphone peut être contrôlée à distance via des icônes ou par la voix, en arabe et en anglais, ainsi qu'en d'autres langues sur demande. Ce qui permet d'intégrer les cas écartés et les cas particuliers des personnes dans la technologie des maisons intelligentes. Il est à noter que la maison intelligente que nous avons réalisée est alimentée par l'énergie solaire propre et renouvelable. De plus, il dispose d'un système contre le gaspillage d'eau et d'énergie, ce qui lui permet de contribuer à la sécurité de l'eau, de l'énergie, de l'alimentation et de la santé.

Mots-clés: Maisons intelligentes, contrôle automatique, énergie photovoltaïque, Arduino, application Android.

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General Introduction

General Introduction

Nowadays, advancements and developments in the world of electronics and technology have led to the emergence of the Internet of Things (IoT). This technology enables smart devices to communicate, learn, and adapt to their environments, with the goal of improving the quality of life and meeting daily needs. Technological development in various fields is supported by the proliferation of communication means and small, easy-to-use components. As well as the availability of low-cost embedded systems and open-source platforms, encouraging experts and enthusiasts to develop and implement their projects in this field.

Among the applications of modern technology, smart home control stands out. Smart homes are known by their ability to connect devices and interact with users in ways that enhance comfort and safety while reducing energy consumption. Users can remotely control household devices using smartphones, making daily life easier and more efficient.

The advantages of smart homes also include the use of sensors to detect changes and risks, such as gas and smoke detectors that trigger alarms when needed, as well as weather detection devices. With the integration of these technologies, the home environment can be customized and adjusted to meet the residents' needs and preferences. However, blind and old persons, remote camps and houses can not benefit from the smart home technology due to language, internet and electrical power leak. Moreover, the housing sector knows a significant electricity and water wastage, which threats the environment, the energy, water and food security.

In this context, the objective of our project is to mitigate these problems. A smart home prototype using Arduino and ESP32 boards has been realized.(ESP32: A microcontroller developed by Espress if Systems, widely used in IoT applications for its Wi-Fi and Bluetooth connectivity.)The prototype will include various scenarios, such as displaying data on an LCD screen, door control, in door lighting with a motion sensor, regular and colored outdoor lighting, as well as high-precision detection of smoke, gas, fire, and theft. Additionally, it will features mart and efficient water storage and consumption management. We will also develop an Android application to remotely control the devices via icons or voice commands in both Arabic and English. Finally, a control device has been created to control real appliances.

Our project will be presented in four chapters, where we will discuss the basics of smart home control and the available technologies. We will also explore the different uses of Arduino and introduce the Android platform and how to create applications through it. Furthermore, we will provide detailed information on the design and implementation of the photovoltaic system for the smart home in an efficient and integrated manner. Finally, all realization steps and tests will be detailed in the last chapter with the creation of the Android application and its features.

In conclusion, we will present a general summary that covers the project results, challenges, and future opportunities in this exciting field.

Chapter I: Home automation and photovoltaic energy

I.1 Introduction

Human beings have always sought to make their lives more comfortable and convenient, utilizing technology and innovations to enhance their living conditions, including their homes. Among the significant advancements in this area is the emergence of smart homes, which rely on automation, smart devices, and connectivity.[1]Smart homes offer a wide range of functions and capabilities that enhance comfort, security, and energy efficiency, thereby improving the quality of life. They allow users to control and monitor various aspects of their homes remotely, leading to increased convenience and peace of mind [1].

In this introduction, we will explore the concept of the smart home and its importance, as well as the concept of using solar energy in homes. We will also address the benefits and challenges of implementing smart technology and solar energy in homes. Additionally, we will introduce the Renewable Energy Research Unit in the Saharan Medium (URERMS) in Adrar, where we conducted a scientific internship.

I.2 Definition of the home automation

Automated home operating system is a technological solution that enables the automation of most electronic, electrical, and technological tasks with in a home. It utilizes a mix of hardware and software technologies that allow for controlling and managing devices within the home. Automated home operating system is also known as domestics, and a home with such a system is referred to as a smart home [2].

Devices with in an automated home operating system connect and communicate with each other via a local wired or wireless network. A complete automated home operating system typically requires system management software, installation of device controllers, motion sensors, temperature sensors, and other components[3].Smart homes encompass various field such as electronics, information technology, electrical engineering, communications, hydraulics, gas, etc. Due to the rapid evolution of this field, it has be come possible to find user-friendly solutions for many features and benefits [4].

I.3 Smart home

The smart home is a home equipped with technological systems that allow residents to remotely control many different aspects of the home, typically over the internet. Smart home control devices can perform tasks such as adjusting room temperatures, turning electrical appliances on and off, opening and closing doors, and controlling lighting systems. The smart home aims to provide greater comfort and security for its residents and improve energy efficiency [5], [6]. FigureI.1 illustrates an example of a smart hom

Figure.I.1: Example of a smart home [7].

I.3.1 Features and benefits of the smart home

1) Providing security against fires and theft.
2) Improving ease of navigation and control of devices.
3) Adjusting the temperature according to needs and preferences.
4) Providing all comforts and entertainment for family members.
5) Reducing electricity and water consumption.
6) Utilizing artificial intelligence technologies to enhance system performance[8].

I.3.2 How does the smart home work

Smart home systems include a set of keys and sensors connected to a central unit known as "the gateway". This central unit is controlled through a user inter face that the user typically interacts with through a wall station or an app on smartphones or tablets. Machine-to-Machine (M2M) communication technology allows communication between different devices and the gateway, where sensors and measuring devices use this technology to transmit data to the gateway. The function of the gateway is to collect this data and send it to the application, which translates it into understandable information for the user [9].

For example, smart devices like smart washing machines or smart refrigerators can use M2M technology to send data about status or suggestions to the gateway. These devices can interact with the user intelligently, such as providing recipe suggestions based on the ingredients available in the refrigerator [10].

Low-power wireless communication technologies like WiFi, Zigbee, and Bluetooth Low Energy are used to efficiently connect devices to the gateway in terms of power consumption. The M2M gateway is usually connected to a server through a GSM network (3G or 4G) or broadband line, allowing data to be sent and commands to be received from and to smart home appliances remotely [10]. Figure I. 2 is an example of that

Figure.I.2: Communicating from machine to machine [11].

I.4 Areas of application of home automation

Home automation systems can provide a variety of different services. There are three basic standards that are often found in smart homes [12].

I.4.1 Energy saving

By using home automation, energy efficiency can be greatly improved, costs can be saved, and the environment can be protected by reducing carbon emissions. Additionally, it can help in optimizing water usage by scheduling irrigation based on weather conditions, and by using automatic sensors to detect moisture levels in the soil, thus conserving water resources. Heating control can be automated to adjust the temperature for different rooms based on occupancy and to regulate heating schedules for optimal comfort and energy savings. Moreover, automatic lighting systems can be used to illuminate outdoor spaces like gardens, providing security and enhancing the aesthetic appeal of the landscape [12].

I.4.2 Security and protection

The home is exposed to many risks that threaten its security, such as break-ins or burglaries. To prevent these risks, security measures such as surveillance cameras, motion detectors, alarm systems, encrypted locks, and others have been implemented.

There are also technical malfunctions such as gas leaks or fires. To prevent these, detection devices and alarm systems can be installed for early warning. Thanks to these features, home automation provides peace of mind for homeowners and their families [1].

I.4.3 Health and well-being

Smart home technology provides energy management based on needs and preferences, enhancing the user's sense of security and comfort. This makes it even more important as it simplifies daily life for people with special needs and helps elderly individuals by enabling them to perform certain tasks independently without needing assistance from others [1].

I.5 How does home automation work

Automatic home operation relies on transferring information between the automated home control system and the devices that execute specific commands. This is done through sensors that collect the necessary data, after which the control system activates the required devices to

carry out the instructions. There are three different technologies available for communication between these two components[13].

I.5.1 Wired bus technology

Wired communication technology relies on cables to ensure communication between system components for information exchange and processing. Data is sent through cables to receiving devices that convert it into signals to execute the required tasks. Installation of this system includes a wired network connecting sensors to controllers, as well as a power supply network connecting controllers to the electrical source.

Wired communication technology is highly reliable and allows multiple units to be connected to a single transmitter, making it a suitable choice for systems requiring control of multiple devices connected within the same system [6], [13].

I.5.2 Power line carrier (PLC) technology

This technology uses electrical wiring in homes to exchange information between the transmitting and receiving devices. It is characterized by not requiring a specific installation location and its ability to provide communication over long distances. However, there liability of PLC technology remains questionable, as the protocols that use power lines may be susceptible to interference from the surrounding environment, and the equipment use din them can be costly[13].

I.5.3 Wireless or radio frequency technology

This technology is used to exchange information between the transmitter and receiver without the need for cables. It includes using various technological mediums such as radiofrequencies, infrared, Bluetooth, and Wi-Fi, all of which rely on wireless communication technologies. Implementing these technologies is simple and easy.

Wireless protocols are popular due to their ability to provide freedom in placing smart devices and keys without the need for cable connections. However, the main drawback of these protocols remains the rapid battery consumption, which hinders their use for extended periods without the need for recharging[6], [13].

I.6 Solar and photovoltaic energy

I.6.1 Definition of solar energy

Solar energy is produced from the thermonuclear fusion reactions that occur in the solar core. The sun is the primary star of our planet, with a diameter of 1.4 million kilometers, which is 109 times larger than the diameter of the Earth. The surface temperature of the sun is approximately 6000 degrees Celsius, but its internal temperature is much higher. The sun is considered a source of photovoltaic energy, thermal energy, and even wind energy, through the emission of various spectra and its influence on atmospheric pressure on the Earth's surface. Solar energy encompasses all types of radiation such as visible light, infrared radiation, ultraviolet radiation, X-rays, and radio waves [14], [15],

I.6.2 Solar radiation

Solar radiation is the primary source of solar energy, consisting of waves with wavelengths ranging between 0.2 and 4.10^-6 meters. These rays reach the Earth's surface after losing a significant portion of their intensity due to the absorption of some ultraviolet rays.

Solar radiation can be utilized to produce electricity either directly using photovoltaic semiconductors or through solar thermal energy for heating or electricity generation.

There are four types of solar radiation received on Earth:[15],

- ***Global radiation:*** It is measured with a pyranometer and represents the radiation received on a horizontal surface from the entire sky dome.

- ***Diffuse radiation:*** It is measured using a pyranometer equipped with a shading device (a metal ring or a ball shading the solar disk). Diffuse radiation is emitted from the sky dome, excluding the solar disk. It represents the portion of solar radiation scattered by solid or liquid particles suspended in the atmosphere.
- ***Direct radiation:*** It is measured using a pyrheliometer, which has a sensor surface always perpendicular to the sun's rays. Direct solar radiation is the radiation that reaches the Earth without scattering.

The figure I.3 below represents all solar radiation received on the Earth's surface The intensity and duration of useful solar radiation constitute the fundamental factors for solar resource assessment, relied upon by researchers to estimate solar energy production[15],

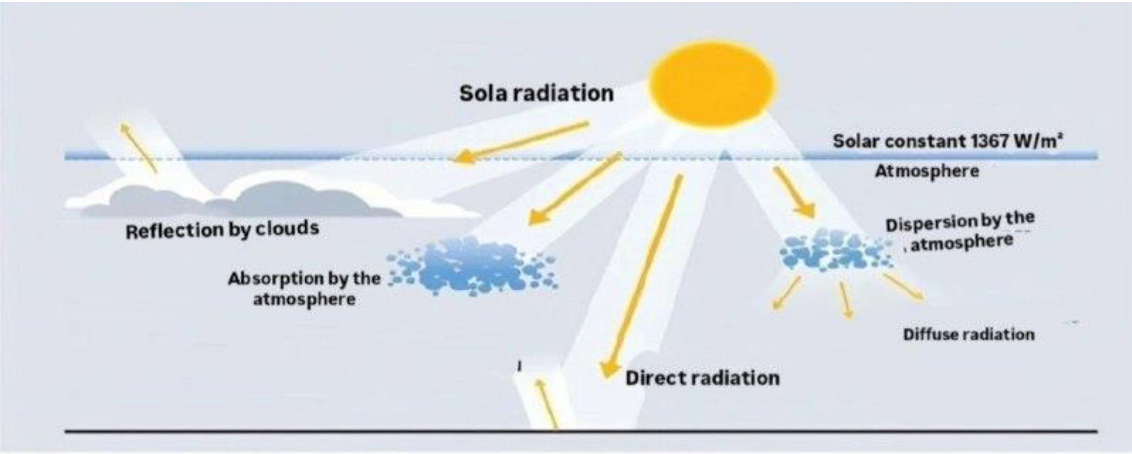


Figure.I.3: Types of solar radiation[15].

I.6.3 Solar potential in Algeria

Algeria enjoys a significantly high solar stock, making it one of three countries with the best solar energy reserves in the world.

Algeria represents the most important solar potential in the entire Mediterranean Basin, where its annual production of solar thermal energy is 169,000 terawatt-hours and 13.9 terawatt-hours for solar photovoltaic energy. The solar energy potential in Algeria is equivalent to the discovery of 10 large natural gas sites in Hassi R'Mel.

Among the technologies relying on the utilization of solar energy is the use of photovoltaic panels to convert direct sunlight into electricity [15].

I.6.3.1 Photovoltaic energy

Photovoltaic energy is a type of renewable energy produced by converting solar radiation into electricity. All cells are used to construct a photovoltaic panel, which is the main component of solar power generation systems. These cells consist of semiconductor materials such as silicon that absorb solar light. Since silicon is slightly reflective, the cell is covered with an anti-reflective coating to absorb photons and prevent their reflection outside the cell.

The cells are covered with a glass cover to protect them from environmental conditions and scratches, and the solar panel is a collection of these cells connected together in a frame. The operating principle relies on the cell receiving light, where free electrons receive energy through dopants and the PN junction, then move to the negative region of the semiconductor material. This movement generates electric current [15].As shown in the following FigureI.4

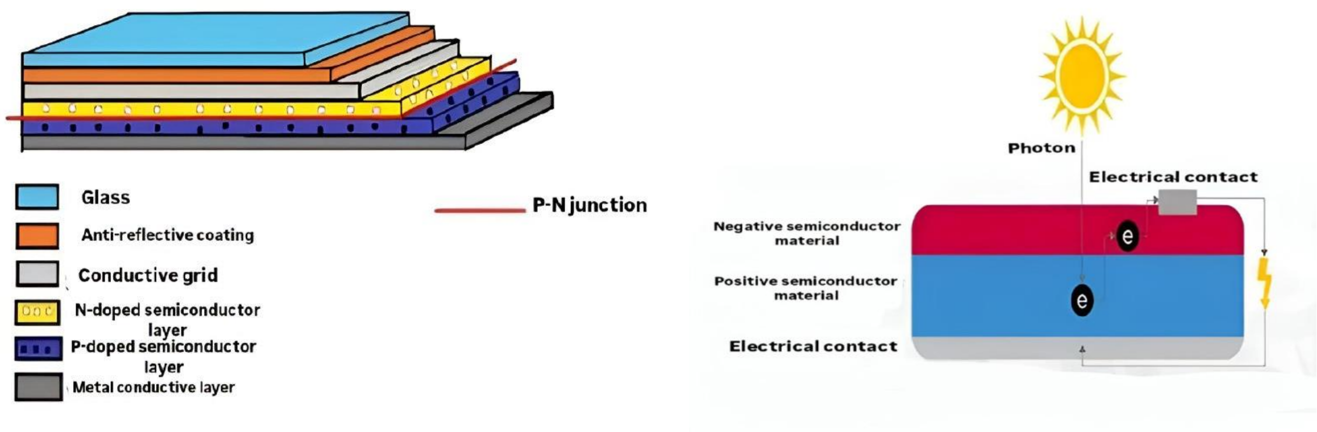


Figure.I.4: Principle of Operation and Layers of Solar Cells[15].

When a charge is applied across the cell, electrons in the n-region move to the holes in the p-region through the external connection, resulting in the emergence of a voltage difference and the flow of electric current [15].

I.6.3.2 Different photovoltaic cell technologies

Solar cell technologies vary in three main categories based on the methods used:

The first generation is the most costly. The second generation, known as thin-film, is evolving with lower costs and is currently under development. Meanwhile, the third generation, consisting of organic cells, aims to increase productivity and reduce costs.

Among the most commonly used and readily available types in the market[15].

I.6.3.2.1 Monocrystalline cells

Monocrystalline silicon panels are a type of solar cells distinguished by their manufacturing from a single piece of high-purity crystalline silicon, enhancing the purity of their crystalline structure. These panels exhibit high efficiency, reaching up to 22.5% in laboratory conditions, al though commercially, the average efficiency is around17.5%.Widely used in the solar energy industry, these panels have the capability to generate large amounts of electricity and have a long lifespan that can reach 25 years or more [15] .

I.6.3.2.2 Polycrystalline cells

The difference between polycrystalline silicon cells and monocrystalline silicon cells is clearly visible in the Figure I.5,where polycrystalline silicon cells appear as compact squares,

Figure.I.5: Monocrystalline Solar Panel[15].

While monocrystalline solar panels exhibit their beautiful and smooth blue appearance. is clearly visible in the FigureI.6
Al though polycrystalline silicon cells are cheaper than monocrystalline silicon cells, their efficiency reaches approximately 16.9%, with a lifespan of 25 years or more[15].

Figure.I.6: Polycrystalline solar panel [15].

I.6.3.2.3 Amorphous cells

Non-crystalline cells are considered an economical alternative as their manufacturing costs are significantly lower than those of crystalline silicon the FigureI.7. These cells are used in places requiring minimal electricity, such as operating clocks, calculators, emergency lights, or in locations where units are expected to experience intense heating. However, their efficiency is lower by more than twice compared to crystalline silicon, meaning they require a larger surface area to generate the same amount of energy [15].

Figure.I.7: Amorphous solar panel [15].

I.6.3.2.4 Thin layers

This type of solar panels is considered thin and simplified, is clearly visible in the FigureI.8

as it takes the shape of the surface it is installed on. Most of the current developments and research focus on developing this type specifically due to its flexibility, light weight, and thinness. This type is suitable for many applications such as boat surfaces, commercial vehicles, and transportation. Among its drawbacks is that it is considered the least efficient among these types, and therefore its efficiency cannot exceed 12%. Additionally, its lifespan is less than 15 years [15].

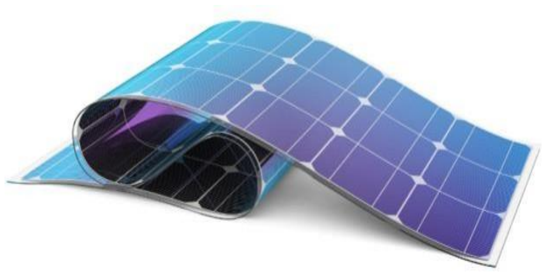


Figure.I.8: Thin-Film solar panel [15].

I.7 Parameters of a photovoltaic panel

Each solar panel is defined by the information provided on its datasheet, and this information is generally determined by the manufacturer according to well-known standards called "Standard Test Conditions" (STC). In English, where the temperature (T) = 25 degrees Celsius and the irradiance (G) = 1000 watts per square meter [16].

There are variables indicated on the nameplate of the panel, which are crucial for determining the size of installations and photovoltaic systems.

I.7.1 Short-circuit current (I_{cc}=I_{sc})

The short-circuit current(Icc)is the current that flows in the solar cell circuit when the voltage across the cell equals zero. It refers to the maximum value of the current in this case, where I(V=0) = Icc[16].

I.7.2 Open circuit voltage (V_{co}=V_{oc})

The short-circuit voltage is the voltage measured across the terminals of the solar cell when the current output equals zero (without any load) [16].

I.7.3 Maximum current(I_{max}=I_{mp})

This is the maximum current value that corresponds to the maximum solar power during solar panel charging [16].

I.7.4 Maximum voltage ($V_{max}=V_{mp}$)

This is the maximum voltage value that corresponds to the maximum solar power during solar panel charging [16].

I.7.5 The peak power operating point $P_{max}(V_{max},I_{max})$

The maximum electrical power that a solar cell illuminated under standard test conditions (STC) can generate is considered a fundamental quantity for evaluating its performance and calculating its output. It is determined by the relationship: [16].

$$P_{max}=V_{max}.I_{max} \quad \text{(III.1)}$$

I.7.6 Form factor(FF)

The fill factor refers to the efficiency of the solar cell.

$$FF= \frac{Pmax}{Vco.Icc} = \frac{Vmax.Imax}{Vco.Icc} \quad \text{(III.2)}$$

This parameter is between 0 and 1,it is expressed in% which qualifies the more or less rectangular shape of the I(V) characteristic of the solar cell.

If this were square the form factor would be equal to1,the power Pmax will be equal to (Isc* V_{CO})this is the case of an ideal cell: FF =1. But, generally the form factor takes values between 0.6and 0.85[16].

I.7.7 Yield(η):

The efficiency of a solar cell is usually defined as the ratio between the maximum energy it produces and the incident solar radiation power (Pincident) reaching the cell. [16]

$$n= \frac{Pmax}{P_{incidente}} = \frac{Vco.Icc}{P_{incidente}} \times FF \frac{Vmax.Imax}{P_{incidente}} = \frac{Vmax.Imax}{G.S} \quad \text{(III.3)}$$

$$P_{incidente}=G.S \quad \text{(III.4)}$$

G: illuminance (W/m2);

S: Surface area (m^2).

I.8 Characteristics and factors affecting the energy of a photovoltaic panel

Several factors affect the efficiency of solar cells in terms of energy production, voltage, current, and lifespan. These factors include: [16].

I.8.1 Effect of temperature

The outside temperature has a negative impact on the out put voltage of the solar panel, as the voltage decreases when the temperature of the solar panel rises. At the same time, the current value may slightly increase, which is an effect that can be disregarded [16]. This is what the figureI.9, figureI.10 shows

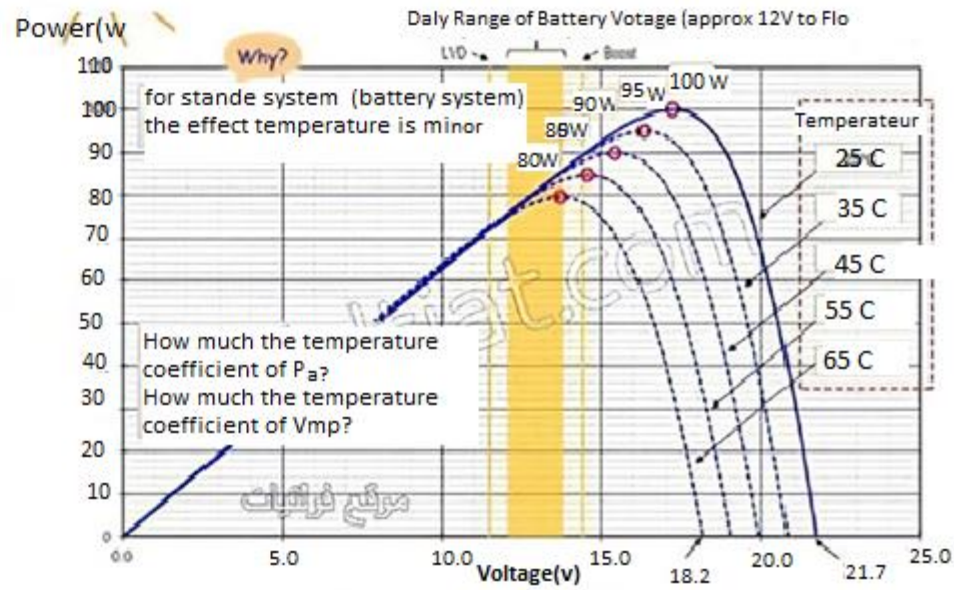


Figure.I.9 The relationship between the performance of solar panels and temperature [15].

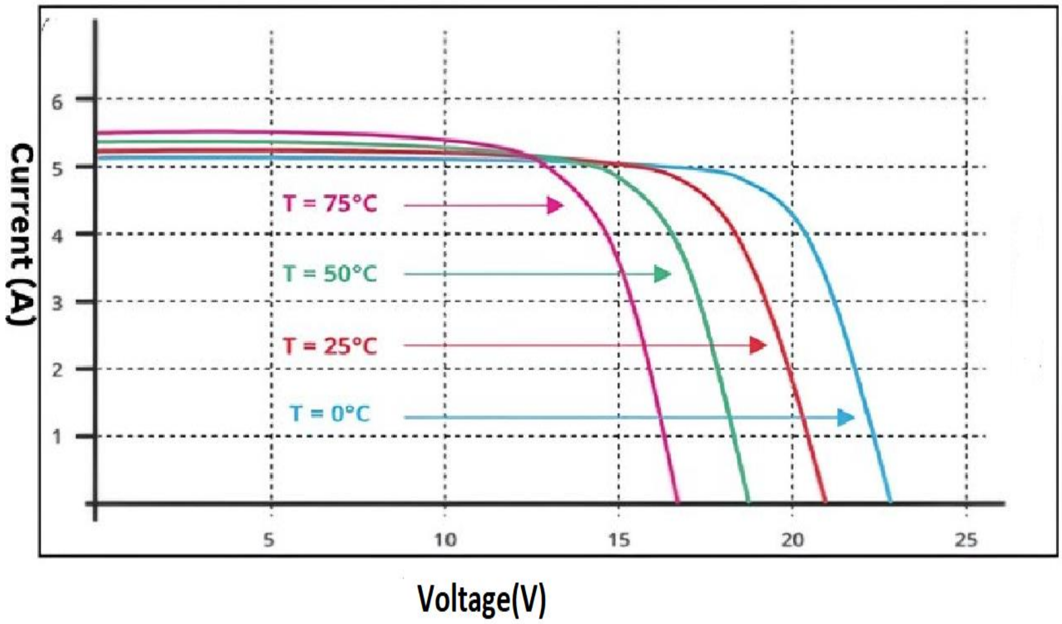


Figure.I.10: The relationship between current, voltage, and temperature of photoelectric energy [15].

The data above indicates that the output voltage gradually decreases with increasing temperature, resulting in a reduction in the power output of the solar panel. This means that the performance of the solar panel is negatively affected by temperature rise compared to the performance measured under standard STC conditions. Therefore, an increase in temperature above 25 degrees Celsius leads to:

- ❖ Decrease in voltage.
- ❖ Slight increase in current.
- ❖ Decrease in generated power.
- ❖ Over the long term, this may lead to panel degradation.

Therefore, it is important to carefully choose the installation location of the panels to avoid exposure to excessive heat, especially when installing them on residential buildings [16].

I.8.2 Effect of illumination

If the cell temperature remains constant and the air speed is constant, the amount of electrical energy generated by the cell depends on the amount of light it receives on its surface. According to figure (I.11), the current varies directly with the intensity of illumination, while the voltage varies very slightly based on the amount of received light [16].

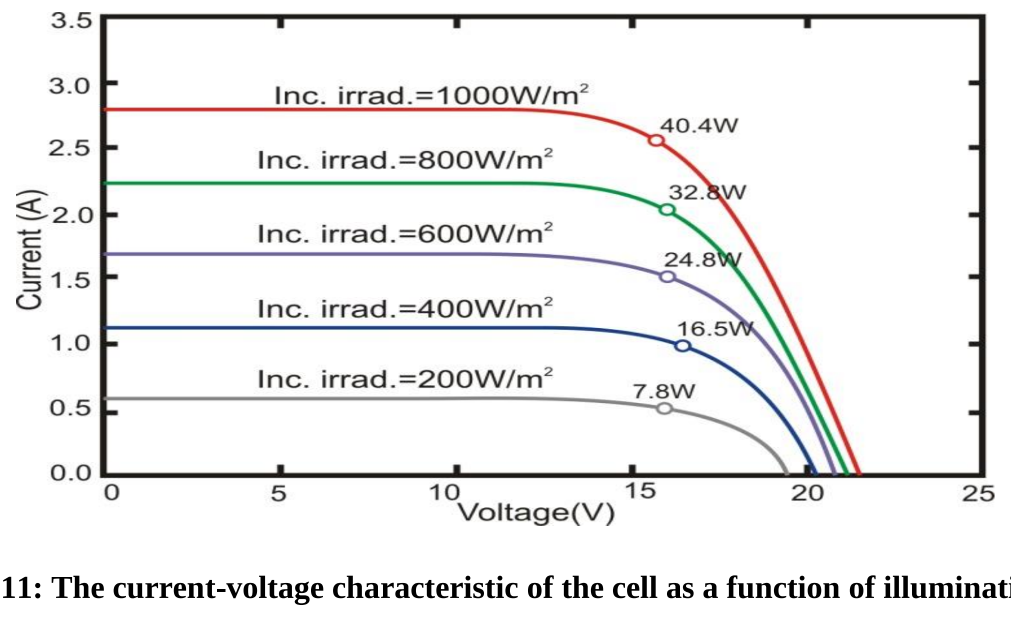


Figure.I.11: The current-voltage characteristic of the cell as a function of illumination [15].

When installing solar power systems for homes, it is important to avoid significant shading from trees, and the location should be accessible for cleaning operations to enhance the efficiency of solar energy reception on the solar panels.

The efficiency of the generated electrical energy is greatly affected by the intensity of the incident light and the temperature. Direct current can be easily converted to alternating current using an inverter, and in some cases, energy is stored in small batteries, which are essential components of solar power systems [16].

I.9 The main components of the photovoltaic system

Components of solar power systems vary based on the application and load requirements. Let's take a general example [17], [18].

I.9.1 Photovoltaic solar panels

You convert sun light in to direct current[17], [18].

I.9.2 Inverter

The energy produced by solar panels is usually in the form of direct current (DC), and it is converted into alternating current (AC) by the inverter for use in operating household appliances or for feeding into the electrical grid [17], [18].

I.9.3 Electrical loads

Electrical appliances that can be powered by a solar energy system include lighting, radios, televisions, computers, refrigerators, and many other devices [17], [18].

I.9.4 Batteries

Energy storage elements convert electrical energy into chemical energy, which can then be reconverted into electricity when solar energy is not available, such as during the night [17], [18].

I.9.5 Charge regulator

The charge controller is one of the essential components in solar power systems, is clear in the figureI.12 and I.13 as it regulates the voltage and current generated by the solar panels. The charge controller plays a significant role in improving efficiency and ensuring voltage compatibility with system requirements, including battery voltage and inverter voltage. It also protects the batteries from over-discharge and overcharging.

There are two main types of charge controllers used in solar power systems, which are PWM

(Pulse Width Modulation) and MPPT (Maximum Power Point Tracking) [17] [18].

Figure.I.12 Components and connections of the photovoltaic system [15]**.**

Figure.I.13: Some types of regulators [15]**.**

I.9.5.1 PWM or MPPT regulator

"Pulse Width Modulation" (PWM) is an abbreviation for Pulse Width Modulation technology. This technique works by reducing the voltage coming from the solar panels to a level compatible with the battery voltage. The drawback of this type is that the voltage is reduced without utilizing the rest of the power, resulting in a decrease in system efficiency. Additionally, the panels can not be connected in series because the panel voltage must be close to the regulator voltage to extract the maximum amount of power. PWM regulators are considered less expensive compared to MPPT types but are only suitable for small systems [17], [18].

I.9.5.2 MPPT regulator

"Maximum PowerPoint Tracking"(MPPT)is an abbreviation for Maximum PowerPoint Tracking technology. This type is manufactured using more sophisticated techniques than PWM, making it ideal for medium and large solar power systems. MPPT utilizes all the power produced by the solar panels without any significant losses in various weather conditions. Panels can be connected in series with MPPT, but they must fall within the specified voltage range of the regulator. However, the downside of MPPT is its higher cost compared to PWM regulators [17], [18]. is clear in the figureI.14

Figure.I.14: MPPT charge controller [15].

I.9.5.3 Mechanism of action of the charge regulator

The charge controller regulates the current and voltage flowing from the solar panels based on the charging current, battery voltage connected to the solar system, and the input of the inverter. The device follows a gradual approach in the battery charging process to ensure full charging while maintaining an optimal charging level at all times. The battery charging process consists of several stages:

Fast charging stage: This stage starts at the be ginning of the battery charging process, where a high charging current is applied.

Absorption stage: The current value used to charge the battery gradually decreases to reach an optimal level.3. Float and balance stage: Aimed at fully filling the battery and maintaining the optimal charging level, allowing the battery to remain charged when not in use for extended periods[17], [18].

I.9.5.4 Functions of the charge regulator

The charge controller is not limited to just charging batteries but also performs additional functions such as:- Protecting the solar panel or solar cells from electrical current in case of a short circuit.- Regulating and filtering the voltage of the solar panels connected to the battery and loads.- Adjusting voltage ranges to protect batteries and loads.- Preventing current flow from the battery to the solar panels at night.- Protection from full discharge of the batteries. Providing a display to show the battery charging status and other information [17], [18].

I.10 Various photovoltaic systems installed in modern homes

Solar power systems have proven to be effective in providing energy for homes regard less of their location.

- Economically, urban homes are typically connected to the public electricity grid, allowing energy users to adjust the amount of energy they consume and produce from solar power. There fore, users only need to maintain a balance between the produced and consumed energy.- For homes located far from the electricity grid, solar energy is considered an effective solution. It can meet the user's needs using energy storage systems and inverters. To reduce interruptions in solar energy availability, it can be integrated with other energy sources such as public electricity, diesel generators, or wind power in what is known as hybrid power systems [19].

I.11 The advantages and disadvantages of the photovoltaic energy

I.11.1 The advantages

- Solar energy is considered a renewable and environmentally friendly energy source.

- Solar energy is particularly inspiring for urban sites and homes due to its small size and quiet operation.

- Solar energy can be used in various environments, whether in the mountains, isolated villages, or in the midst of large cities.

-Solar energy can be utilized in a wide range of applications such as lighting systems and irrigation as a power source in remote areas.

- Solar power systems do not cause pollution.- Solar power systems are characterized by the absence of moving parts and ease of maintenance.

-Due to the availability of sunlight everywhere, solar energy is widely accessible.

-The assumed lifespan of solar panels exceeds 20 years.

-Electricity production from solar energy is clean and non-polluting.

- Solar power systems are highly reliable- Materials used in solar energy like glass and aluminum have high resistance to harsh weather conditions.

- Solar electricity is produced directly at the user's site in a decentralized manner [20].

I.11.2 The disadvantages

Despite the many benefits that solar energy provides, it does have some draw backs:

- The cost of installing solar power systems is among its major draw backs, as the cost per unit is high compared to fossil fuel costs.
- Electricity generation from solar energy is only possible during sunny hours, requiring energy

storage systems to ensure continuous power supply during hours of darkness.

- The efficiency of solar power systems is negatively affected by weather conditions such as dust, high temperatures, fog, and clouds.
- Maintaining the efficiency of solar panels requires regular cleaning, which entails ongoing maintenance and care [20].

I.12 URERMS

Practical training is an important part of academic education and training, as it provides students with the opportunity to apply theoretical knowledge in a real work environment. In this context, we were given the opportunity to intern at the Renewable Energies Research

Unit in the Desert Environment of Adrar (URERMS).This internship played a significant role in developing our practical skills and deep understanding of the renewable energy sector [21],[22]. is clear in the figureI.15.

Figure.I.15: Research Unit in Renewable Energies in the Desert Adrar UERMS [21][22].

I.12.1 Description of URERMS

The Renewable Energy Research Unit in the Saharan Environment in Adrar (URERMS) is a scientific institution specializing in the development and testing of renewable energy technologies suitable for desert environments. The unit operates with in the Renewable Energy Development Center (CDER) and is under the auspices of the Ministry of Higher Education and Scientific Research. Established on March 22, 1988, the unit focuses on various research areas such as solar energy, wind energy, and geothermal energy, aiming to find sustainable solutions to energy challenges in desert regions [21], [22].

I.12.2 Specific projects

We worked on an innovative project related to our university graduation thesis. This project involved the study, design, and management of a smart home, as well as the development of home control technology. The research unit provided us with all the necessary equipment to conduct this project, which greatly helped us achieve our research objectives [21], [22].

I.12.3 Challenges and learned lessons

We faced many challenges during the intern ship, the most prominent being the distance of the unit's location from our residence, the harsh climatic conditions, the limited time, and the scarcity of equipment, from one hand. On the other hand, we learned from this experience how to use, connect, and program electronic equipment and develop applications. In addition, we mastered the sizing of solar energy systems [21], [22].

I.13 Conclusion

In these chapters, the emphasis was placed on the importance of home automation and the integration of solar energy into modern smart homes. By analyzing the benefits of each and highlighting the significance of using technology and renewable energy to improve the quality of life and protect the environment, we shed light on these crucial topics. The Renewable Energy Research Unit in the Saharan Medium (URERMS) in Adrar was also presented due to its importance, encouraging more people to become familiar with it.

By utilizing the information provided in this chapter, individuals are encouraged to start implementing automation ideas and using solar energy in their homes to achieve comfort, security, and effective energy savings.

In conclusion, everyone should recognize the importance of adopting technology and solar energy in their daily lives and strive to apply them sustainably to preserve the environment and enhance their quality of life.

The next chapter is devoted for the electric devices and software used to achieve these goals.

Chapter II: The basics of Arduino and Android application

II.1 Introduction

Arduino is an electronic platform used to build interactive devices and electronic projects. Arduino boards use programmable microcontrollers to analyze and control electrical signals to perform various tasks. They can be used to build standalone interactive devices or be connected to computers to interact with software.

In this chapter, we will provide an overview of MIT App Inventor and how to use it to build smart home applications. We will also cover how to interact with Arduino and ESP32 boards and implement various sensors to create smart home functions such as lighting control, security systems, and comfort features [13].

II.2 The Arduino card

Arduino is an open-source platform used to build a variety of electronic projects , ranging from simple projects like a temperature sensor to more complex projects like robots and 3D printers. The main goal of creating the Arduino platform is to provide an easy-to-use environment for students and hobbyists to quickly and easily complete their projects The Arduino platform

consists of two main parts: the hardware part and the programming part. The hardware part is the Arduino board itself, where electronic components are integrated into the motherboard to create a standard board. Some times it is necessary to connect additional hardware components called "Shields". Shields do not require wires, as they connect directly to the Arduino board without needing to connect pins correctly. On the other hand, modules are smaller in size, lower in cost, and offer greater flexibility when connected to the Arduino board, as they do not require connecting specific pins as with Shields

The programming part consists of the Arduino development environment(Arduino IDE),which serves as an environment for writing program code in the Arduino language and uploading it to Arduino boards to control devices. In addition, Arduino IDE uses a simplified version of both C and C++ languages, making it easier to learn programming[23]. [24].

II.3 History of Arduino

The Arduino story began in 2005 in Ivrea, Italy, where Massimo Banzi, in collaboration with David Cuartielles and Gianluca Martino, launched the Ivrea Arduino project. The project's name was chosen based on a well-known historical figure in the city. The goal of the project was to create a 100% open-source development environment for microcontrollers [13]. The project was designed to ensure a software development environment for microcontrollers, named the

"Integrated Development Environment (IDE)", which was available for free at the same time. The development boards were also designed to be small in size and low in cost to enable students and technology enthusiasts to easily obtain them [13]. By 2013, over 700,000 Arduino boards had been shipped, reflecting the success and widespread adoption of the project among technology enthusiasts [13], [23] .

There are more than 40 types of Arduino boards available, and these types vary in capacity, shape, power consumption, size, and price, allowing for meeting diverse needs and diversity in designs and ideas Table II.1 shows some of the differences between the known types of Arduino. The main advantage of Arduino boards is that they are all open-source, meaning they are available for free to the public with the ability to modify the software [24]. [25]. Among the most famous and widely used types are:

II.4.1 Arduino UNO

The optimal choice for beginners to explore the world of Arduino is the Arduino Uno board. It is simple, reasonably priced, easy to use, and compatible with most available add-ons and shields [24] [25]. is clear in the figureII.1

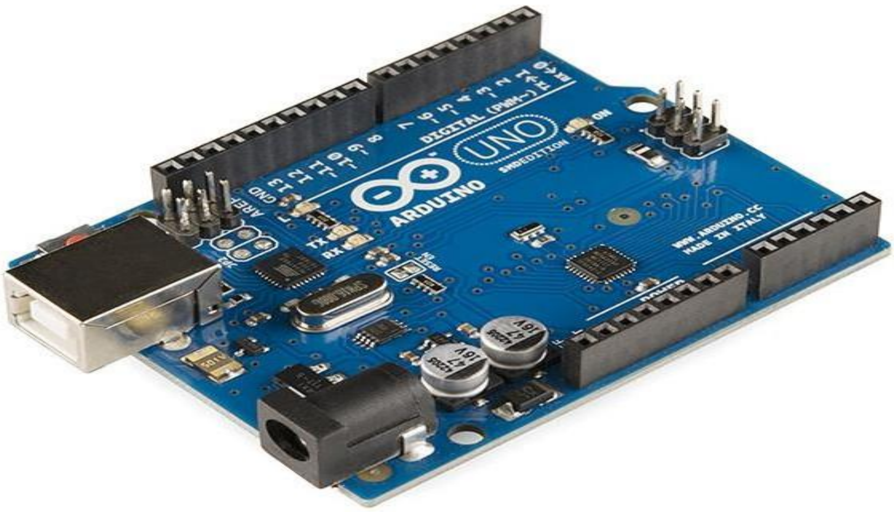


Figure.II.1The Arduino UNO board [15].

II.4.2 Arduino Mega2560

Is one of the famous Arduino boards, designed for projects requiring multiple I/O pins or more memory. It features the AT mega 2560 processor, 256 KB of flash memory, 8KB of SRAM, and 4KB of EEPROM. It has 54 digital I/O pins (15 of which can be used as PWM outputs), 16 additional inputs, and clock speed up to 16 MHz.[26]. is clear in the figureII.2

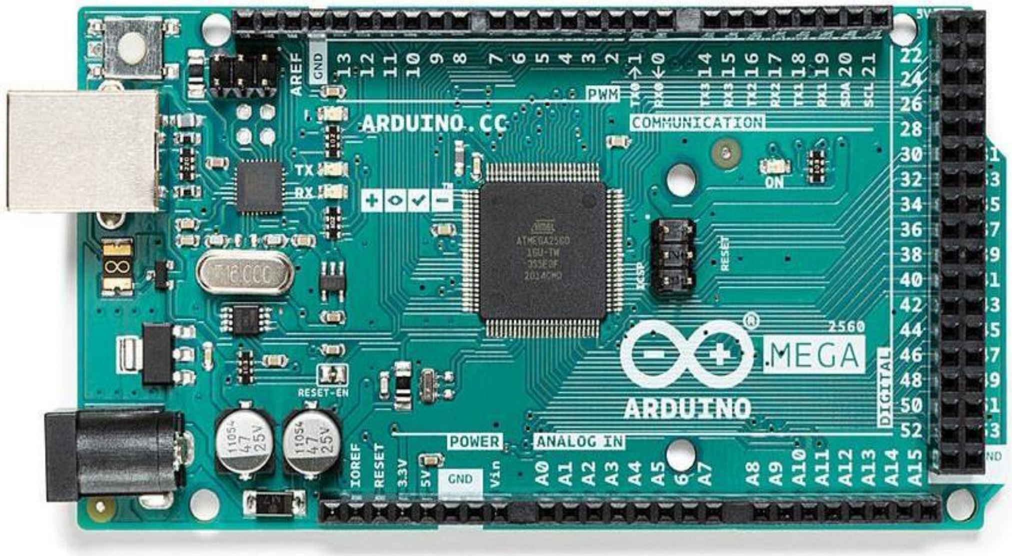


Figure.II.2 The Arduino Mega 2560 board [26].

II.4.3 Arduino Nano

It includes the same micro controller used in the Arduino Uno board, which means they have the same capabilities, but it is characterized by its small size [24] [25]. is clear in the figureII.3

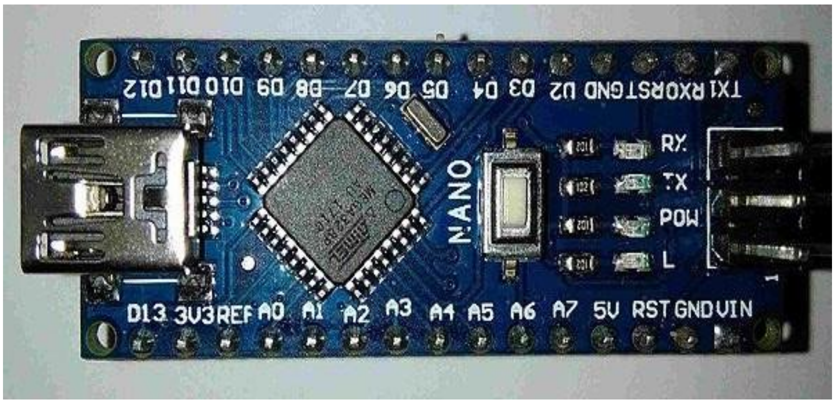


Figure.II.3: The Arduino NANO board [26].

TableII.1: Comparison between types of Arduinos and their Feature's (Uno, Mega, Nano) [24].

Feature	Arduino Uno	Arduino Mega	Arduino Nano
Microcontroller	ATmega328P	ATmega2560	ATmega328P
Flash Memory	32KB(0.5KBused By Bootloader)	256KB(8KBused by Bootloader)	32KB(2KBused by Bootloader)
SRAM	2 KB	8 KB	2 KB
EEPROM	1 KB	4 KB	1 KB
Clock Speed	16 MHz	16 MHz	16 MHz
Digital I/O Pins	14(6PWM)	54(15 PWM)	14(6PWM)
Analog Input Pins	6	16	8
DC Current per I/O Pin	20 mA	20 mA	20 mA
3.3VPin Current	50 mA	50 mA	50 mA
Operating Voltage	5V	5V	5V
Input Voltage (recommended)	7-12V	7-12V	7-12V
Board Dimensions	68.6 mm x53.4mm	101.52 mm x53.3mm	45 mm x18mm
Weight	About 25 g	About 37 g	About 7 g

II.5 ESP32 Card

is a System on Chip (SoC) developed by Espressif Systems, designed to be a powerful and flexible processing unit for Internet of Things (IoT) applications and embedded systems as illustrated in image II.4. It features adual-core Tensilica LX6 processor with speeds of up to 240 mega hertz, and supports connectivity via Wi-Fi 802.11b/g/n and Bluetooth 4.2(LEandClassic). It has integrated flash memory and up to 520 kilo bytes of SRAM, in addition to a wide range of input/output interfaces (I/O) such as ADCs, DACs, I2C, SPI, I2S, UART, PWM, and GPIOs. With these advanced features, Table II.2 highlights some differences between Arduino and ESP32. the ESP32 is widely used in home automation projects, smart devices, robots, and various electronic projects, making it a preferred choice for developers and innovators in the technology field[27].

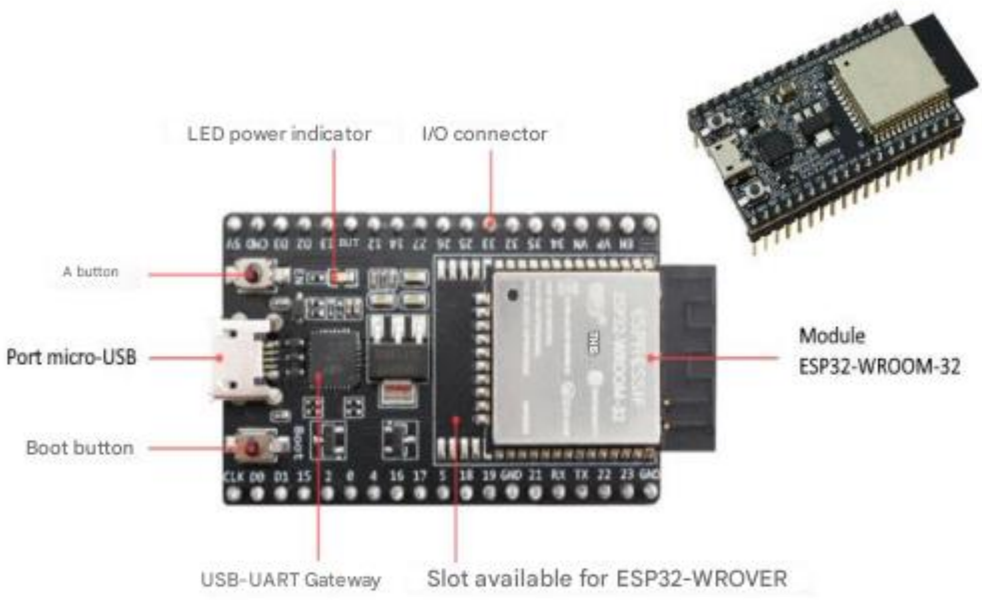


Figure.II.4: The ESP32 board [27].

TableII.2: Comparison between Arduino and ESP32[24].

Feature	**Arduino UNO**	**ESP32**
Processor	ATmega328P(8-bitAVR)	Dual-coreTensilicaLX6 (32-bit)
Frequency	16 MHz	Up to 240 MHz
Flash Memory	32 KB	Up to 16 MB
SRAM	2 KB	520 KB
EEPROM	1 KB	Not available (can be simulated on flash)
Wi-Fi	Not available	802.11 b/g/n
Bluetooth	Not available	Bluetooth4.2(LE and Classic)
GPIO	14digitalpins	Over30pins
ADC	6channels10-bit	Upto18channels 12-bit
DAC	Not available	2channels8-bit
PWM	6 pins	Available on most pins
I2C	Available	Available
SPI	Available	Available
UART	Available	Available
Touch Interface	Not available	Available
Power	5V / 3.3V	3.3V
Price	Low to medium	Medium to high

II.6 Constitution of the Arduino Board

The Arduino Uno board is one of the most popular boards in the Arduino family, and it is distinguished by the following components: [24] [15]. is clear in the figureII.5

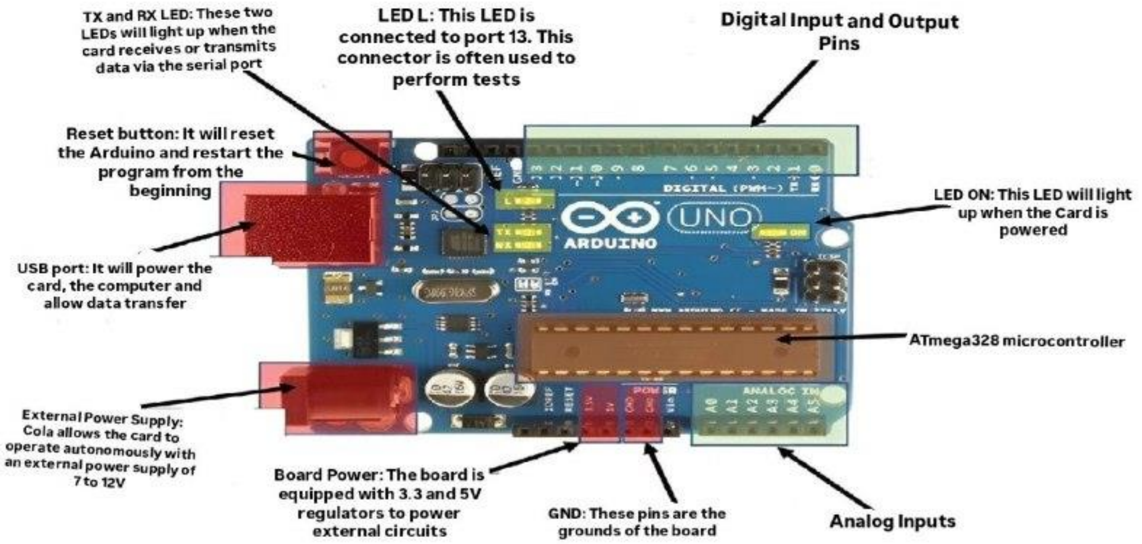


Figure.II.5 Constitution of the Arduino card [15].

II.6.1 Reset button

This is the button or switch responsible for resetting (rebooting)the program installed on the Arduino board [15] [28] [24] [26].

II.6.2 The USB connection

It is used to connect the Arduino board to the computer and upload the program, and it also serves as a power source for the Arduino board.[25][26].

II.6.3 The TX and RX LEDs

Indicator LED lights are used during the process of receiving or sending data to and from Arduino [15] [28] [26].

II.6.4 Voltage regulator

The voltage regulator is responsible for providing and adjusting the operating voltage for the Arduino [28] [24] [26].

II.6.5 Direct current (DC) power connection

It is the port responsible for connecting the Arduino board to an external DC power source [28] [24] [26].

II.6.6 AREF

It is used in the reference analog mode and is used to adjust the exeternal reference voltage [28], [24] [26].

II.6.7 Ground pins(GND)

The negative voltage terminal of the Arduino board is known as "ground". The Arduino board has 3 ground terminals [28], [24] [26].

.II.6.8 Digital input/ Output

These ports are digital ports used to input or output digital signals to and from the Arduino board [28], [24] [26].

II.6.9 PWM pins

They use Pulse Width Modulation(PWM)technology to produce variable analog signals. These ports on the Arduino board are usually identified by the symbol (~) [28], [24] [26].

II.6.10 The power LED

It is used as an indicator to illustrate the operation of the Arduino board[28], [24] [26].

II.6.11 Microcontroller

It is the central device that controls all operations, and it is known as the ATmega 328 processor in the Arduino Uno board [28], [24] [26].

II.6.12 Analog inputs

These are the inputs used for reading analog signals on the Arduino board [28], [24] [26].

II.6.13 Port(PIN) 3.3V

It feeds the sensors with a voltage of 3.3 volts...etc[28], [24] [26].

II.6.14 Port(PIN)5V

This terminal provides a constant voltage source of 5 volts for use when needed in project design [28], [24] [26].

There fore, the importance of the Arduino board is manifested through its design.

II.7 Arduino IDE

The Arduino IDE is a software specifically designed for programming the Arduino board, and it is available for free download from the official Arduino website without any charges. It includes an Arduino development environment with a text editor for coding, a message area, and a control toolbar, as well as a series of menus that allow you to upload the program to the

Arduino board and communicate between the program and the device. When we open the Arduino IDE, we find 6 sections: [26] [15]. is clear in the figure II.6

- Tool bar
- Menus
- Section of code Editeur
- State bar
- Section of program notification
- Section of card and serial port selection

II.7.1 First section: toolbar

The toolbar is considered one of the most important sections of the Arduino IDE software, as it contains tools that are frequently used during programming the Arduino board, including: [15][29][26] .

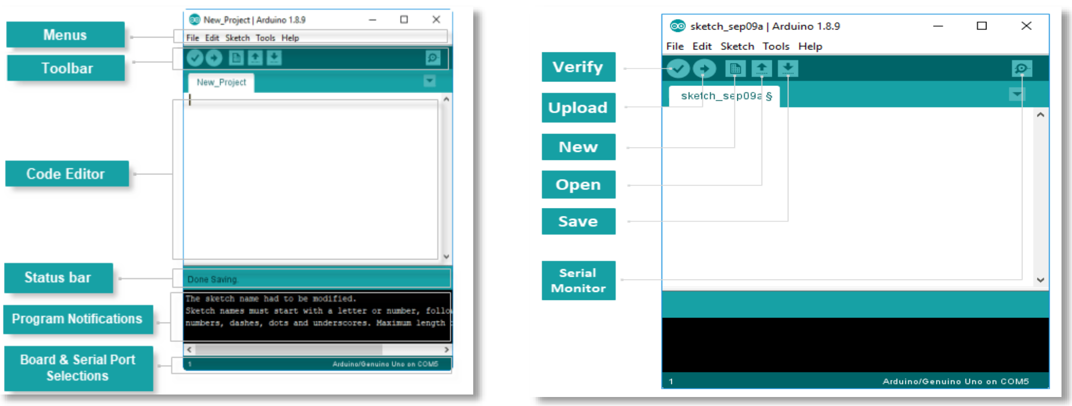
- Verify: This button is used to check the code and ensure that there are no errors.
- Upload: Used to upload the code to the Arduino board.
- New: Used to create a new projector a new code file.
- Open: Used to open a "Sketch" file from the Sketch folder.
- Save: Used to save the current sketch in the Sketch book folder.
- Serial Monitor: Used to display data sent from Arduino.

II.7.2 Second section: Menus

These are them a in menus in the software, including 5menus(File, Edit, Sketch, Tools, Help). They are used to add or edit programming instructions [26] [15].

II.7.3 Third section: Code editor

The code editor is the white area in the software where codes are written and edited[26][15].



A(Board & Serial Port Selections Section) **B(Toolbar)**

Figure.II.6: Getting to know the Arduino IDE interface[15].

II.7.4 Fourth section: status bar

The status bar is the area located below the code editor. It is used to provide clarification a bout the progress status of various operations such as compilation, uploading, etc[15] [29] .

II.7.5 Fifth section: Program notifications

The program provides informative messages about code errors and potential issues during the programming process. It displays the type of error or problem and provides guidance on how to resolve it, helping you effectively deal with it[15] [29] .

II.7.6 Sixth section: card and serial port selections

The sixth and final section is known as "Board and Serial Port Selection," where the program displays the type of port used to connect Arduino to the computer and the type of Arduino board being used. Once the Arduino software and drivers are installed, the board becomes ready for use with the Arduino IDE. The Arduino IDE provides a wide range of tutorial examples for running and learning programming [15] [29] .

II.8 Arduino syntax

The Arduino language closely resembles C/C++ languages, where all standard C or C++ structures and expression supported by the Arduino compiler can be used. In your Arduino code, the main functions usually consist of two basic functions: the setup)(function and the loop)(function that interprets and connects to the setup function [26], [15].

Let's take a look at the code shown in FigureII.7 which represents the basic Arduino language syntax:

```
int LED_PIN =13;

void setup () {
  pinMode (13, OUTPUT); // إعداد
المخرج 13 ليكون مخرجا فقط.
}

void loop () {
 digitalWrite(LED_PIN,HIGH);
//تشغيل المصباح//
delay(1000); // (ألف // إنتظار ثانية
ملي ثانية)
digitalWrite(LED_PIN,LOW); //
إطفاء الليد
delay(1000); //إنتظار ثانية//
}

}
```

Figure.II.7 LED blink example[15].

II.8.1 The initial structure of the code

Each Arduino code must contain the declaration area and the following two functions:[15],[30].

II8.1.1 Declaration area

It is used to declare variable types, define modes, define leg positions, initialize libraries to be used in the code, etc [26], [15].

II.8.1.2 The setup() function

The function setup() is called first when executing the program instructions (known as the "sketch" in Arduino). It is used to initialize variables, define pin positions, set up interfaces, start using libraries, and more. It is important to note that the setup()function is executed only once after powering on the Arduino board or resetting it.

Once the setup task is completed and exited, the loop() function is called and executed repeatedly in the main program [26], [15].

II.8.1.3 The loop() function

After creating the setup() function, which initializes the values to be used, the loop() function repeats the code inside it sequentially, as its name suggests. This allows your program to control the Arduino board, interact with the environment, and the elements connected to it [26] [15]. The following FigureII.8 shows an example of how to configure and start the serial interface and set pin 13 to be in input mode:

```
int x; // تحديد متغير

void setup () {
Serial.begin(9600); //تشغيل
السيريال بسرعة 9600بت
pinMode(3,OUTPUT); // ضبط مخرج
المصباح
}
void loop () {
if (Serial.available())
{
x=Serial.read(); //المتغير هو قراءة
السيريال
if (x=='1')
{
digitalWrite(3,HIGH);
}
else
{
digitalWrite(3,LOW); //إطفاء الليد
عندما لا تكون القراءة 1
}
}
}
```

Figure.II.8 Example of turning an LED on and off via bluetooth[15].

9.General information about sensors

Sensors work by converting physical quantities into electrical signals that are compatible with processing systems using voltage or current. These sensors are essential elements in data acquisition systems, producing an electrical signal that represents the monitored physical quantity After converting analog signals to digital, the measurements are sent to the central processing unit for further processing. An analog-to-digital converter is used to convert analog information into digital, representing the recorded data in a digital form that can be easily processed The use of this digital information allows the central processing unit to understand the state of the physical system and make necessary decisions based on enhanced data. This can be done automatically through a pre-programmed system or manually by a human operator [30].

In general, sensors work in collaboration with the processing unit and the communication unit to effectively transfer and process data [30].

II. 9.1Processingunit

The processing unit includes a processor that operates on a specific operating system dedicated to micro sensor devices. This unit executes communication protocols that enable establishing the relationship between input and output nodes. Additionally, the processing unit can analyze captured data .In our work, the processing unit is the Arduino board [32].

II.9.2 Transmission unit

The function of the transmitter unit is to send and receive data through various communication channels. These channels may include optical communication, Wi-Fi, infrared, Bluetooth, radio frequencies, or third generation GSM networks[33].

II. 10 Classification of sensors

Sensors can be classified according to several categories (power input, type of out put[31].

II.10.1 Energy in take

Based on the power input, sensors can be classified in to active and passive devices[31].

II. 10.1.1 Active sensors

Active sensors can be represented using generators, where they generate either an electric current or voltage based on the intensity of the physical phenomenon being monitored. For example, generators can be used to represent a mechanical timing clock, a strain gauge (also known as a pressure gauge), a gyro meter, and other sensors that rely on converting physical phenomena into electrical signals [34].

II. 10.1.2 Passive sensors

These are sensors that can be modeled using impedance and require external power supplies to operate. The difference in impedance arises due to the variation in the physical phenomenon being monitored, for example: thermistors, voltage meters, temperature sensors, etc In general, the difference in impedance is caused by the variation in the dimensions of the sensor, such as moving contacts, variable capacitors, voltage meters, position sensors, and so on [34].

II.11 Type of output

Sensors can also be classified based on the type of output as follows:

II. 11.1 Digital sensors

Digital sensors can output signals in sever always, such as:

1. Pulse signal, where it emits a specific number of pulses or at a precise frequency
2. Bus signal, where data is transferred over a shared channel(bus) between different devices.
3. Digital code, where it generates a digital signal that represents the measured reading or value directly in a digital form [35].

II. 11.2 Analog sensors

The signal output from analog sensors can be of this type: Analog Signal.

1. Voltage output, where the devices generate an analog signal that changes proportionally with the monitored physical phenomenon.

2. Current output, where the devices generate an analog signal with a variable current level based on the measured phenomenon.

3. Graduated scale, where the devices generate an analog signal that changes gradually and proportionally with the changes in the environment or the monitored phenomenon [35].

II. 12 Sensors

Many sensors are readily available for easy integration with an Arduino board. With simple code, Arduino can control and interact with a variety of sensors that measure different phenomena such as: [35], [15].

-Light, temperature, flex, pressure, proximity, acceleration, carbon monoxide, radiation, humidity, barometric pressure, heart rate, fire detection, motion…

The diagram below illustrates examples of sensors that can be easily used with an Arduino board [15].

In our project, we focus on a specific set of sensors used in smart homes, which will be detailed extensively in the final chapter[15]. FigureII.9 shows a group of the most commonly used sensors

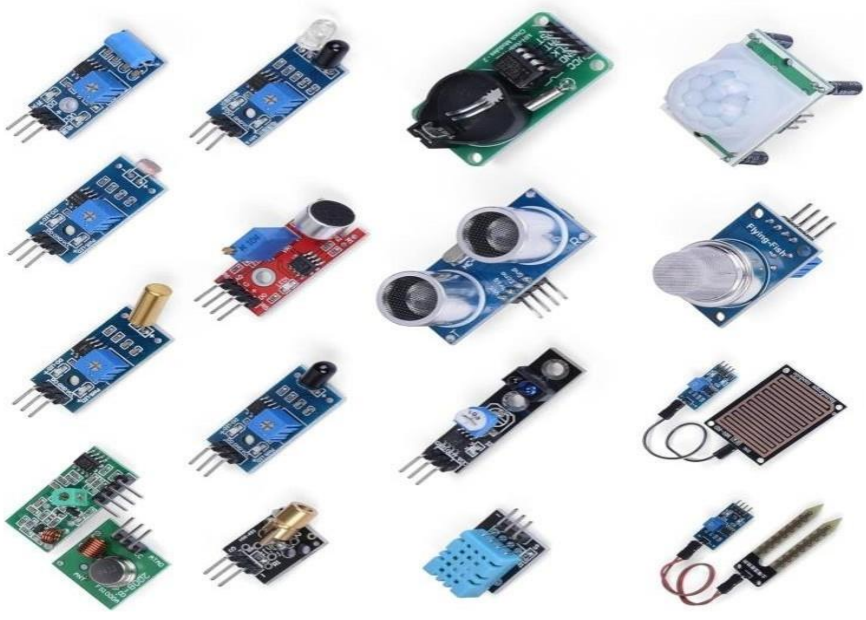


Figure.II.9 Some sensors compatible with the Arduino board[15].

II.13 Android Application

MIT app inventor is a software development environment developed at the Massachusetts Institute of Technology (MIT) that enables users to easily create interactive Android applications without the need for advanced programming skills. The MIT App Inventor interface allows users to develop a variety of applications easily, including smart home applications, using simplified, and easy-to-understand visual elements. The importance of MIT App Inventor in the development of smart home applications lies in its ease of use and compatibility with applications for controlling smart devices, such as lighting systems, heating and cooling systems, security devices, and more. MIT App Inventor helps simplify the application development process, allowing users to efficiently and easily turn their homes into smart homes [36], [37].

In MIT App Inventor, applications consist of a set of core components that help build and design the application's functionality. These are shown in Figure II.10. Some of the basic components are explained below: [36], [37].

II.13.1 Screens

- Screens are used to display the main content of the application, and an app can have multiple screens

- Users can design screens using different elements like text, images, and buttons[36], [37].

II.13.2 Buttons

- Buttons are used to trigger actions, switch screens, or execute specific functions in the app.
- Buttons can be customized by changing text, color, size, and assigning specific actions when clicked: [36], [37].

II.13.3 Menus

- Menus display multiple options for the user, enabling them to choose the action they want to perform.

- User scan customize menus, add items, and modify available options: [36], [37].

II.13.4 Text boxes

- Text Boxes are used to input textual data such as names, numbers, or messages.

- Properties of text boxes like size, color, and back ground can be customized[36], [37].

II.13.5 Images

- Images are used to display pictures or icons in the application.

- Users can add various images and customize their size and position on the screen: [36], [37].

II.13.6 Control menus

- Control Menus provide interactive interfaces for users to control specific elements in the app.
- Users can add custom control menus and assign the actions they perform.

These basic components are used cohesively to build and design app functionalities in MIT App Inventor in an easy and straightforward manner: [36], [37].As the next figure shows

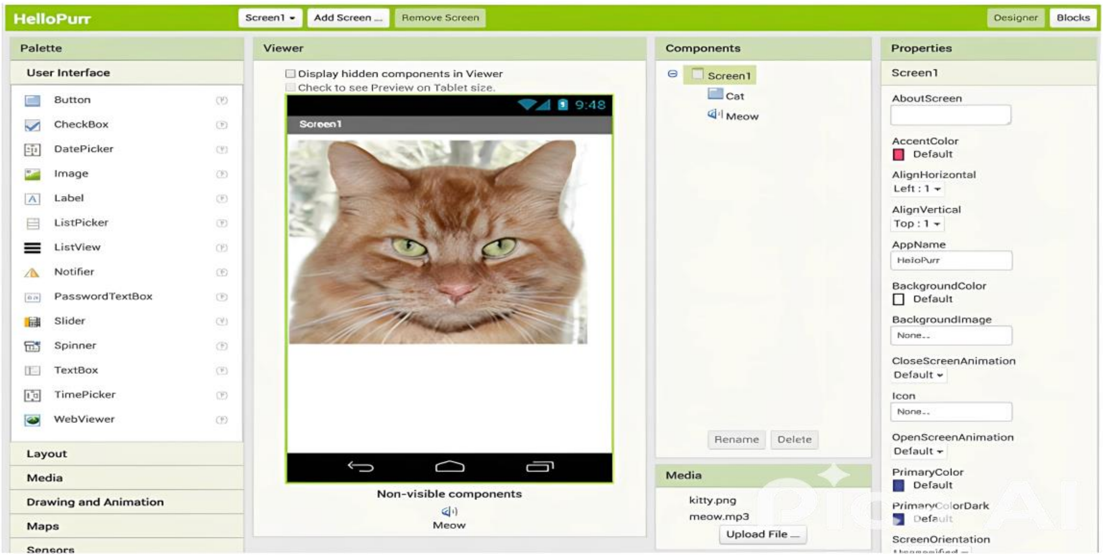


Figure.II.10: Main screen of MIT app inventor [36].

In addition to the basic components previously explained, there are advanced components in MIT App Inventor that allow users to integrate applications with sensors and communicate with external devices. Below is an overview of some of these advanced components in FigureII.11: [36], [37].

II.14 Sensor components

-These components allow the application to interact with a variety of sensors such as motion sensors, temperature sensors, light sensors, and more users can use these components to gather data from the surrounding environment and execute specific actions based on the measured values : [36], [37].

II.15 External device components

- These components enable the application to communicate with external devices like Arduino, Raspberry Pi, and others.
- Users can use these components to control external devices connected to the application. And perform specific tasks, such as turning lights on and off or controlling temperature [36], [37].

II.16 Internet communication components

-These components enable the application to communicate with internet services such as web services, databases, and cloud services. These components can be used to fetch data from the internet or to publish data to cloud services and more : [36], [37].

II.17 Connectivity components

- These components allow the application to connect and interact with other applications over the local network or the internet.

- These components can be used to build multi-user interactive applications or to remotely control devices . [36], [37].

By using these advanced components, users can expand the capabilities of the applications they develop in MIT App Inventor and make them more interactive and intelligent . [36], [37].

II.18 Linking MIT app inventor to your smart home

MIT App Inventor can be used to easily connect applications to smart home devices such as smart lights and air conditioning units using advanced components like External Device Components and Internet Communication Components. To do this, we follow the following steps: [36], [37].is clear in the figure II.11.

II.18.1 Connect smart devices to the wireless network

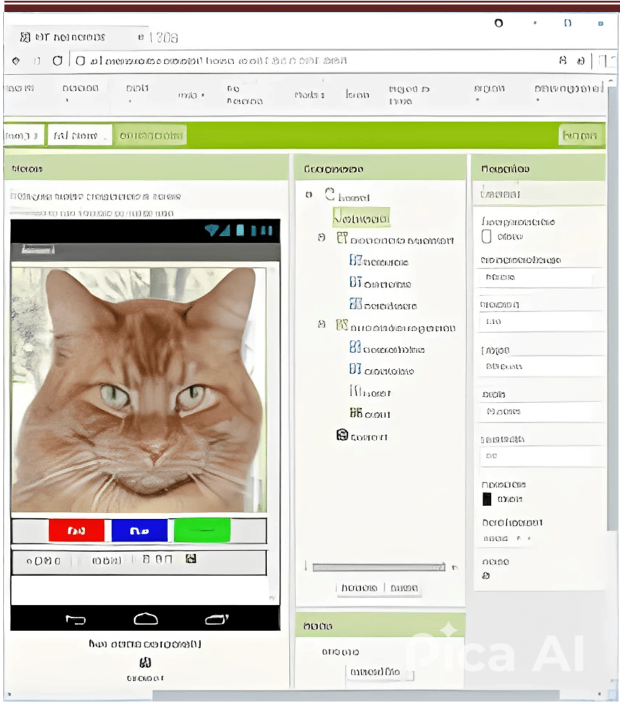
Ensure that smart devices like smart lights and air conditioning units are connected to the home's wireless network . [36], [37].

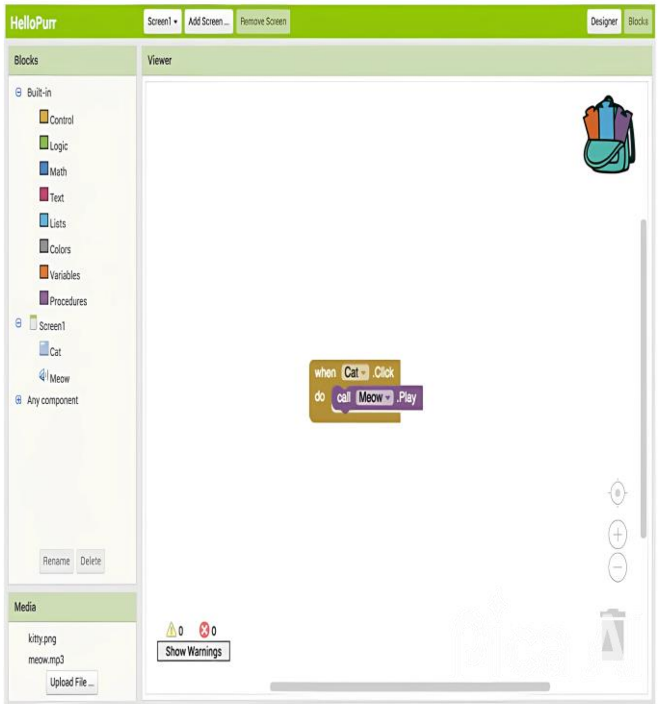
II.18.2 Use External Device Components

Add External Device Components in MIT App Inventor. You can use components such as BluetoothLE, Arduino, and Firebase to communicate with smart devices. [36], [37].

II.18.3 Develop the smart application

Design and develop the smart application using MIT App Inventor, adding visual elements and functions you want to include in the application : [36], [37]





A(Creating the Application Interface **B(Programming the Application**

Figure.II.11: An example of creating an application using the MIT app inventor platform [36].

II.18.4 Program device control functions

Use External Device Components to program device control functions, such as turning on and off smart lights, adjusting the temperature of the air conditioning unit : [36], [37].

II.18.5 Test of the application and devices

Run the application and test the connection to smart devices. Ensure that all functions work correctly and that the application interacts smoothly with the devices : [36], [37].

II.18.6 Deploy and install the application

After testing the application, publish it on smart phones for general use. By using MIT App Inventor, users can easily create smart applications that interact with smart home devices and enable them to control them with ease and flexibility:
[36],[37].

II.19 Control of the smart home devices using MIT app inventor apps

Controlling smart home devices using applications developed with MIT App Inventor can be achieved in several ways. Here are some of the most important methods: [36], [37].

II.19.1 Use of a simple control interface

You can create a simple control interface in a MIT App Inventor application that displays buttons or sliders to control smart device functions, such as turning on/off smart lights or adjusting the temperature of the air conditioning: [36], [37].

II.19.2 Voice control

Integration of voice recognition components in applications developed with MIT App Inventor allows users to send voice commands to control smart home devices, such as turning on lights or changing the temperature of the air conditioning[36], [37].

II.19.3 Scheduling and timers

The scheduling and timer feature can beaded to MIT App Inventor applications to enable users to set specific schedules for operating smart devices in the home, such as automatically turning on lights at a certain time : [36], [37].

II.19.4 Remote control

MIT App Inventor applications can support remote control of smart home devices, allowing users to control devices over the internet from anywhere using their applications [36], [37].

II.19.5 Interaction with PCs and other devices

MIT App Inventor applications can respond to signals from other devices such as personal computers, enabling them to interact with smart home devices based on other determinants like weather conditions or environmental changes. By utilizing these methods, users can develop multifunctional smart applications using MIT App Inventor to control smart home devices with ease and flexibility: [36], [37].

II.20 Conclusion

In this chapter, we have explained the capabilities of the Arduino board and the ESP32 board in controlling systems through sensors, such as managing door and window operations or activating motors. In many applications, the Arduino is connected to sensors to inter act with the physical world, where sensor readings are converted in to analytical data based on programmed codes. Subsequently, the board makes decisions based on programmed conditions, such as turning on lights when darkness is detected.

Moreover, we delved into the concept of MIT App Inventor and its pivotal role in developing smartphone applications, especially in the field of smart home applications. We explored the basic and advanced components of MIT App Inventor, enabling users to design innovative user interfaces and seamlessly integrate sensors while connecting effortlessly with external smart devices. Additionally, we studied how to link MIT App Inventor applications with smart home devices such as smart lights and air conditioning systems, and were viewed the various control methods that can be harnessed through these applications.

The next chapter will show the home design and explain the steps of the realization and control of the smart home using software and hardware.

Chapter III: Design and realization of the smart home

III.1 Introduction

In this chapter, we will demonstrate the practical implementation of the smart home project that integrates automated control, utilizing modern technologies to enhance comfort and safety and fixe the limitations in previous smart homes. Through this smart system, we will be able to control both external and internal lighting, open and close doors, and receive alerts for gas, smoke, and fires, including automatically opening windows upon receiving an alert. Additionally, the system will manage water consumption and storage automatically, and include a smart camera that interacts with motion sensors in the front yard. Furthermore, we will program an Android application that allows us to control remotely home devices through buttons and voice commands in both Arabic and English.

III.2 Encrypted door lock system

We have programmed and implemented an advanced door lock system that uses a keypad for entering the secret code to enhance security and automate the door's opening and closing. Additionally, there is an LCD screen to display information about the system's status and interact with the user and password. This system provides an innovative and secure solution for securing premises with easy and efficient management capabilities. This is what the figure III.1, figure III.2 shows.

Figure.III.1: Implementation and testing of the door lock system

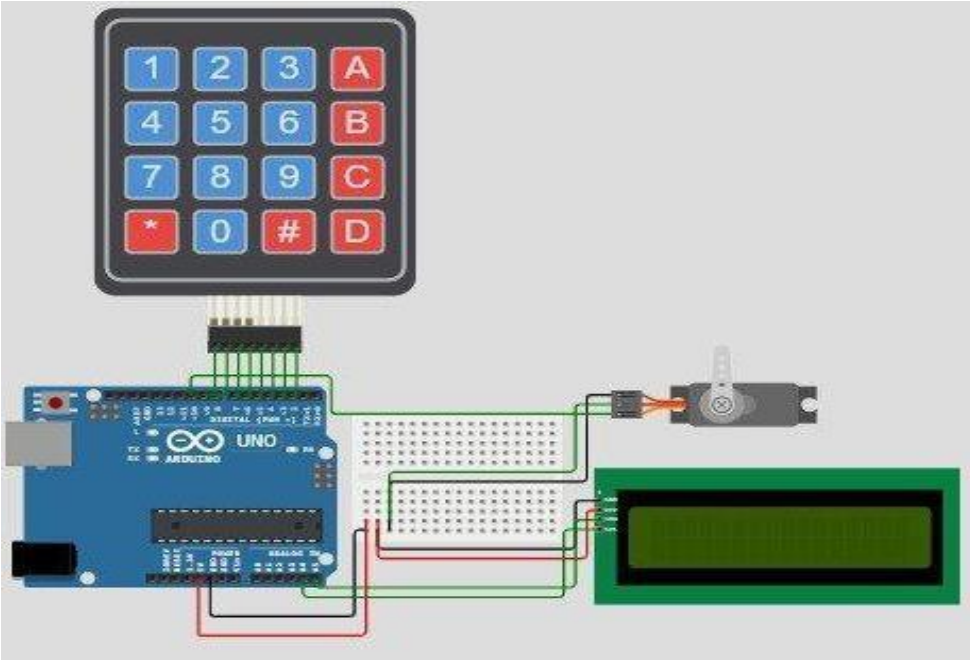


Figure.III.2: Electrical diagram for the coded door lock system

III.3 Interior lighting system

We have designed an innovative indoor lighting system that relies on motion sensors. This system automatically lights up rooms and are as when some one enters and turns off the lights when they leave, providing convenience for users and promoting energy efficiency. By using motion detection technology, energy can be saved effectively, contributing to environmental preservation by reducing energy consumption and, consequently, lowering greenhouse gas emissions. These technological innovations combine practicality and efficiency to create a smart and advanced indoor environment.

Additionally, we have integrated a feature for controlling the lighting with a touch of a smartphone screen through an application we developed from scratch, which can function even without an internet connection. This feature allows its use in remote homes, excavation sites, agriculture, and other areas.

Further more, the lighting can be controlled via voice commands, making it suitable for blind and low vision persons. This is what the figure III.3, figure III.4 shows.

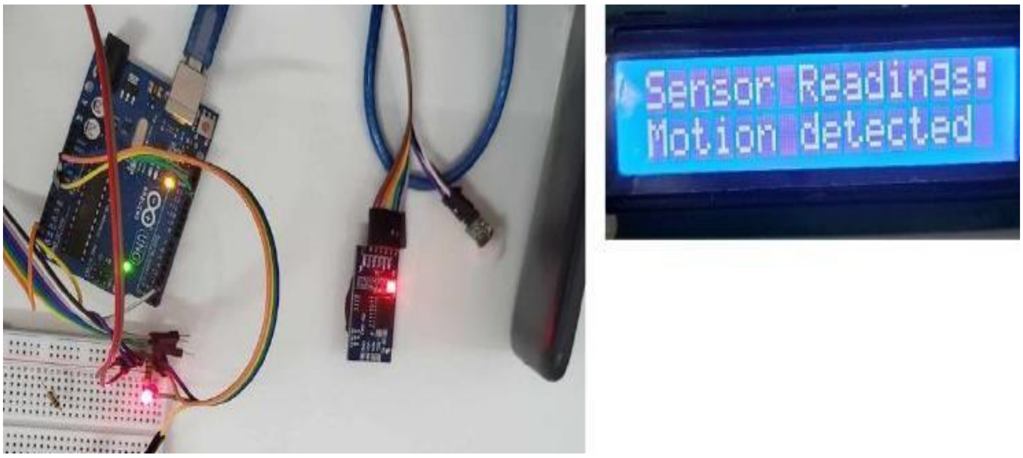


Figure.III.3: Implementation and testing of the interior lighting system

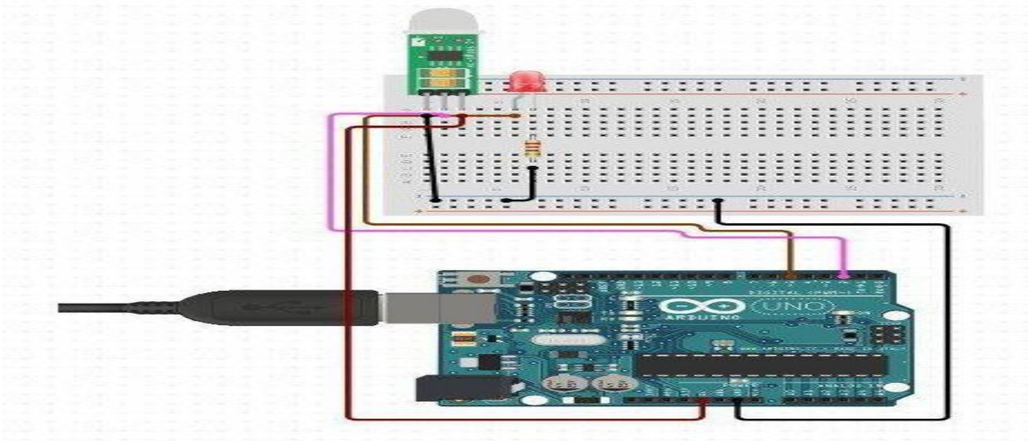


Figure.III.4: Electrical diagram for the interior lighting system

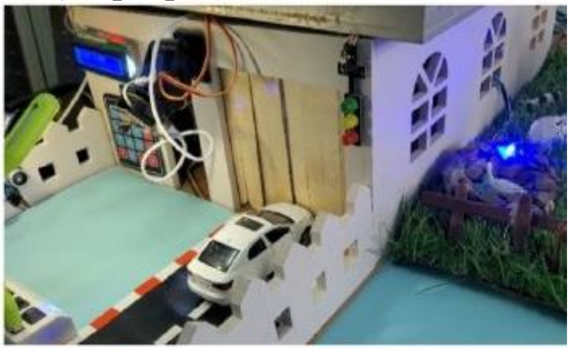
III.4 Exterior lighting system

We have developed an innovative outdoor lighting system that relies on a brightness sensor and sunlight detection. The system features the ability to automatically turn off the outdoor lights in the morning when natural light is sufficient, and turn them on at night or during dark, cloudy weather to provide visibility and safety.

Additionally, the system has been enhanced with RGB(Red, Green, Blue) technology to improve the aesthetics of the space and enhance the lighting ambiance. We have programmed the brightness of multiple colors in the garden fountain adjacent to the smart home, and the colors can be easily adjusted according to mood or desired settings, creating a magical and colorful environment in outdoor areas.

This smart system not only provides an efficient solution for controlling outdoor lighting but also enhances the aesthetics of the space, creating a unique and delightful lighting experience for residents and visitors alike. This is what the figure III.5, figure III.6 shows.

A) Turning off the light when light is detected **B) Light glows when dark ness is detected**



C) The light glows blue in the dark **D) The light glows green in the dark.**

Figure.III.5: Explaining Automatic Changes in Light Brightness and Colors According to Ambient Light Levels and RGB Programming

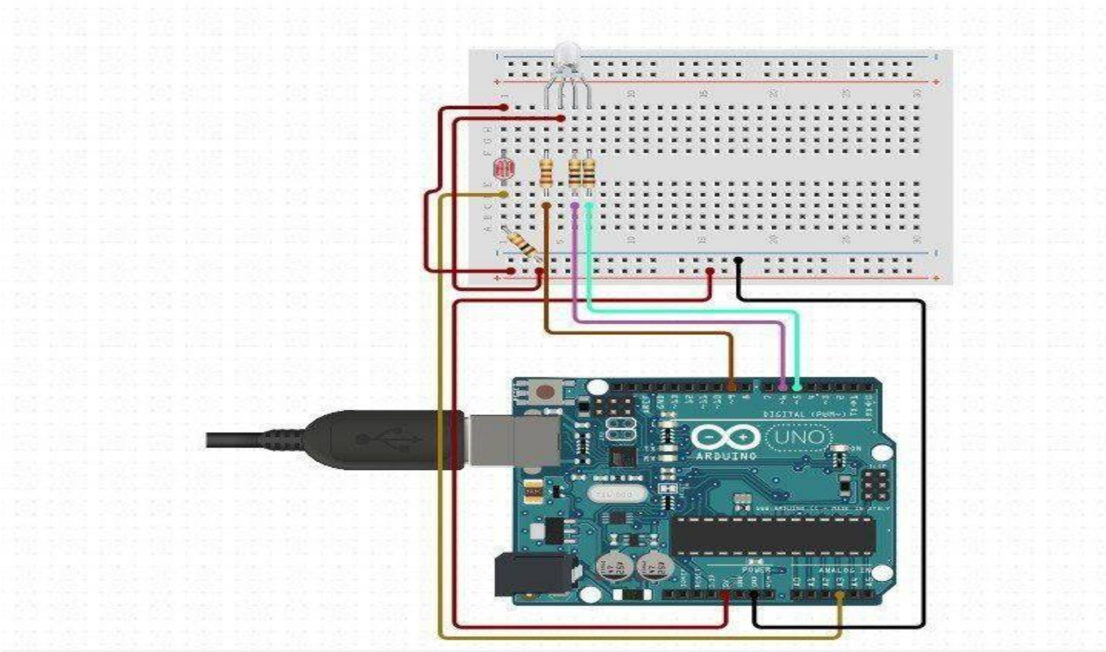


Figure.III.6: Electrical diagram for the outdoor lighting system

III.5 Gas and smoke alarm system

We have developed a gas and smoke sensor system that is used to detect gas leaks and the presence of smoke, identifying the onset of a fire even before it ignites. As soon as the sensor detects gas or smoke, the system triggers multiple alarms (audible, visual, and textual). The buzzer emits a distinctive ringing sound to alert individuals in the area, the light flashes as a warning signal, and the automatic opening system activates to open the window without manual intervention. Additionally, a warning message is displayed on an LCD screen, indicating the presence of gas or smoke in the area, requiring necessary actions to be taken.

This system provides a comprehensive solution for gas leak detection and alerting. It can be used in homes or commercial places to protect and ensure the safety of individuals and property from the dangers of gas leaks or the presence of smoke. Further more, the alert is displayed in the home's system application as a quick and clear notification due to its importance This is what the figure III.7, figure III.8, figure III.9 shows.

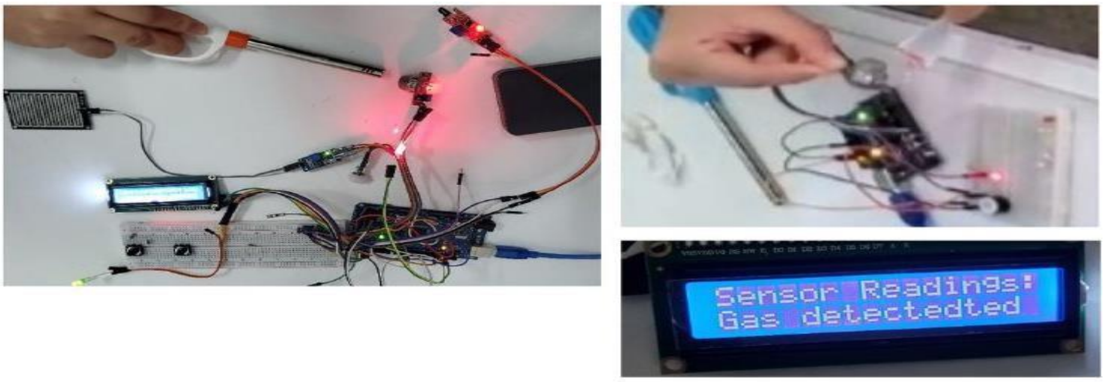


Figure.III.7: Implementation and testing of the gas and smoke alarm system

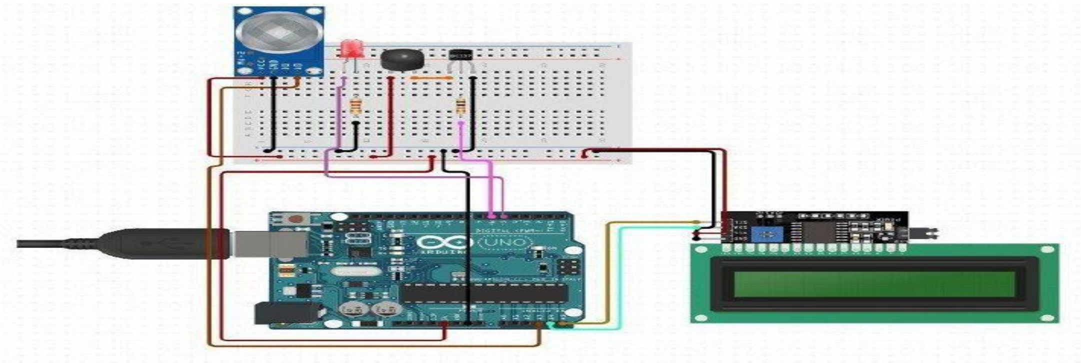


Figure.III.8: Electrical Diagram for the gas and smoke alarm system

The accompanying imageIII.9 combines a graph and text related to gas or smoke detection. The graph displays the concentration levels of gas or smoke over time, where sudden increases can be observed, indicating a potential hazard. The accompanying text clarifies the timing of the detection, helping to pinpoint the moments when gas or smoke was sensed. Overall, the image signifies that there is a system in place monitoring gas or smoke levels, recording data to alert users in case of any abnormal increases that may indicate danger.

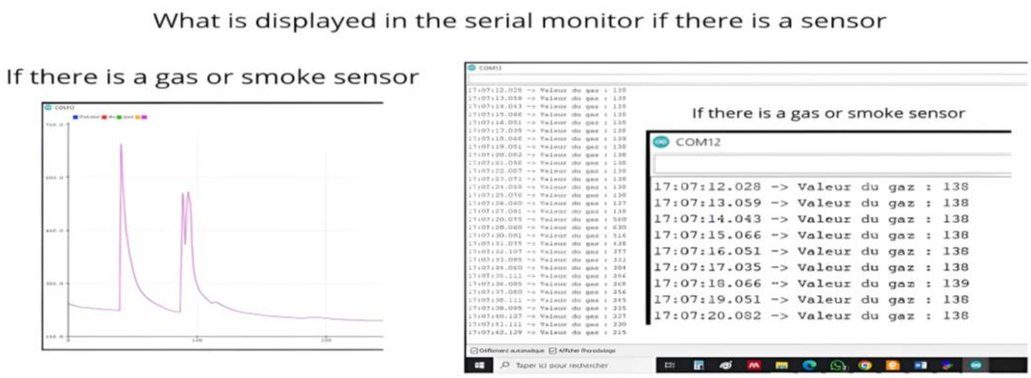


Figure.III.9: Displaying Sensor Reading sin the Serial Monitor

III.6 Fire alarm system

We have developed a fire detection sensor system that is used to detect the outbreak of fires. When the sensor detects a flame, the buzzer emits a distinctive sound (different from other cases) to alert individuals in the area, and the light flashes (different from the gas alert) as a warning signal. Additionally, the automatic opening system activates to open the window without any manual intervention. A warning message is also displayed on an LCD screen, indicating the presence of a fire in the area, requiring necessary and appropriate actions to be taken.

This type of alarm system is useful for protecting the safety of individuals and property from the risk of fires. Further more, the alert is displayed in the smart home system application as a quick and clear notification due to the severity of the situation. This is what the figure III.10, figure III.11 shows.

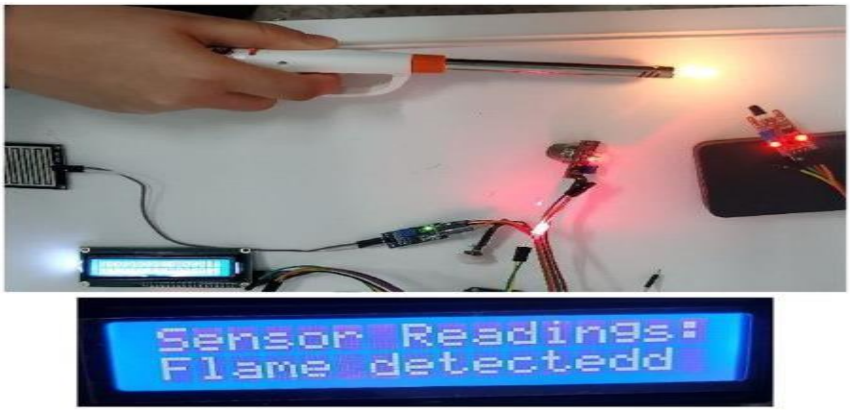


Figure.III.10: Implementation and testing of the fire alarm system

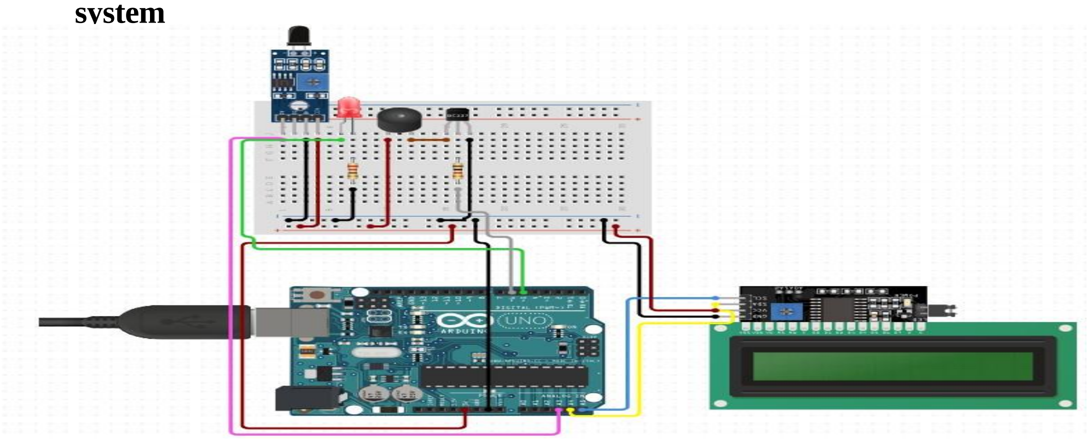


Figure.III.11: Electrical diagram for the fire alarm system

III.7 Water storage and consumption system

To ensure efficient and economical use of water, we have developed an innovative system that combines modern technologies. This smart and integrated system is designed to ensure sustainable water conservation. It consists of two integrated parts:

The first part is a system that includes a sensor to measure the water level in the tank. It operates the pump to automatically fill the tank when the water level is low, and stops the pump once the water reaches the upper

level to prevent overflow and leakage, thus conserving water and electricity. Additionally, the water level is displayed on an LCD screen and in the smart home system application, allowing for remote monitoring.

The second part is a system that includes a smart faucet equipped with a motion sensor. This allows water to flow automatically when hands are brought close to it and stops when the usage is complete. These smart technologies represent a step towards sustainability, efficiently conserving both water and electricity, and contributing to water and energy security. is clear in the figure III.12.

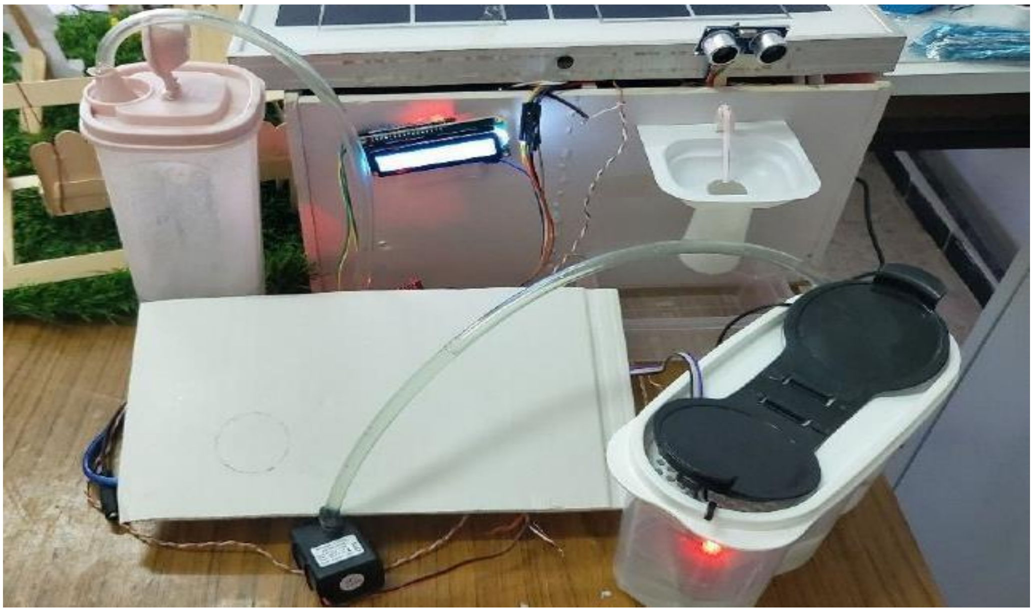
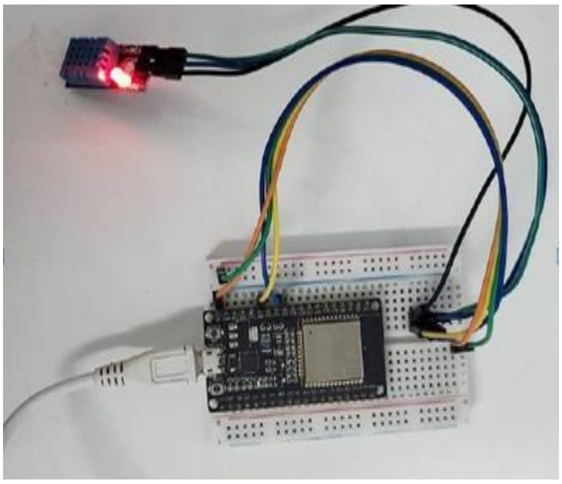


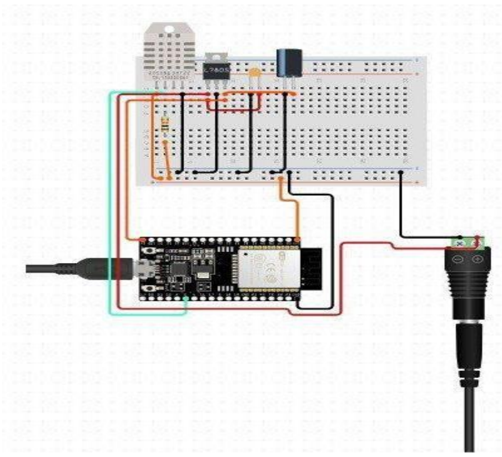
Figure.III.12: Implementation and testing of the water consumption and storage system

III.8 Temperature and humidity measurement system

We have developed a system that measures the temperature and humidity levels inside and outside the home using a DHT11sensor, displaying the results on an easy-to-read LCD screen as well as in the smart eco-home system application. This system provides users with ac curate readings of the environmental and climatic conditions both indoors and outdoors, enabling residents to take appropriate actions when leaving the house or adjusting the indoor environment to ensure comfort and well-being.

This smart technology allows for easy and effective monitoring of data, helping to maintain ideal conditions in the home at all times for people, pets, food, medications, and equipment a like. is clear in the figure III.13.





A) Implementation and testing of The temperature and humidity monitoring system

B) The electricals chematic for The temperature and humidity measurement system

Figure.III.13: Temperature and humidity measurement system

III.9 Rain sensor system

We have developed a rain sensor system to detect rain fall and display the data and results on an LCD screen. The system also includes an automatic window-closing feature that activates if the rain continues for more than 5 minutes. This system helps make weather monitoring more accurate and effective, improving weather forecasts and providing early warnings to users to take precautions before leaving the house. is clear in the figure III.14.

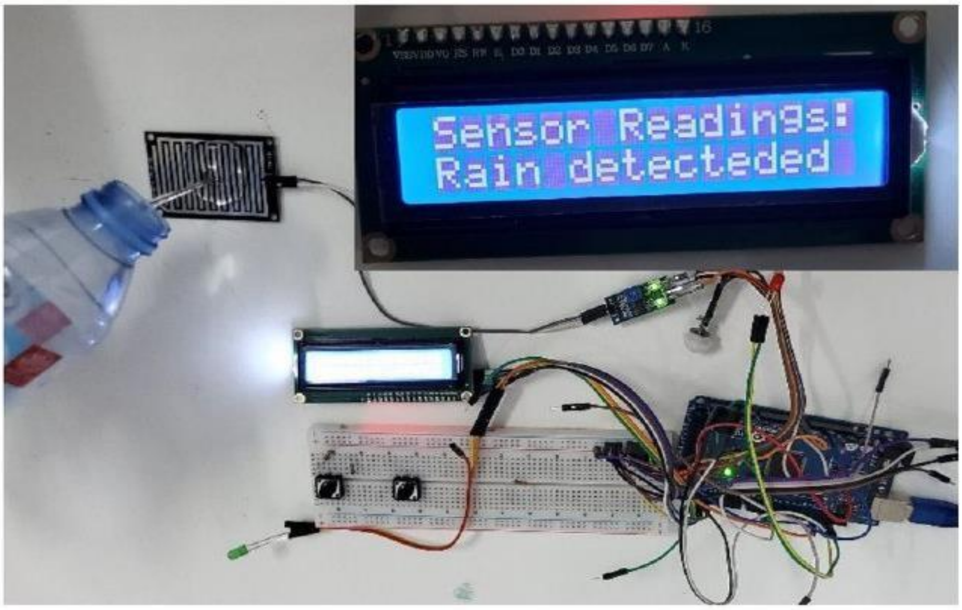


Figure.III.14: Implementation and testing of the rain sensor system

III.10 Smart camera system

We have developed a smart surveillance and security camera system. A camera with a movable mount is utilized, providing the capability to rotate in both directions, zoom in and out automatically, and track moving objects. This allows for remote viewing and monitoring of the house's surroundings via computer and mobile phone. The camera interacts with sensors, redirecting towards any motion detected by one sensor, then automatically returning to scan other directions in case of intrusion from another direction. Additionally, the camera features video recording technology on the phone with options to upload images, control lighting intensity, facial recognition, and several other functionalities. is clear in the figure III.15.

Figure.III.15: Implementation and testing of the smart camera system

III.11 Smart home control application

We have developed a comprehensive smart home application from scratch, enabling control over various household functions including indoor lighting, fans, air conditioners, entry doors, storage room doors, windows, and curtains. What distinguishes this application is its ability to control all devices remotely even without internet access, addressing the issue of fluctuating internet connectivity in smart home environments. It opens up possibilities for integrating smart homes in remote or internet-challenged areas, agricultural exploration workshops, and other contexts. Moreover, the application allows control using in-app buttons for easy appliance operation, and it can be voice- controlled through built-in voice recognition technology, making it highly accessible for individuals with special needs or visual impairments to benefit from smart home technology with just a touchscreen tap, without external assistance.

The user-friendly interface of the application facilitates easy control of these functions, while also providing features such as displaying real-time temperature and humidity inside and outside the home, monitoring water levels in tanks, and displaying important alerts in the form of quick and clear notifications for various scenarios (gas leaks, smoke detection, fire out breaks, rainfall). By using this application, users can enhance their experience in conveniently and efficiently managing household functions, thereby maintaining their comfort and security. This application represents an innovative and forward-thinking solution in the field of smart home control, offering numerous advantages and benefits to its users. Further more, this application integrates both Bluetooth and WiFi connectivity between the application and devices as per priority. It also ensures room-specific control for enhanced comfort and security, while providing the ability to close or open the main power supply with as ingle touch in emergency situations.

It's worth mentioning that we have developed two versions of this application available in both Arabic and English languages.

III.12 View application details

III.12.1 Home page

Here, you can measure and view the temperature and humidity outside your home, as well as easily control the locks of doors, rooms, bathrooms, kitchens, and storage areas. Additionally, you can use the locks to access services such as controlling smart cameras, device control via voice commands, monitoring water levels, and receiving important alerts efficiently .Finally, the lock function allows you to lock or unlock all devices with just one click. is clear in the figure III.16.

A) Application Interface Page –Arabic Version

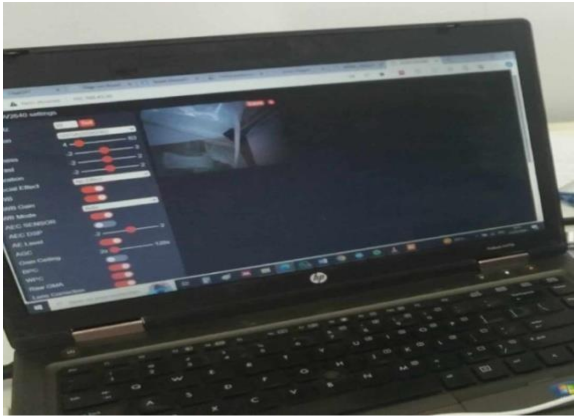
B)Application Interface Page - English Version

Figure.III.16: The Application Interface Page

III.12.2 Camera

We have programmed a button in the application specifically for the smart camera, allowing users to access a live video feed of the front yard of the house. The integrated camera in the application features amount that can rotate in all directions, right and left, with adjustable angles upward and downward. Additionally, it is equipped with zoom technology and the ability to capture images when detecting any object close to the home. Moreover, the camera boasts facial recognition capability, facilitating image saving on the phone and adjusting the flash according to needs. Further more,the programmed smart camera can display the video on the phone or computer as desired. is clear in the figure III.17.

A)Displaying the Camera and Features on the Phone



B)Displaying the Camera and Features on the Computer

Figure.III.17: Displaying the camera and its features on both phone and computer

III.12.3 Voice control

Through our application, users can now easily control all devices in their homes either with just one button click or with a single voice command, either in Arabic or English, or any other language. For example, with a simple phrase, users can turn lights on or off, open or close windows, operate air conditioners, turn fans on or off, open and close doors, move curtains, and control windows, and more. All of this and more can be done effortlessly, with the added feature of smart voice control. This is extremely beneficial for visually impaired individuals, elderly people, illiterates, and those who are not proficient in navigating smartphones. What sets our smart application apart is that it operates with out the need for the internet , making it usable even in remote areas, shaded areas, and places with fluctuating internet connectivity.is clear in the figure III.18.

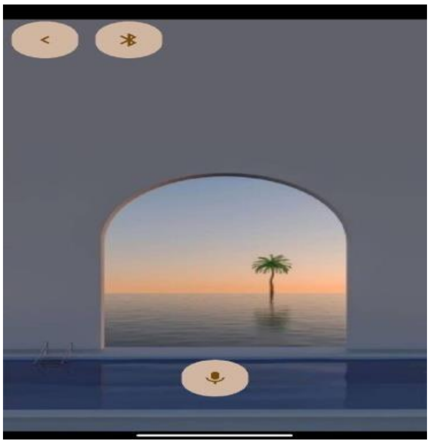
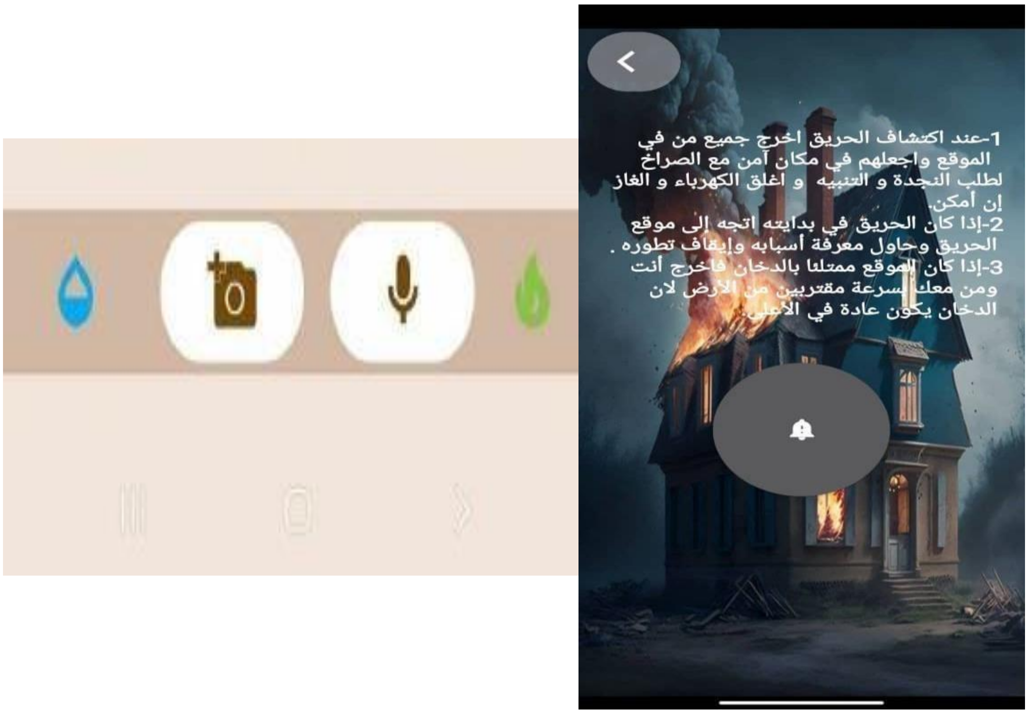


Figure.III.18: Displaying the application interface using voice control technology

III.12.4 Alerts

Our application features an icon that displays important notifications. The icon is activated in the app with a red color indicating a danger in the home. When clicked, the icon reveals a comprehensive report containing the source of the alert and all relevant information, including safety procedures to be taken. This report allows you to gain a comprehensive overview of the situation and effectively deal with emergencies that may occur in the home. is clear in the figure III.19.



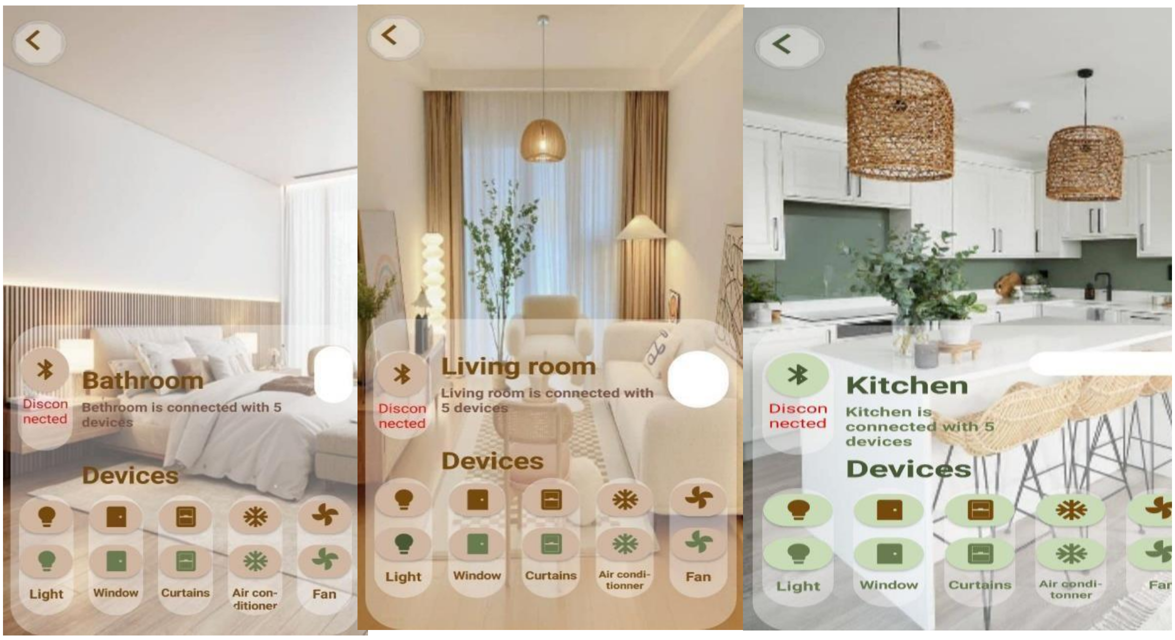
A)Icons of warnings in normal situations **B)Fire Warnings with instructions**

Figure.III.19: The alert icons and the page displaying the details of the alert in the application

III.12.5 Rooms

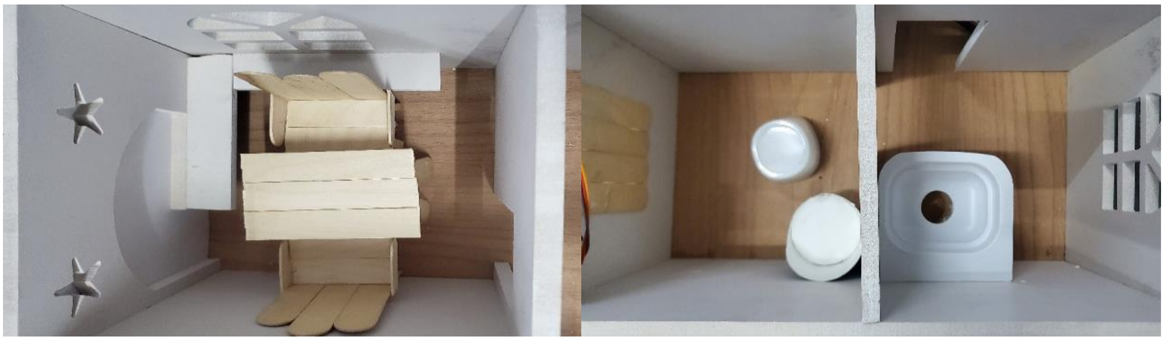
III.12.5.1 Bedroom, living room and kitchen

We have programmed and integrated several rooms equipped with various devices, with the possibility of adding and changing them as needed. When you press the button of the requested room, you will be directly transferred to it. After connecting to its Bluetooth, you will have full control over turning on and off the room's lighting, fan, air conditioner, curtains, and more, even the window to let in fresh air and natural light. Additionally, you can access the temperature and humidity in the area and take necessary actions either manually or automatically. This is what the figure III.20, figure III.21 shows.



A)The Bedroom with Its devices in the application **B)The living room with its appliances** **C)The kitchen with its Appliances in the application**

Figure.III.20: The interface of the bedroom, living room, and kitchen with Their appliances in the application.



A)Kitchen design **B)Living Room and Bathroom design**

Figure.III.21: Interior design for the kitchen, living room, and bathroom

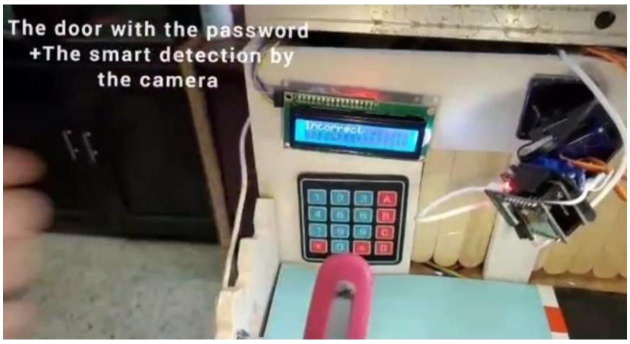
III.12.5.2 Bathroom

When you press the bathroom button, you will be directly taken to its dedicated page .After remotely connecting via Bluetooth, you can view the temperature and humidity inside the bathroom, as well as the water level in the tank. is clear in the figure III.22.

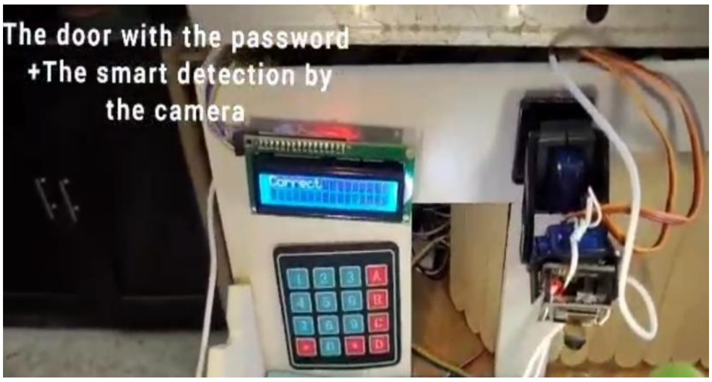
Figure.III.22: Bathroom interface with its appliances in the application

III.12.5.3 Exit door

The application allows the user to control the smart home door with just a single button on the screen, enabling them to easily open and close the door through two dedicated buttons for this purpose, providing them with a smooth and convenient user experience. Additionally, the door can be controlled using a code or by voice command, among other methods. is clear in the figure III. 23.



B) Door Off



A) Door in the application **C) Door On**

Figure.III.23: Displaying the door control interface in the application

III.12.5.4 Ware house door

The application allows users to control the warehouse via an icon on the warehouse-specific screen, where they can easily open and close the door using dedicated buttons. Additionally, we have programmed and equipped the warehouse with warning lights (red, yellow, green) that flash sequentially to signal any movement of the doors, ensuring the safety of individuals and interaction with the car driver. This provides smooth, safe, and convenient usage. It's worth noting that we have also implemented voice control for the warehouse door, making it easier for the driver to open and close it without needing to browse the phone or the application, available in both Arabic and English. is clear in the figure III.24.

B)Garage Off

A)Garage in the application C)Garage On

Figure.III.24: Garage door control interface in the application and prototype

III.13 The final prototype and schemes of the smart home

The figures below present the schemes of the wiring of the smart home system using Arduino and ESP for others devices. While the last figure presents the realized and tested prototype During the realization of the smart home system, we used many software (Wokwi, Arduino IDE, CSS, Android, Fritzing…). This is what the figure III.25, figure III.26 shows.

After mastering the system, we did the design and the realization of the whole smart home with its farm. Then, all the control system and devices have been implemented and tested successfully. The obtained results encourage implementing the control system in a real house to be a smart home thanks to our produced application. is clear in the figure III.27.

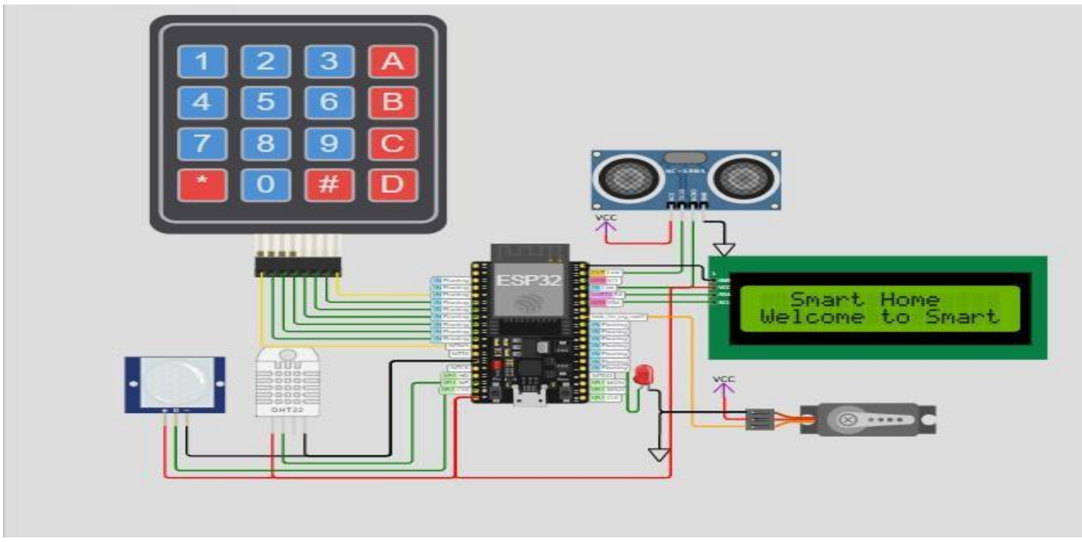


Figure.III.25: Scheme of control using ESP32

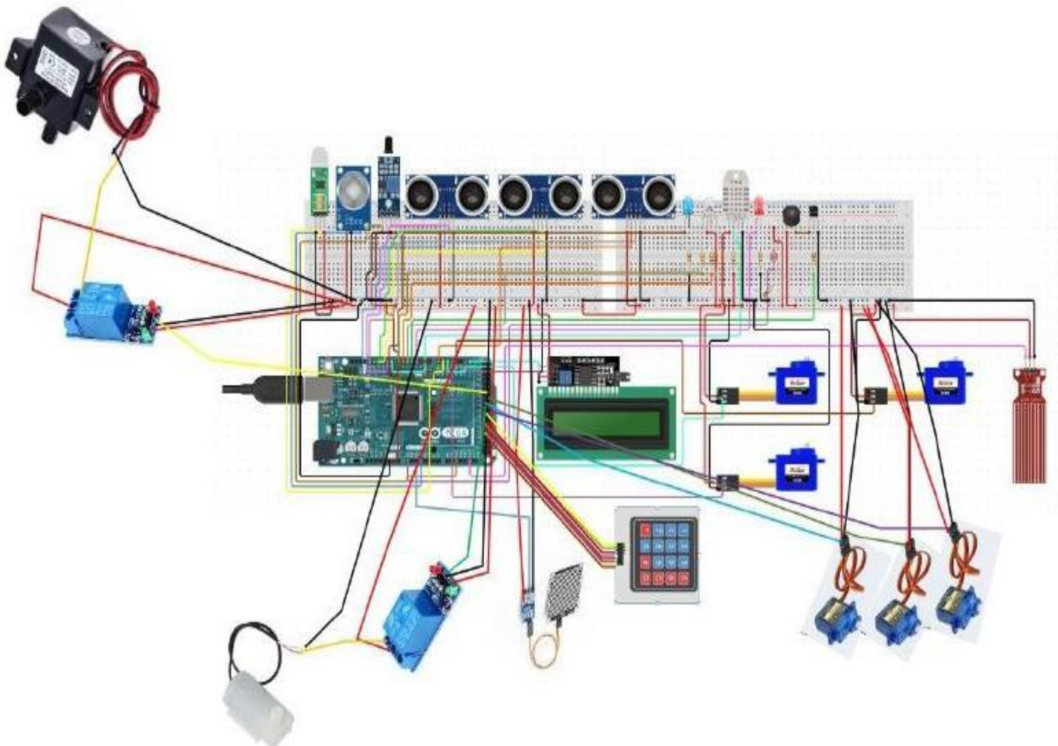


Figure.III.26: Control diagram using Arduino.

After having good results on the prototype, we realized a real device that control remotely the real smart home appliances,is clear in the figure III. 28.

Figure.III.27: The realized smart home with the farm

Figure.III.28: The realized device to control real appliances of smart home

The prototype and the realized device control have been tested, the system worked with a high performances. The obtained results were very satisfactory and encourage to install it in houses anywhere.

III.14 Conclusion

In this chapter, we presented the steps of the smart ecological home realization which fixes many problems and answers blind persons and remote area needs. The Arduino with sensors and electrical schemes have been presented with real system implantations and tests. Then, the developed Android application has been presented with its features. The interaction between Android, Arduino, real device, sensors and the human has been tested and presented successfully. Then, we realized a device to control real appliances. All the scenarios we planned for the smart home, providing an effective and convenient solution to improve the quality of life at home. Through the automated control of home elements, we can ensure the safety and comfort of the residents and enhance energy consumption efficiency. Additionally, providing alerts for risks and executing automatic solutions without waiting for human intervention enhances the safety of the home and its occupants.

In conclusion, this project represents an important step in the application of smart home technologies, reflecting progress and innovation in the fields of engineering and technology.

General Conclusion

General Conclusion

In recent times, comfort, improving living conditions, ensuring citizens' safety, and saving energy at home have become very essential. The development of computing, communication technology, and electronics has made it possible to create smart homes that meet the needs of residents.

This project is part of this context, where we aimed to design a home automation system by integrating the concept of intelligence into a miniature prototype of a house. The objective of this work is to design and control an ecological smart home that is remotely controlled and adapted to blind persons and remote areas even in absence of electrical grid and internet. For this, the smart house is autonomy you s and powered by photovoltaic energy. It is programmed on Arduino using multiple sensors to achieve comfort, increase safety levels, and facilitate daily tasks, especially repetitive ones, such as controlling lighting, fire alarms, and opening or closing the door with a keypad. Additionally, a smartphone application has been created and programmed on the Android system for remote controls, camera and alarms.

At first, we provided definitions regarding home automation and the importance of smart homes in daily life and the assistance they offer in various functions. Next, we discussed the fields of home automation and explained the types of operations that make homes smart. In order to create a smart home, we introduced the control and management board (Arduino), its programming, the IDE interface, and the necessary sensors and electrical tools for creating a smart home. We also explained how to use to create an Android application. To exploit renewable energies, we highlighted the importance of integrating photovoltaic energy into modern smart homes to ensure its autonomy. Then, we began by describing the Renewable Energy Research Unit in the Saharan Medium (URERMS/CDER) where we did our training and the smart home realization. URERMS focuses on renewable energies research, particularly solar energy. After that, we defined solar energy and the basic principles of the two types of solar energy (photovoltaic and thermal). Following this, we presented the commonly known types of photovoltaic panels and their characteristics, along with the components of the photovoltaic system and the necessary information to understand the operation and integration of the photovoltaic system into home automation.

The last chapter was dedicated to the realization of the smart home powered by photovoltaic energy and presenting the application designed to control the smart home. We presented nine scenarios created for the smart home. Such as unlocking a coded lock using a keypad, automated control of indoor and outdoor lighting, fire or gas leak alarms, an integrated

General Conclusion

Water storage and rational consumption system, temperature and humidity measurement inside and outside the house, a smart camera that reacts to movement in the front yard, a rain detection system. We then explained their operations with accompanying illustrative images of successful experiments and electrical diagrams using many software (Wokwi, Arduino IDE, CSS, Android, Fritzing…), to clarify the connections.

We also presented the Android application used for remote control. We began by explaining the application and the offered features. Then, the main interface of the application in both Arabic and English have been shown. This included the section dedicated to the smart camera and its features, the voice control section, the notifications section, and then the rooms with their specific devices, such as the bedroom, living room, kitchen, bathroom, doors and garage. Finally, we presented the overall electrical diagram of the smart home using Arduino and ESP32, and concluded with a final image of the smart home prototype and real devices controller.

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Appendix

Appendix A

The equations necessary for studying and sizing standalone photovoltaic home system

[43].

1. Calculation of daily energy consumption

$$\mathbf{E_c = P * n * h} \qquad \textbf{(A.1)}$$

Where;

E_c:the consumed energy(Wh / day).

P: Electrical power(W).

n: Number of the used appliances(devices). h: time (hour).

[43].

2. Determining the required size of the solar panels

$$P_C = E_C/(KI_r) = E_P/I_r \qquad \textbf{(A.2)}$$

Where;

Pc: Peak power in peak watts(Wc). Ep: Peak energy in peak (KWhc.j).

Ir: Average annual daily irradiation (kWh/ m^2.j)

k: is a coefficient often taken(0.65), that takes in consideration all these factors:

- Un corrected tilt modules according to season and meteorological uncertainty;
- Losses in the module efficiency, cables and connections losses, dusts effect, error in the PV operating point
- Charger efficiency (90 to 95%)and the performance of charge and discharge cycles of the battery (80%);

[43].

3. Calculation of the number of solar panels

$$N = P_C/PU \qquad \textbf{(A.3)}$$

Pu: unit peak power of the modules watts (W).

Number of panels connected in series Exemple for a house consumes power of 4kW,the inverter voltage 48V:

$$NS = \frac{Uond}{Umod} = \frac{48}{36.99} = 2\,serialconnections \quad (A.4)$$

Uond: the input voltage at the terminals of the inverter.

Umod: the unit voltage of the modules.

3.2. Number of solar panels connected in parallel

$$Np = \frac{Pc}{NsPmod} = \frac{5000}{(2).(250)} \quad (A.5)$$

Pmod: the peak power of a PV module[66]

4. Determining the diameter of the connecting wires

$$R = (\Delta U/I) \quad (A.6)$$
$$S = (\rho L/R) \quad (A.7)$$

ΔU: maximum voltage drop in the cable.

I: current circulating in the cable.

R: cable resistance.

5. Choosing the inverter

It is necessary that the boosting power(P-reg) and the inverter power (P_ond)beat least20% higher than the peak power (Pc), in order to

$$P\_reg \geq (1.2)P\_c \quad (A.8)$$
$$P\_ond \geq (1.2)P\_c \quad (A.9)$$

6. Determining of the battery capacity

$$CD = (E_C.N)/(D.U) \quad (A.10)$$

Where

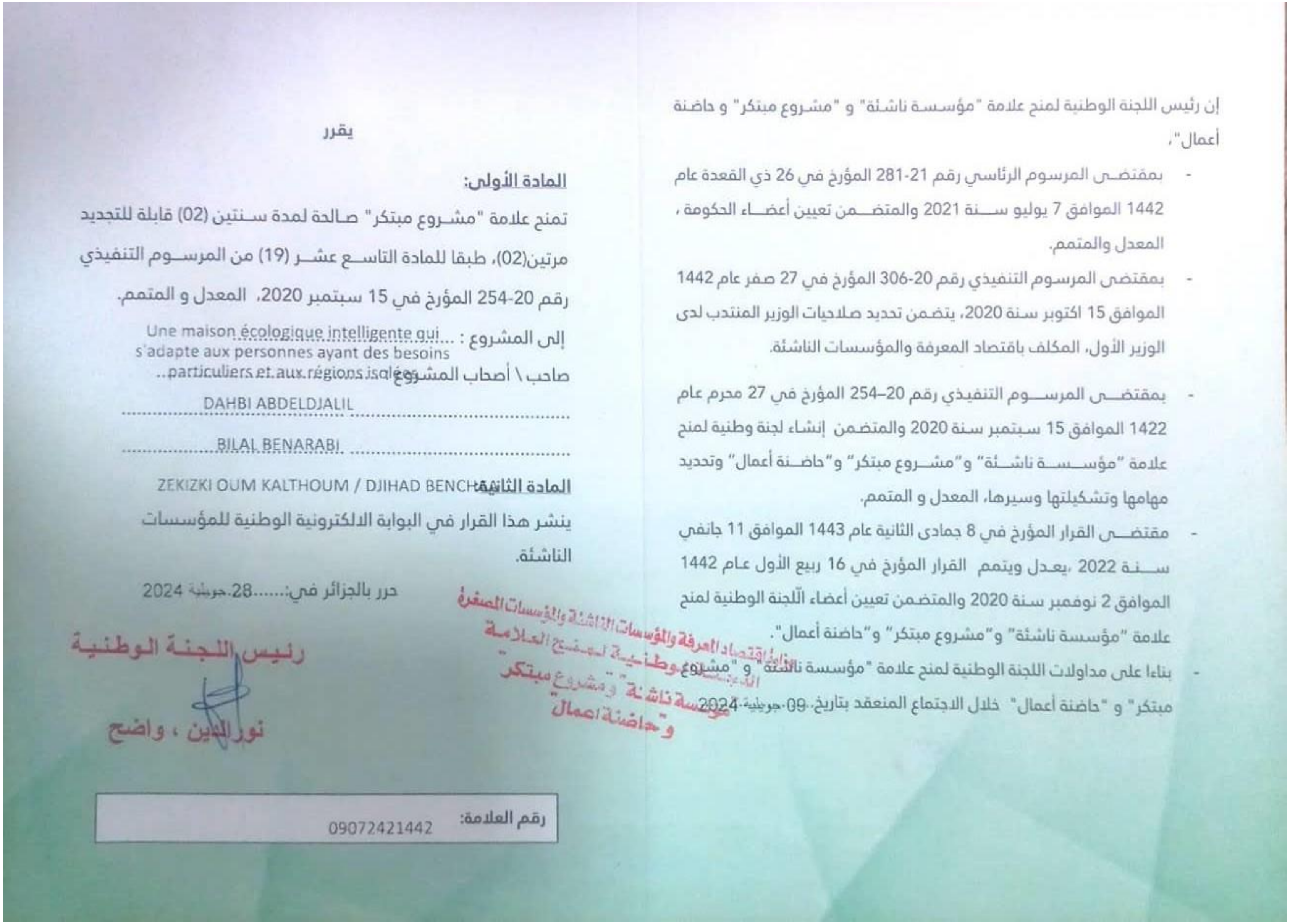
N: Number of autonomy days.

D: Maximum permissible of discharge of the battery

U: The nominal voltage of the battery

Appendix B

Ce travail a fait l’objet d’un Label, Logiciel et Brevet.



إن رئيس اللجنة الوطنية لمنح علامة "مؤسسة ناشئة" و "مشروع مبتكر" و حاضنة أعمال"،

- بمقتضى المرسوم الرئاسي رقم 21-281 المؤرخ في 26 ذي القعدة عام 1442 الموافق 7 يوليو سنة 2021 والمتضمن تعيين أعضاء الحكومة ، المعدل والمتمم.
- بمقتضى المرسوم التنفيذي رقم 20-306 المؤرخ في 27 صفر عام 1442 الموافق 15 اكتوبر سنة 2020، يتضمن تحديد صلاحيات الوزير المنتدب لدى الوزير الأول، المكلف باقتصاد المعرفة والمؤسسات الناشئة.
- بمقتضى المرسوم التنفيذي رقم 20–254 المؤرخ في 27 محرم عام 1422 الموافق 15 سبتمبر سنة 2020 والمتضمن إنشاء لجنة وطنية لمنح علامة "مؤسسة ناشئة" و"مشروع مبتكر" و"حاضنة أعمال" وتحديد مهامها وتشكيلتها وسيرها، المعدل و المتمم.
- مقتضى القرار المؤرخ في 8 جمادى الثانية عام 1443 الموافق 11 جانفي سنة 2022 ،يعدل ويتمم القرار المؤرخ في 16 ربيع الأول عام 1442 الموافق 2 نوفمبر سنة 2020 والمتضمن تعيين أعضاء اللجنة الوطنية لمنح علامة "مؤسسة ناشئة" و"مشروع مبتكر" و"حاضنة أعمال".
- بناءا على مداولات اللجنة الوطنية لمنح علامة "مؤسسة ناشئة" و "مشروع مبتكر" و "حاضنة أعمال" خلال الاجتماع المنعقد بتاريخ 09 جويلية 2024

يقرر

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إلى المشروع : Une maison écologique intelligente qui s'adapte aux personnes ayant des besoins particuliers et aux régions isolées

صاحب \ أصحاب المشروع : DAHBI ABDELDJALIL

BILAL BENARABI

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6 TITRE DE L'INVENTION / عنوان الإختراع — 54

Une maison écologique intelligente qui s'adapte aux personnes ayant des besoins particuliers et aux régions isolées

7 DOMAINE TECHNIQUE DE L'INVENTION / المجال التقني للإختراع — 51

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4 INFORMATIONS SUR L'INVENTEUR 6 معلومات حول المخترع — 72

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