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Title:

Monitoring d'un système photovoltaïques autonome par les techniques de l'iot (Internet of things)

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Dedications

First of all, thank Allah the Almighty for giving me the courage and patience to carryout this work I dedicate this modest work: To my dear parents (to their appreciationand their support for me). To my brothers and sisters To Malak, Mimoune family To Amro Said and all dear friends To Ms. Tawfik beghriche To all who i love and love meTo all those who have contributed directly or indirectly to carrying out this work.

M.Malak

Dedications

Above all, I thank God the Almighty for giving me the courage and patience to achieve this work despite all the difficulties encountered. I dedicate this modest work to my dear parents for their sacrifices May God guard and protect them for their moral and financial support, To my brothers and sisters and all my family All my study colleaguesespecially El bagor Abdellatif

H.Sihem

Abstract

Abstract:

In this work, we provide monitoring of a self-contained photoelectric system basedon real-time measurements.

The graphical interface of the system is implemented using a programming environment and the parameters have been extracted the graphical interface of the system is implemented using a programming environment Excel system in order to make a real- time comparison of the data obtained. The system lets you publish format data for more analysis and internet participation.

KEYWORDS: Monitoring, Iot, System photovoltaic

ملخص:

في هذا العمل، نقدم مراقبة لنظام كهروضوئي قائم بذاته يعتمد على قياسات في الوقت الفعلي

يتم تنفيذ الواجهة الرسومية للنظام باستخدام بيئة برمجة وتم استخراج المعلمات ويتم تنفيذ الواجهة الرسومية للنظام باستخدام بيئة برمجة

Excel

من أجل إجراء مقارنة في الوقت الحقيقي للبيانات التي تم الحصول عليها. يتيح لك النظام نشر بيانات التنسيق لمزيد من التحليل والمشاركة على الإنترنت

List of figures

List of figures

List of symbols

h: Planck's constant [j. s^{-1}].

C: the speed of light [m. s^{-1}].

λ: she wavelength [m].

I_{ph} : is the distance between the elements .

I_0 : Diode saturation current [A].

V_t : Ideal unit Cell thermal voltage [V].

a: Diode quality factor.

k : Boltzmann's constant (1.381×10-23) [J/K] .

T: Kelvin Temperature at standard test condition [K].

Q : Charge of the electron [C].

n_s : Number of PV cells connected in series.

Rsh : Cell parallel (shunt) resistance [Ω].

Rs Cell series resistance [Ω].

I_L : represents the light-generated current in the cell.

I_sh : represents the current lost due to shunt resistances.

I_D : is modelled using the Shockley equation for an ideal diode.

Isc : The short circuit current.

Voc : The diameter of the equivalent antenna surface

Liste of Abbreviations

PV : Photovoltaic

PPM : Maximum power point

MPPT : Maximum Power Point Tracking

DC : Direct current.

Vmpp : maximum voltage

Summary

General conclusion

For a very long time, humans have benefited from energy emitted by the sun. Most uses are direct as in agriculture, through photosynthesis and drying of agricultural crops, desalination of seawater or in various heating applications, as well as in other fields, but this exploitation was limited and with the great development of technology and the scientific progress achieved by man opened up new scientific horizons in the field of solar energy exploitation.

In the face of increasing global energy needs, the foreseeable depletion of fossil fuel resources and the global degradation of the environment, the development of environmentally friendly energy sources is necessary.

One solution is to develop cheap renewable energy sources. These include photovoltaic energy, which consists in the direct conversion of solar energy into electrical energy. It is one of the most promising and is the subject of intense research. Unlike other renewable energies (from wind, biomass, water, etc.), solar energy is available all over the world with varying degrees of intensity[1].

Efforts to eliminate fossil fuels can seem as difficult as swimming against the tide. Economic reasons, such as the exorbitant costs of solar panels, charge controllers or batteries, have prompted many entities to give up or at least reduce their carbon footprints as much as possible. However, the effort may soon be less onerous thanks to technology. For example, the use of grid-linked inverters allows a solar panel to send energy back to the grid without necessarily using batteries or load controllers, or rewiring the site. In addition, the Internet of Things (IoT) accompanies you to enable you to monitor solar panel performance anywhere in the world [2]..

To do preventive maintenance and maintain the photovoltaic installations on time, it is necessary to have a system that allows to measure, record and transfer the data obtained by the instrumentation, and to be able to process the measured data and detect failures on any photovoltaic installation, this is called a monitoring system.

The proposed solution is an IoT system consisting of three subsystems, namely: a access control, laboratory room management subsystem and database server to manage researchers and laboratory equipment. Therefore, each of the sub systems manages features and uses several hardwares and softwares technologies making it easy to manage the laboratory.

The manuscript is organized into four chapters:

Chapter 1: IOT (Internet of Things).

Chapter 2: General information on the photovoltaic system

Chapter 3: PREPARATION AND IMPLEENTATION PART

In the end we conclude the work done.

Chapter I:

IOT (Internet of things)

1 .1 Introduction:

IoT is the concept of connecting any device to the internet and other connected devices. The Internet of Things is a vast network of connected things and people, all of which collect and share data about their usage and their surroundings. Experts estimate that by 2020, the Internet of Things will consist of around 30 billion objects. This survey presents research based on the Internet of Things and its applications in various fields of science and technology, and discusses the architecture and elements of the Internet of Things and its various applications.

The Internet of Things is a platform where everyday devices become smarter, everyday processing gets smarter, and everyday communications become information-rich. We are talking about a new revolution on the Internet. Objects make themselves identifiable and gain intelligence by making or enabling contextual decisions as they communicate information about themselves [3].

1 .2 Definition of the IoT:

If the concept is fashionable, defining the IoT is not easy. Indeed, IoT concerns hardware and software, network technologies as well as data science, services and infrastructure deployment, wireless sensor networks such as cloud computing. Is IoT still just a vision? Isn't that vision already a reality? And to begin with, what is IoT? The answers to these questions are many and debatable. It is a bit like asking the question of the definition of the Internet.

In this document, we consider the IoT as the tangible form of a important component of the next generation Internet. From this perspective, IoT represents a broad set of technologies that:

• build bridges between the digital world and the physical world.

• bridge the gap between Internet technologies and increasingly diverse embedded systems**.**

IoT terminology is not yet completely fixed. In this paper, we talk about the IoT as an equivalent of the Internet of Everything (Cisco/W3C terminology), the physical Internet (Physical Web, Google), physical computing (Arduino), machine-to-machine (M2M), cyber physical systems (Cyber Physical Systems, theory of enslavement) or the World-Sized Web [4] (a concept proposed by Bruce Schneier).

1. 3 History of the IoT

Before the Internet, at the end of the seventies, home automation products such as X10 had already appeared on the market. Then, in the early 1990s, futuristic concepts such as the Digital Desk emerged, creating «augmented objects» cooperating on the network by means of interfaces allowing tangible interactions opening gaps in the separation between the digital and physical worlds. Around the same time, others anticipated the Internet of Things, Including Mark Weiser and his vision of «ubiquitous computing and virtuality» embodied a vision that is gradually becoming reality.

At the end of the 1990s, the Auto-ID Centre opened the era of RFID chips, foreshadowing a world where almost every object could be identified with a unique address on the network. With this preliminary system, each label was equipped with a simple chip containing only a

Serial number (the objective being to limit the cost) that could be read nearby by local wireless communication. The data associated with the label serial number was stored separately in an online database.

In the two thousand years, new concepts and new techniques have allowed the creation of wireless sensor/actuator networks (WSAN or WSN): tiny battery-powered computers, initially collaborating to establish wireless networks (multi-jump) before using these networks to transport data from their sensors, or to transmit actuator controls.

Giving these notions a more general scope, the term «omnipresent computing» (pervasive computing, a term that approaches the concept of ubiquitous computing) captures the tendency to integrate computational and communication skills into everyday objects. Synonymous, the use of the term Internet of Things (IoT) began to become widespread in the nineties.

Over the last ten years, more and more objects have appeared, integrating different levels of computing power and cooperation on the network…

1 .4 Components involved in the Internet of Things:

The Internet of Things concept requires the coordination of the following devices:

- a physical label identifies each object / a virtual label identifies each location.
- a mobile device (cellular phone, organizer, laptop, etc.) with additional software, which reads physical labels or locates virtual labels.
- a wireless network connecting the portable device to a server containing the information related to the tagged object.

- information about objects is managed by web pages;
- a display device (screen of a mobile phone) allows to view information about the object or a set of objects.

1 .5 Characteristics of the IoT system:

The basic features of IoT are:

- Inter-connectivity: everything can be interconnected with the global information and communication infrastructure.
- Connected Object Services: IoT is capable of providing object-related services within constraints, such as privacy protection and semantic coherence between physical things and their associated virtual objects. In order to provide services related to things (i.e., objects) in constraints on things, technologies in the physical world and the world of information will change.
- -Heterogeneity: IoT devices are heterogeneous across hardware platforms and networks. They can interact with other devices or service platforms via different networks.
- -Dynamic changes: The state of devices changes dynamically, for example sleeping and waking up, being connected and/or disconnected as well as the context of the devices, including location and speed. In addition, the number of devices can change dynamically.
- Huge scale: The number of devices that need to be managed and communicate with each other will be at least an order of magnitude greater than the number of devices connected to the Internet. Even more critical will be the management of the data generated and their interpretation for application purposes. This concerns data semantics, as well as efficient data management.
- -Security: As we gain benefits from IoT, we must not forget security. As creators and recipients of IoT, we need to design mechanisms to ensure security. This includes the security of our personal data and the security of our physical well-being. Securing the endpoints, networks and data that pass through them means creating an evolving security paradigm.
- Connectivité : La connectivité permet l'accessibilité et la compatibilité du réseau. L'accessibilité se met sur un réseau alors que la compatibilité fournit la capacité commune de consommer et de produire des données.

1 .6 Application examples:

There are many different applications of IoT-based technologies. These technologies are used in process automation, home automation, smart cars, decision analysis and smart grids. As technology advances in the coming years,

1.6.1 10 Best Real-World IoT Examples:

In our opinion, here are the 10 best examples of IoT based applications in today's world[5].

1) IoT Sensors:

The list of IoT applications will increase. IoT sensors consist of manual or digital sensors connected to a circuit board such as an Arduino Uno or Raspberry Pi 2. The board can be programmed to measure a range of data collected from sensor devices such as sensors. B. Carbon monoxide, temperature, humidity, pressure, vibration and motion. IoT sensors differ from simple sensors in that they can not only collect data in different physical environments, but also send data to connected devices. IoT sensors enable seamless control of data through automation and provide actionable insights. Companies can use them to perform predictive maintenance, increase efficiency and reduce costs.

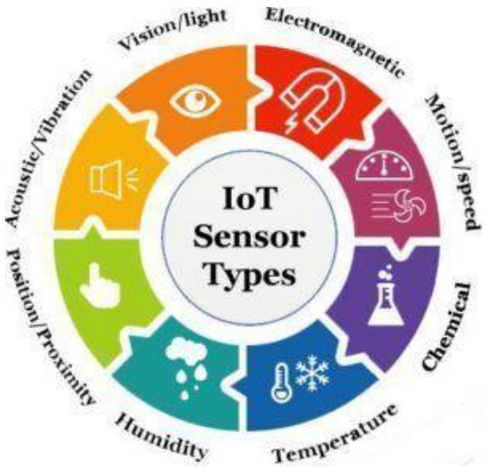

Figure 01: IoT sensor types

2) IoT Data Analytics:

Organizations are increasingly using IoT data analytics to identify trends and patterns by analyzing large and small amounts of data. IoT data analytics applications can analyze structured, unstructured, and semi-structured data to generate meaningful insights. IoT can be applied to data analytics to examine different types of data, including exercise datasets, geographic data, and health data. Organizations can use it for predictive and descriptive analytics to improve customer knowledge, improve operational efficiency, and create business value.

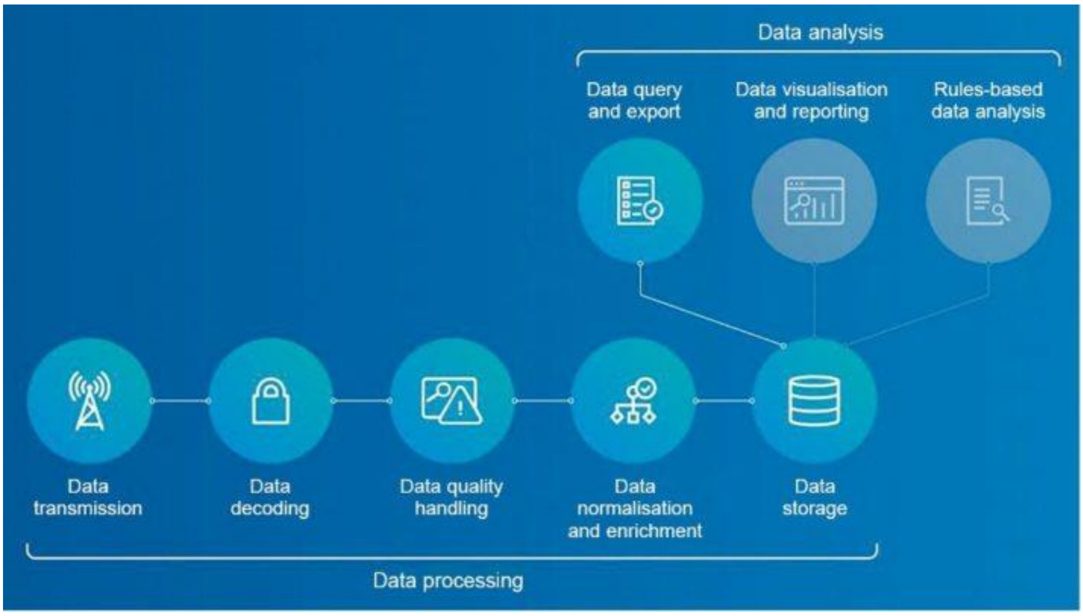

Figure 02: Description image for IoT

3) IoT Tracking and Monitoring System:

Many companies use IoT systems for inventory tracking. IoT asset tracking devices use GPS or radio frequency (RF) to track and monitor real estate. Smart devices can be used to identify and authenticate assets from a distance.

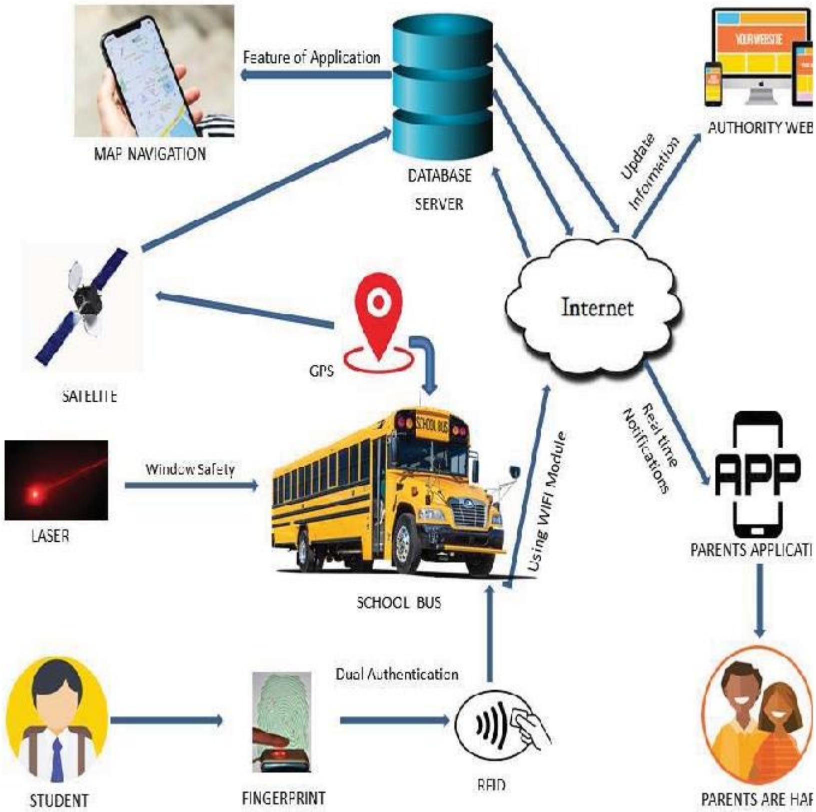

Figure 03: Overview of the proposed system

4) IoT Connected Factory:

Businesses can also use IoT Connected Factory solutions like Azure IoT to manage industrial IoT devices. Connected cloud software can populate various resources, allowing it to control a range of devices.

Connected Factory solutions can report on key metrics, including equipment efficiency and telemetry data. Data may be collected from assets located in different geographic locations. You can use connected factory solutions to connect, monitor and control remote industrial equipment.

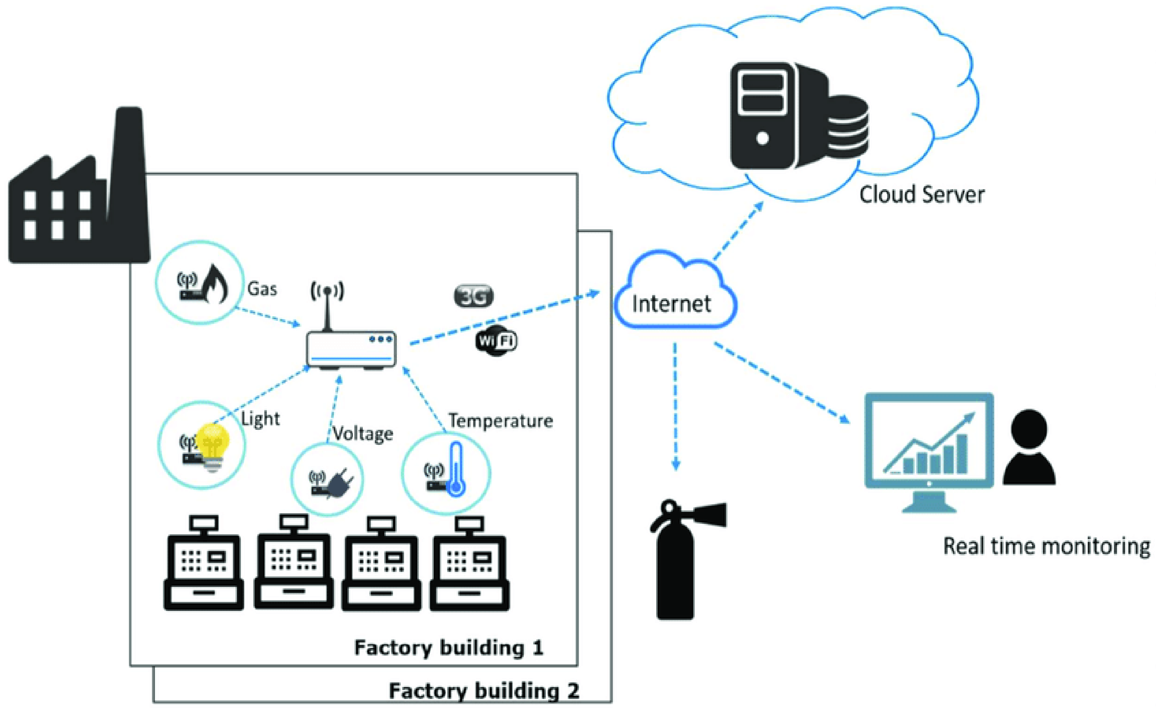

Figure 04: The possible IoT architecture for factory monitoring scenario

5) Smart Supply Chain Management:

Supply chain managers can make improved forecasts through intelligent routing and rerouting algorithms. Smart IoT devices connected to packages can provide facts via GPS and RFID signals immediately after an event, which can help make informed decisions in the supply chain. IoT applications can help mitigate the risk of uncertainty in supply chain management.

upply chain managers can leverage intelligent supply chain management programs to minimize variance, reduce costs, and increase profitability. These programs can help with inventory management, supplier relations, fleet management, and scheduled maintenance

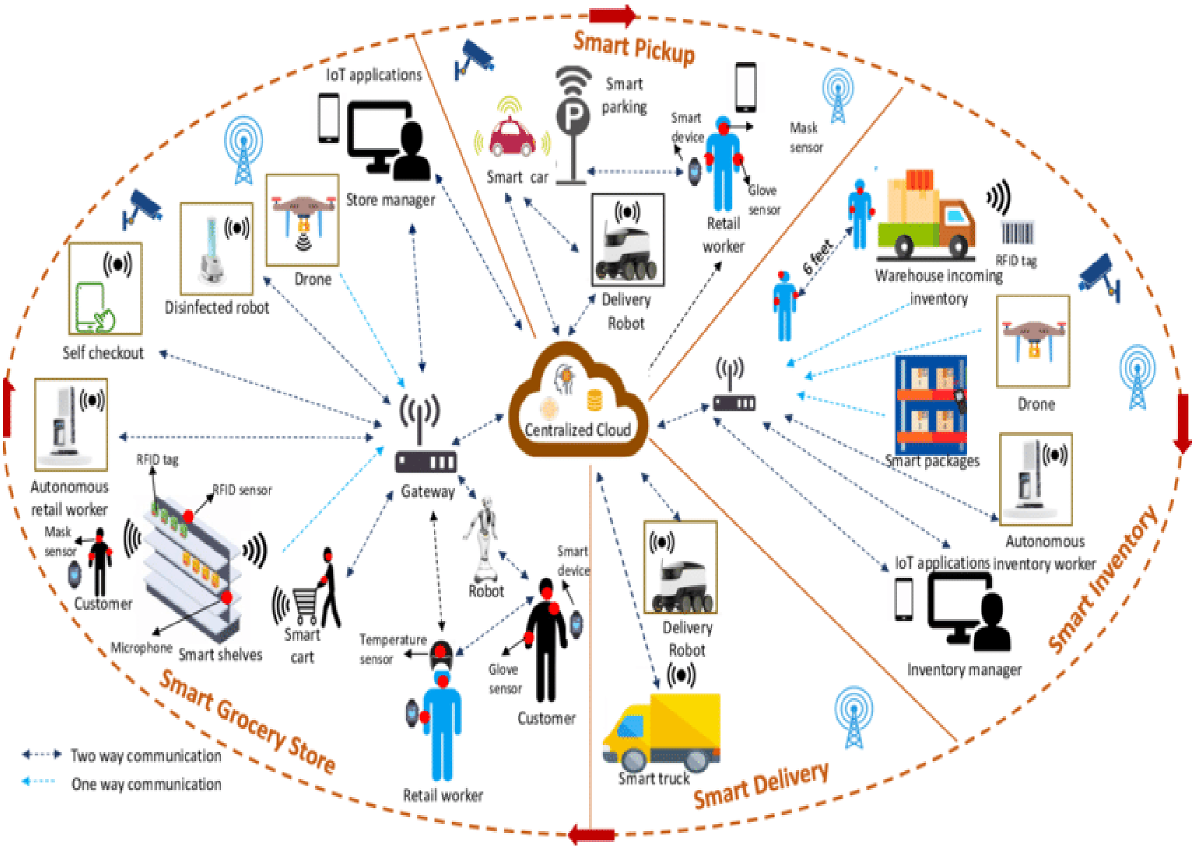

Figure05: Smart and Connected Supply Chain Management Scenario

6) Smart Barcode Readers

IoT barcode readers can help retailers better manage their inventory. The reader supports AI-based digital signal processing. These devices can simplify operations in many industries, including retail, logistics, warehousing, and more. The IoT based strip reader has cloud data connectivity to connect to other systems. Inventory management is easier with the included barcode reader. IoT barcode readers can be integrated into shopping carts. The reader uses artificial intelligence-based sensors to detect when products are dropped or removed from the cart. The card reader can automatically transfer the data to the computer, which can save a lot of checkout time and bring a better experience for customers.

Figure06:Smart Barcode Readers

7) Smart Grids:

Another industrial IoT use is the smart grid. The grid makes it possible to track data on the supply and demand for electricity in real time. It involves using artificial intelligence to manage resources more effectively.

Utility firms may handle outages more effectively by utilizing IoT smart grid technologies. They can determine load distribution and raise reliability using the technique. Additionally, the technology can help with issue finding and fixes.

Utilities can connect all of their assets, including their meters and substations, through the smart grid. Utility firms can have more control over the resources and equipment for producing electricity by integrating IoT technologies into the grid ecosystem. Additionally, they make energy more accessible to people with greater quality.

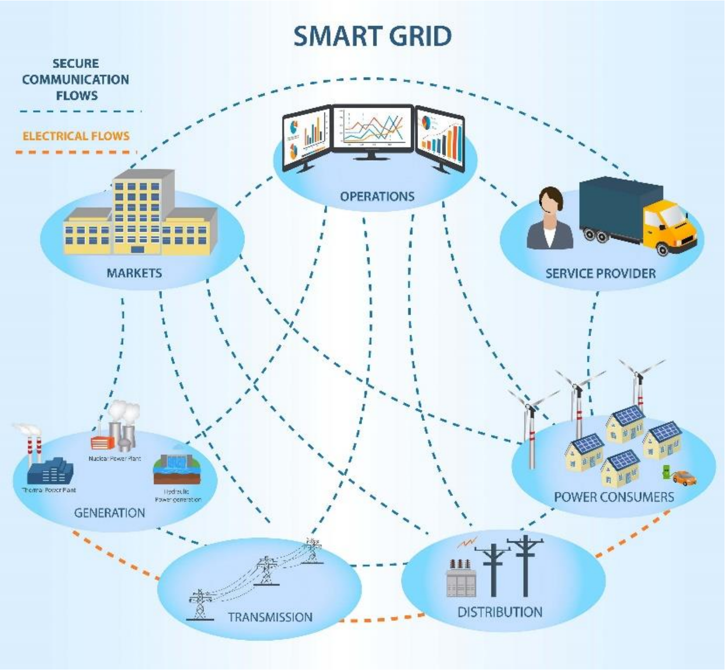

Figure07: Smart Grids

8) Connected HealthCare System:

In the field of healthcare, IoT has many uses. Smart medical devices can be utilized with the technology to deliver high-quality medical services.

The technology, also known as the Internet of Medical Things (IoMT), can assist in monitoring and supporting crucial data that can aid in clinical decision-making. Medical services can be made more accessible to the general public via IoT medical devices.

IoT medical equipment can support remote real-time patient monitoring. The gadgets can alert a doctor right away to an emergency, such as an asthma attack, heart failure, etc. Many people's lives might be saved as a result of this.

IoT devices can gather information about your weight, blood pressure, sugar levels, and oxygen use. A doctor has access to data that is saved online at any time. By enabling the delivery of efficient healthcare services to the patients, IoT automates the workflow.

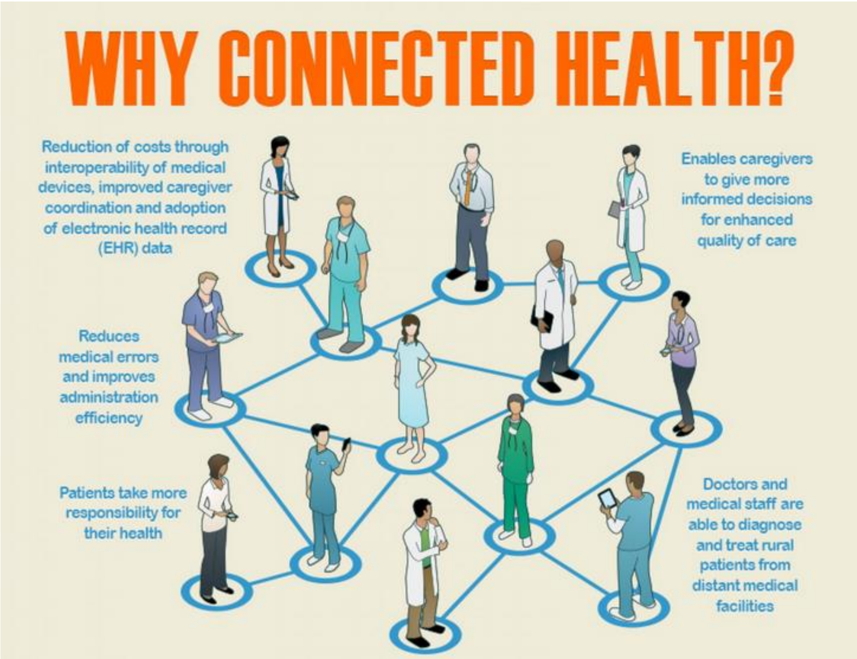

Figure08: Why connected health.

9) Smart Farming:

Farmers to optimize a variety of various tasks can use smart IoT farming apps, including figuring out when to harvest plants, developing fertilizer profiles based on the chemistry of the soil, and sensing soil nutrients and moisture levels.

Precision farming with the use of IoT technologies can lead to increased yield. According to a BI Intelligence analysis, the installation of IoT devices in agriculture is expected to expand at a rate of 20%, reaching 75 million units by 2022.

Smart Elements, AllMETOE, and Pynco are a few IoT farming gadget examples. These gadgets can pick up information about the environment, including the weather. The idea of smart farming has the potential to transform the agricultural sector. Applications of IoT technologies can improve agricultural production in terms of both quality and quantity.

Figure09: IoT-Driven Precision Agriculture Helps Feed the Globe

10) Smart energy management:

By connecting appliances to an internet-connected hub that monitors and manages energy flow, energy management via IoT focuses on energy conservation.

IoT energy management offers a number of advantages, including lower energy costs, decreased carbon emissions, regulatory compliance, improved asset maintenance, process automation, etc.

IoT is used by energy management systems in the following instances:

a- smart meters:

Real-time information on energy supply and use is provided by smart meters. Utility companies utilize this information to distribute energy in a way that maximizes gains and minimizes outages. Customers can change their energy usage and become more energy-conscious thanks to this knowledge.

b-Smart grids:

Energy suppliers can fulfill the increasing energy demands thanks to IoT-enabled smart grids. Utilizing this technology, they can pinpoint load distribution and boost dependability. Energy suppliers now have more control over the resources and electrical infrastructure thanks to smart grids.

c. Gas and oil

Intelligent energy management systems are used by the oil and gas sector to maximize production and guarantee secure extraction and delivery. To identify and address issues as soon as they arise, the businesses gain improved insights into the health of their infrastructure.

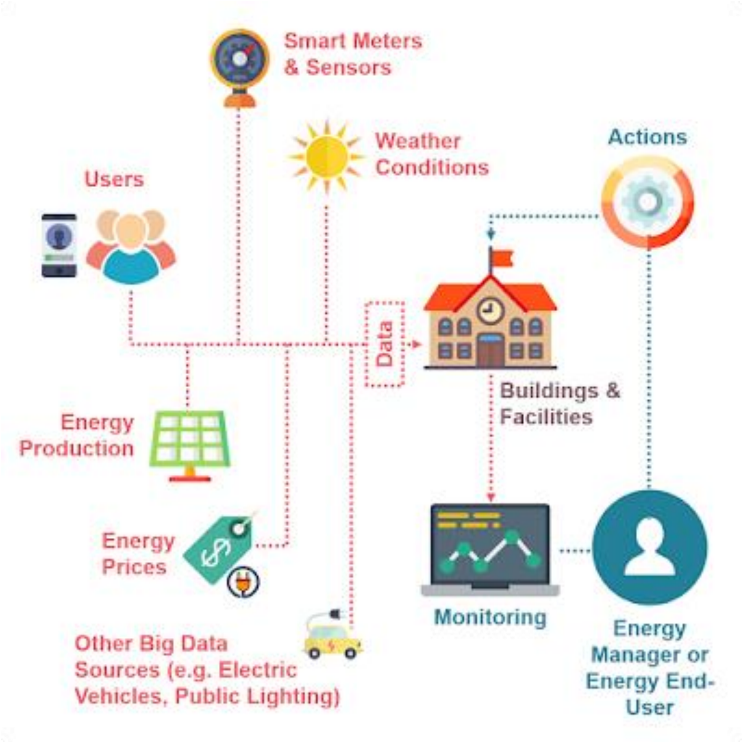

Figure 10:IoT energy management systems

1.7 Conclusions

This chapter was the subject of a study on IoT technology. We presented the different concepts and components as well as the characteristics of IoT systems, their application areas and their challenges.

In particular, we have studied communication and IoT systems management platforms that make it easier for developers to implement communication, thus accelerating and reducing the development costs of IoT products and applications. From the study of application domains, we can say that smart cities encompass almost all areas of IoT application. The following chapter II will therefore be the subject of a general study of photovoltaic systems

Chapter II : General information on the photovoltaic system

2.1 Introduction

The sun is an almost unlimited energy source, it could cover several thousand times our total energy consumption [6]. This is why man has long sought to make use of this important energy distributed throughout the planet, he was able to achieve this goal by means called photovoltaic cell. The name Photovoltaic comes from the Greek is composed of two parts:

Photos: Light.

Volt: Electric voltage unit, named Alessandro Volta.

This phenomenon was discovered in the 19th century by the physicist Alexandre Edmond Becquerel. The first photovoltaic cell was developed in early 1954 for the power supply of satellites. Since 1958, the Photovoltaic cells only power the satellite energy system until its first terrestrial applications in the early 1970s. Photovoltaics were used to power small, isolated houses and telecommunications equipment. [7]

Today, thanks to its reliability and environmentally friendly concept, photovoltaics is taking a leading place. To understand this phenomenon, we have recalled in this chapter some basic notions about solar radiation and the properties of semiconductors; basic materials of photovoltaic cells**.**

2.2 Solar energy:

The solar constant is the density of solar energy that reaches the outer boundary of the atmosphere facing the sun. The value of the illumination is commonly taken equal to 1360W/2m. At ground level, the solar energy density is reduced to 1000 W/2m because of absorption into the atmosphere. Albert Einstein discovered while working on the effect Photoelectric that light did not have only a wave character, but that its energy is carried by particles, photons. The energy of a photon being given by the relation: [8]

$$E = (h.c)/\lambda \qquad (1)$$

h: Planck's constant [j. s^(-1)].

C: the speed of light [m. s^ (-1)].

λ: the wavelength [m].

Thus, the shorter the wavelength, the greater the energy of the photon

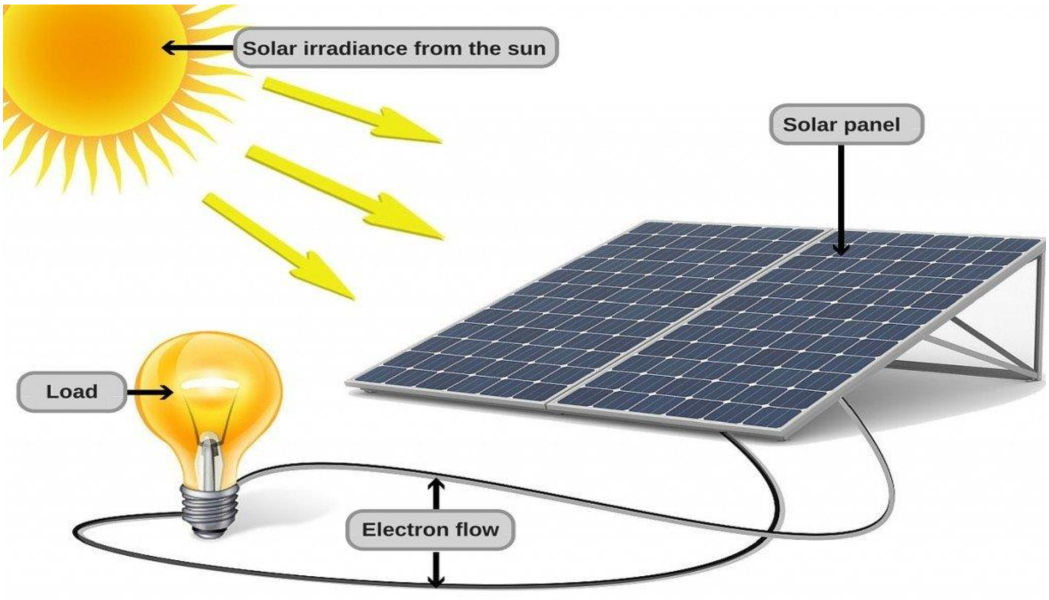

Figure 1: Solar energy

2.3 The history of photovoltaics:

Some important data in photovoltaics [9].

1839: French physicist Edmond Beckerel discovers the photovoltaic effect.

1875: Werner von Siemens published an article on Photovoltaic effect in semiconductors.

1954: Three American researchers Chapin, Psion and Prince built a cell Photovoltaic.
1958: Battery with 9 c/o efficiency; first cell powered satellite Solar energy is sent into space.

1973: The first house powered by photovoltaics is built University of Delaware.

1983: The first photovoltaic-powered car travels long distances 4000km in Australia

2.4 The different types of photovoltaic systems

2.4.1 Autonomous photovoltaic installations

The role of autonomous systems is to feed one or more consumers located in an area isolated from the electricity grid. The photovoltaic field see figure (2) can provide directly the electrical energy required to operate receivers (lighting and household equipment). A regulation system and a battery of accumulators allow storing the electrical energy, which will then be used in the absence of the Sun. Batteries are used to store electrical energy in chemical form. They return electrical energy as required according to its characteristics. The main function of the charge controller is to protect the battery from overloads and deep discharges. It is an essential element for the life of the battery .In isolated locations, AC receivers may also be used. In this case, the installation will include an inverter.

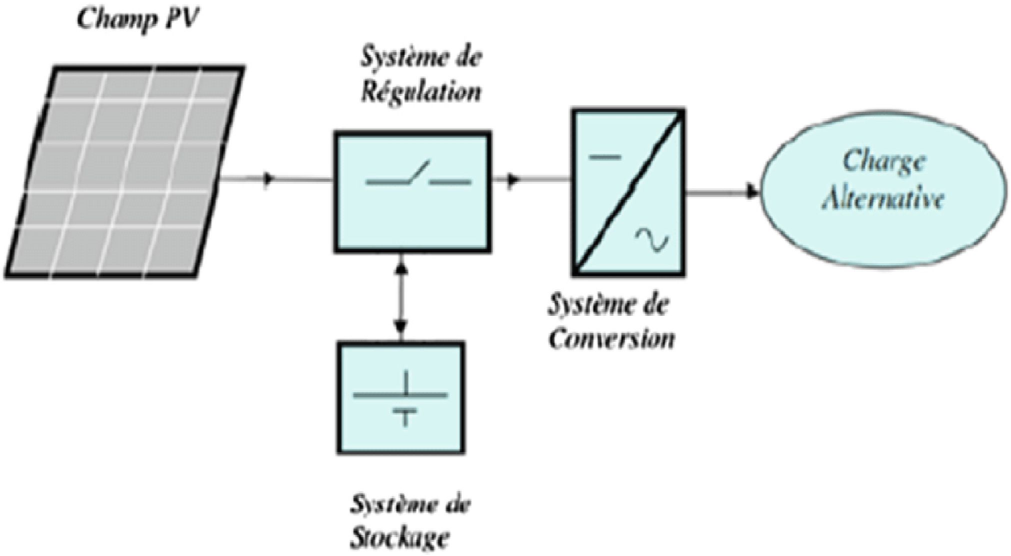

Figure 2: Simplified diagram of an autonomous photovoltaic installation

2.4.2 Grid-Connected Photovoltaic Systems:

Such a system is installed on a site connected to the network . Usually on homes or businesses that wish to use a form renewable energy and that benefit from good sunshine. A grid-connected photovoltaic generator does not need energy storage and thus eliminates the most problematic (and expensive) link. It's actually the network as a whole that serves

as a reservoir of energy. There are two types of photovoltaic current injection:

- Or inject all photovoltaic production into the grid.

- Either inject the surplus of photovoltaic production into the grid.

Two energy meters are required:

A meter counts the energy purchased from the energy supplier (consumption) and another meter measures the energy returned to the electricity grid when the exceeds consumption.

A third meter is added if the energy produced is injected in integrity in the network (non-consummation counter).

An inverter for the conversion of DC panels to AC must be certified by the electricity company that will receive this current. In order to ensure its "sinusoidal" quality.

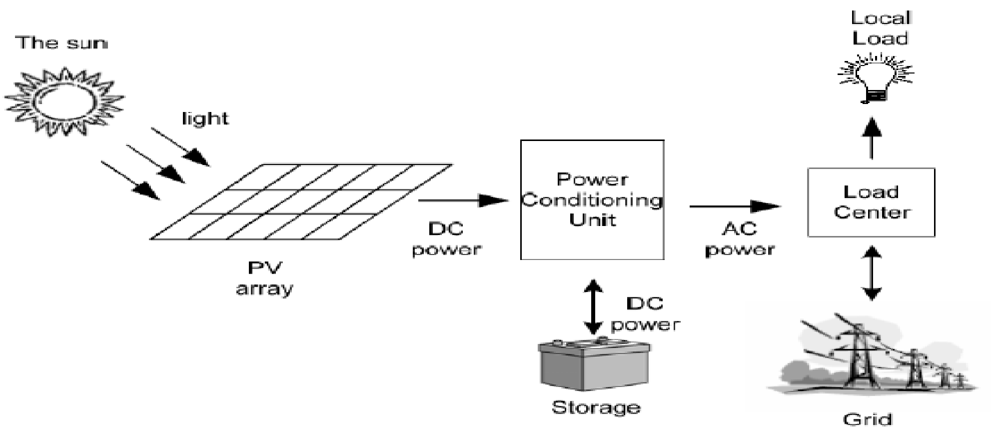

Figure 3: Grid-Connected Photovoltaic Systems

2.4.3 Hybrid photovoltaic systems:

These are systems that bring together different sources of energy such as a wind plant, diesel generator or cogeneration plant in addition to photovoltaic generator.

This type of installation is used when the photovoltaic generator alone does not cover all the energy required

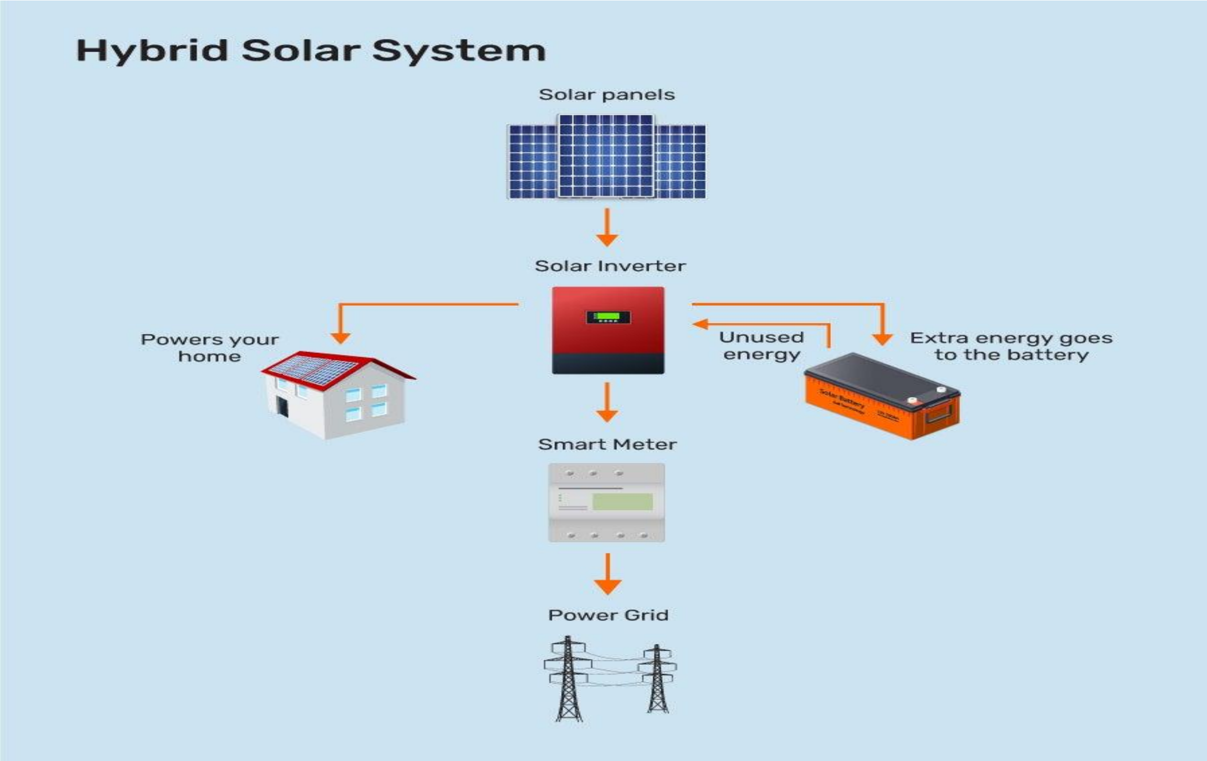

Figure 4: Hybrid photovoltaic systems

2.5. Elements of a photovoltaic system:

The basic element of a photovoltaic system is a photovoltaic cell. In general, several photovoltaic cells can be connected in series and/ or in parallel to form a photovoltaic module. On the other hand, a photovoltaic generator consists of several photovoltaic modules in series and/ or in parallel.

2.5.1The photovoltaic cell:

A photovoltaic cell is based on the physical phenomenon called the effect photovoltaic, which consists in establishing an electromotive force when the surface of this cell is exposed to light. The voltage generated can vary between 0.3V and 0.7V dep used and its arrangement as well as the temperature of the cell and the aging of the cell. Figure (5) illustrates a typical PV cell where its constitution is detailed. ending on the material[10].

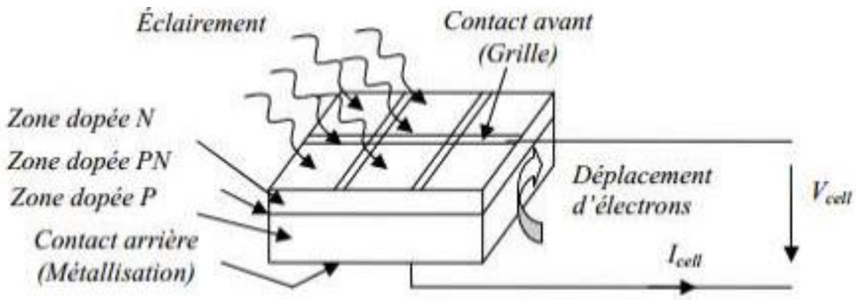

Figure 5: Cross-section of a PV cell

A PV cell is made from two layers of silicon, a doped P (doped to the boron) and the other doped N (doped with phosphorus) thus creating a junction PN with a barrier of potential. When photons are absorbed by the semiconductor, they transmit their energy to the atoms of the PN junction in such a way that the electrons of these atoms are released and create electrons (N charges) and holes (P charges). This then creates a potential difference between the two layers. This potential difference is measurable between terminal connections positive and negative cells

2.5.2 Cell types:

There are three main categories of silicon cells: mono crystalline, poly crystalline and amorphous [1-3]. In the following, the principle of each type of cell is presented.

2.5.2.1 Monocrystalline silicon cell

For such technical applications, pure silicon is obtained from quartz or silicon by metallurgical chemical transformation. Crystalline silicon has about twice the electrical efficiency and lifespan of amorphous silicon, but it is much more expensive . shows the internal structure of a single crystalline silicon cell. As the figure shows, monocrystalline silicon consists of silicon in which the crystalline network of the whole solid is continuous. This crystalline structure does not break on its edges and is free from any grain limit

2.5.2.2 Polycrystalline silicon cell

Polycrystalline silicon or polysilicon is a misaligned silicon glass material (polycrystalline) as shown in Figure 1.7 below. It occupies an intermediate position between amorphous silicon, in which there is no long-range order, and monocrystalline silicon.

Polycrystalline silicon is a material composed of juxtaposed crystals obtained by moulding. This material is cheaper than single crystals. Square or rectangular cells are easy to use**.**

2.5.2.3 Amorphous silicon cell

A thin film solar cell is a second generation of solar cells that consists of depositing one or more thin layers, or a thin film (TF) of photovoltaic material on a substrate, such as glass, plastic or metal.

The ability of amorphous silicon to absorb solar radiation is 100 times greater than that of crystalline absorption. The cells are composed of very thin layers. Thus, the film thickness varies from a few nanometres (nm) to several tens of micrometres (µm). This type is used in the construction of integrated photovoltaic systems. Other commercial applications use rigid thin-film solar panels (inserted between two glass panels) in some of the world's largest photovoltaic installations.

2.5.3 Electrical characteristics of a photovoltaic cell

The electrical characteristic depends on the power of the radiation received per unit area (illumination (W/ m²). Its main parameters are:

The short circuit current Icc, which is proportional to the surface and illumination of the cell, is obtained by placing the PV module in a short circuit (Voc=0), this is

− The open circuit voltage Voc which is proportional to the temperature. It represents the maximum voltage generated by the photovoltaic panel. This voltage is obtained under open circuit conditions (Icc = 0).

− The maximum power point PPM, which represents the point for which the product V*I is maximum, is located on the bend of the curve. At this maximum power we have a maximum voltage Vmpp and a maximum current Impp given by the following equation:

$$Pmax = Vmpp * Impp \qquad (2)$$

Each panel is characterized by four values (Voc, Isc, Impp and Vmpp), which are obtained

under Standard Test Conditions (STC), that is, an illumination of 1000 W/m² and a temperature of 25°C.A

-Form factor FF (Fill Factor) this is the ratio of the maximum power supplied to the PV module and the product of the Icc short circuit current and the open circuit voltage Voc given by:

$$FF = \frac{Pmax}{Icc} * VOC \qquad (3)$$

-Energy efficiency this is the ratio of the maximum electrical power Pmax

2.6. Modelling of the photovoltaic generator:

2.6.1. Model of a photovoltaic cell

The equivalent circuit of a photovoltaic cell is presented in the Figure 2. It includes a current source, a diode, a serial resistor and a shun resistance. [11]

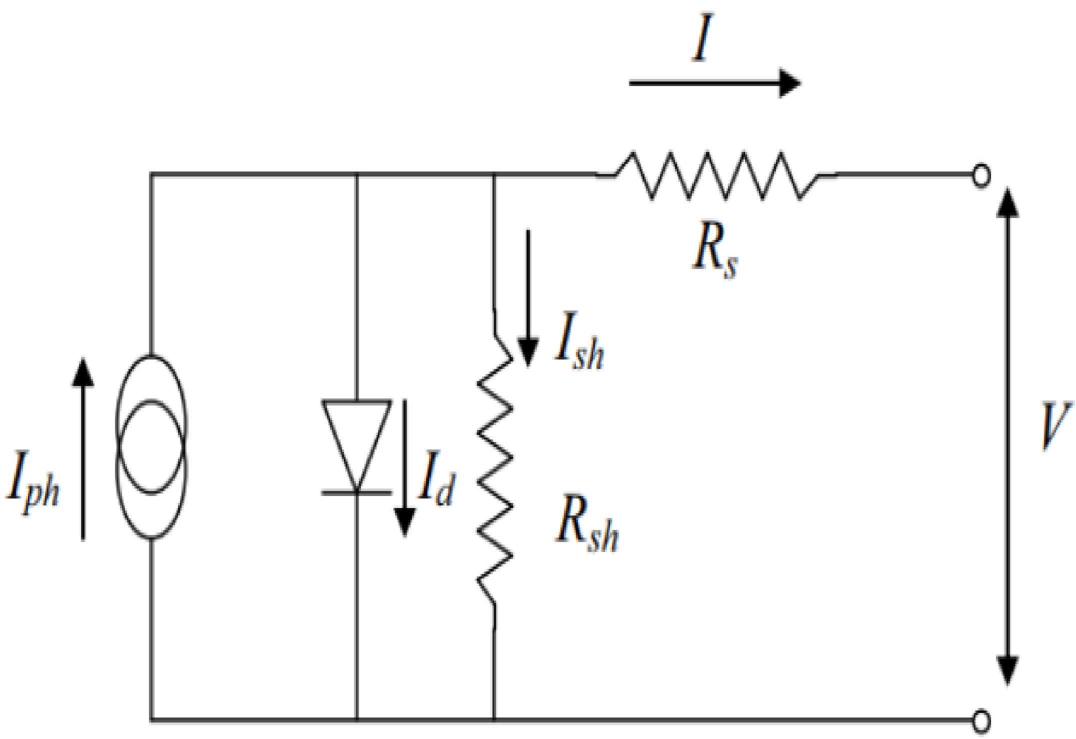

Figure 6: the equivalent circuit of PV cell module

Cells can be electrically modelled with five elements including diode constants (I0, vt), photo current (Iph), series resistance (Rs), and shunt resistance (Rsh)

$$I_{PV}{=}I_{PH}{-}I_0\left(e^{\frac{v_{pv}\ -I_{pv}\,R_S}{N_S V_t}}-1\right)-\frac{V_{PV}+I_{PV}R_S}{R_{sh}} \qquad (4)$$

Here $v_1 = \frac{akT}{q}$

I_{ph}: Current generated by solar energy [A]

I_0: Diode saturation current [A]

V_t: Ideal unit Cell thermal voltage [V]

a: Diode quality factor(1~1.5)

k: Boltzmann's constant (1.381×10-23) [J/K]

T: Kelvin Temperature at standard test condition (=25°C+273.15) [K]

Q: Charge of the electron (1.602×10-19) [C]

n_s: Number of PV cells connected in series

Rsh: Cell parallel(shunt) resistance [Ω]

Rs: Cell series resistance [Ω]

2.6.2. single-diode:

The ideal equivalent circuit of a solar cell is a current source in parallel with a single-diode. The configuration of the simulated ideal solar cell with single-diode is shown in Figure 7.

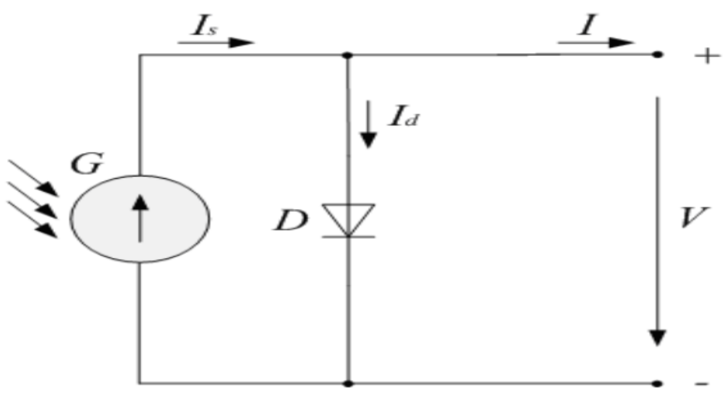

Figure 7: Ideal solar cell with single-diode.

The governing equation for this equivalent circuit is formulated using Kirchhoff's current law [12] for current I:

$$I = I_L - I_{D-}I_{sh} \qquad (5)$$

Where

I_L : represents the light-generated current in the cell

I_{sh} : represents the current lost due to shunt resistances. In this single diode model

I_D: is modelled using the Shockley equation for an ideal diode:

$$I_D = I_0\left(e^{\frac{v_{pv} \ -I_{pv} R_S}{N_S V_t}} - 1\right) \qquad (6)$$

Where:

n : is the diode ideality factor (unit less, usually between 1 and 2 for a single junction cell),

I_0 : is the saturation current

V_T: is the thermal voltage given

A solar cell can at least be characterised by the short circuit current Isc, open circuit voltage Voc and Diode ideality factor m.

At the same irradiance and pn junction temperature condition, the short-circuit current Isc is max. The current value produced by the battery. Short the circuit current Isc is given by:

$$Isc \ = \ I \ = \ Is \, for \, V \ = \ 0 \qquad (7)$$

at the same irradiance and pn junction temperature condition, the open circuit voltage Voc is at the highest Voltage value at the battery terminals. Opening ceremony The circuit voltage Voc is [13]given by:

$$v = v_{sc} = \frac{akT}{q}\ln(1 + \frac{I_{SC}}{I_0}) \quad for \, I \ = \ 0 \qquad (8)$$

The output power comes from:

$$P = v[I_{sc} - I_0\left(e^{\frac{akT}{q}} - 1\right)] \qquad (9)$$

2.6.3 Characteristic of the photovoltaic

The characteristics I=f (V) and P=f (v) of a photovoltaic generator Figure 1.8 shows the curves

I = f (V) and P = f (V) of a photovoltaic module typical under constant irradiation and temperature conditions. Radiation standard used to measure the response of a photovoltaic module to an intensity of radiation of 1000 W / m2 and a temperature of 25 ° C [13].

PV module specifications under standard test conditions (STC):

Maximum power, Pmax	60w
Voltage of Pmax ,Vmp	1.17V
Current of Pmax , Imp	3.5A
Short circuit current, Isc	3.8A
Open circuit voltage, Vco	21.1V
Open-circuit temperature coefficient Voc, Kv	-80Ma/°C
Short-circuit temperature coefficient Isc, Ki	2.4mA/°C
Number of cells	36

Table 1: Solarex MSX-60 PV Module Specifications

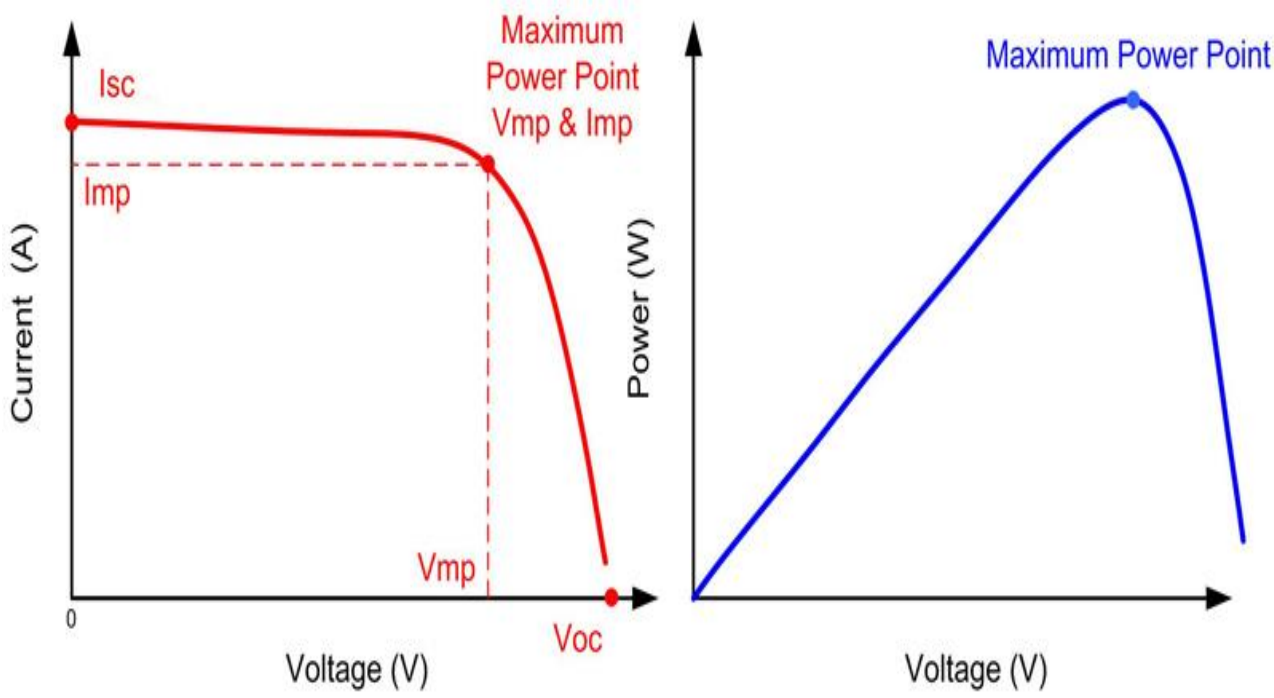

Figure 8: The current-voltage characteristic of a photovoltaic cell

2.7. DC-DC converters

The (Figure 9) shows the representation of a DC/DC converter, which can be used as an interface between source and load [14]

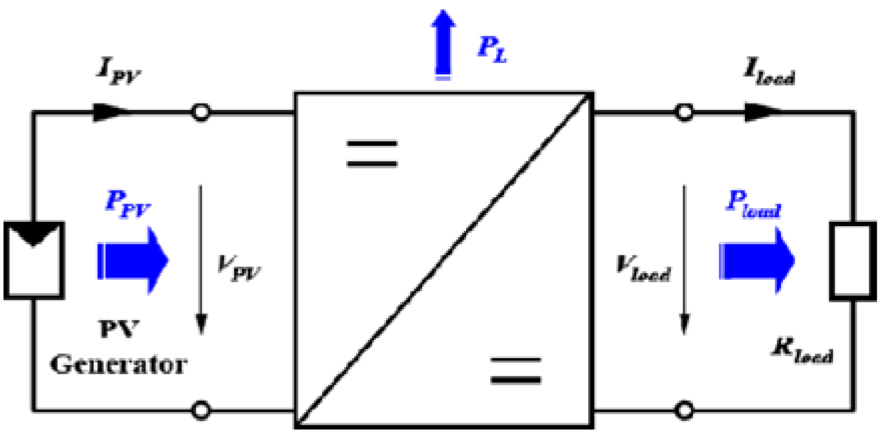

Figure 9: DC/DC Converter

The role of the DC/DC converter (in the context of PV) is to make the adaptation between the source (GPV) and the load for maximum power transfer. This is done by keeping the power supplied on or close enough to the MPP for any operating conditions unlike the general case where the DC/DC converter is used to regulate the output voltage; here it is rather the input voltage that is regulated. The reference voltage (set point) is then constant or imposed by a control algorithm.

If the internal PL losses of the converter are negligible, then the input powers and output are equal.

There are several types of DC-DC converters. Among which, we present the principle of the three types of switching converter (desolator, booster and mixed), frequently used in photovoltaic systems to generate the desired voltages and currents as well as for the adaptation of solar panels with the deferent loads.

2.9 MPPT algorithm:

The MPPT technique is a controller that varies the duty cycle of the DC-DC converter in order to extract the maximum power from PV panels. In this paper, a classical algorithm named the HC algorithm is used to make the MPPT control of the PV system. But, as reported in the literature, this algorithm suffers from drift problem when the fast variation in insolation Therefore, a modified HC algorithm is proposed to solve this problem.

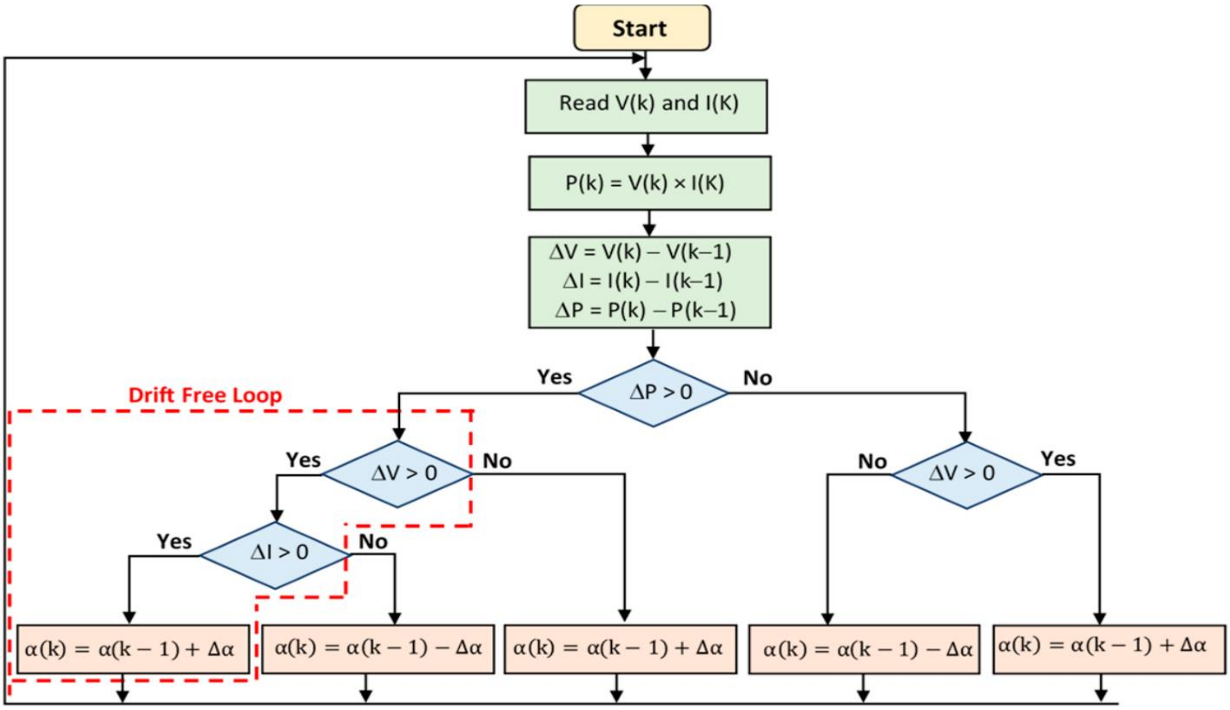

Figure 10. The flowchart of the modified HC MPPT algorithm.

10. Conclusion:

we have presented in this present the various elements that go into the building a PV system such as the cell and PV module and their different connections, different types of PV systems like the stand-alone system, connected to the network and hybrid . then we became interested in the different technologies of the elements constitutive of a PV system, finally we have cited the advantages and disadvantages PV systems in general, and The modelling of each component of the complete photovoltaic system was developed from literature models this modelling is an essential step that allows to introduce a number of models then evaluate the characteristic of each element of the installation as well as the constituent parameters.

Chapitre III

PREPARATION AND IMPLEENTATION PART

3.1 Introduction

The use of renewable resources to generate electricity is increasing as non-renewable energy sources are exhausted. Solar panels are becoming more and more popular. Solarpanels collect energy from the sun, convert it into electricity and store it in batteries. This energy can be used on demand or as a direct replacement for utility electricity. Dueto the rotation of the earth, the position of the sun relative to the solar panel changes. Forsolar panels to be most effective, they must be continuously aligned with the sun. Continuous alignment is the only way to maximize solar energy production. Therefore,solar panels should always face the sun. To get the most out of a solar power plant, keeping an eye on it is crucial. To keep a close eye on the performance of these power plants, solar panel defects such as dust and other contaminants can degrade solar panel performance. Using an IoT-based Solar Monitoring System,

The characterization or monitoring of photovoltaic systems will always be done in threestages: the collection of information (current, voltage.), the storage of data and the exploitation of the latter. This process is continuously performed by the different blocksof the monitoring board. In this third and last chapter, it will first be a question of validating the different blocks of the map. Then, these validated blocks will be put together to form a single card working together. The block allowing the acquisition of the voltage values will be studied and validated first. Then comes the block that allows the acquisition of current values. The environment block will be processed last. Validations will be carried out in accordance with the methodology presented in the previous chapter.

3.2Monitoring System:

The data processing modules and transmission protocols of the solar PV monitoring system have been thoroughly reviewed. With the data transfer module, connected devicesand networks can be recorded, controlled and managed in a real-time environment. Theyalso act as a kind of cloud computing middleware, connecting different devices through the cloud.

The solar panel is the main equipment of the solar power generation system, which is designed to convert sunlight directly into electricity. The solar panel performance monitoring system is designed with current and voltage measurement sensors integrated into an Excel spreadsheet using the PLX-DAQ application. An Arduino Uno based system designed and connected to a computer via USB. The advantage of this monitoring system is that the measurement results from the sensors can be processed directly and displayed in the form of data and graphs under real-time conditions. This facilitates dataprocessing.

3.3 Arduino

3.3. 1 Definition of Arduino

Arduino is an open source programmable circuit board that can be integrated into a variety of simple and complex makerspace projects. The board contains a microcontroller that can be programmed to sense and control objects in the physical world. By responding to sensors and inputs, the Arduino can interact with various outputs, such as LEDs, motors, and displays.

Due to its flexibility and low cost, Arduino has become a popular choice for makers and makerspaces looking to create interactive hardware projects. Arduino was launched in Italy in 2005 by Massimo Banzi as a way for non-engineers to get cheap, simple tools to create hardware projects. Since the board is open source, it is released under a Creative Commons license, allowing anyone to create their own board[15]

3.3.2 Arduino Hardware

They are programmable electronic cards (therefore equipped with a processor and memory) on which we can connect temperature, humidity, vibration or light sensors, a camera, buttons, adjustment potentiometers, contacts electric…

There are also connectors for connecting LEDs, motors, relays, displays, a screen...

An Arduino board is a brain that makes electronic systems intelligent and animates mechanical devices.

Figure 1: An Arduino Uno board with its connectors.

3.3.3 Arduino Software

The creators of Arduino have developed software to make programming Arduino boardsvisual, simple and complete at the same time. This is called an IDE, which stands for Integrated Development Environment or “Integrated” Development Environment in French[16] (therefore IDE).

The Arduino IDE is the software used to program Arduino boards.

The IDE displays a graphics window that contains a text editor and all the tools needed for programming activity.

You can therefore enter your program, save it, compile it, check it, and transfer it to an arduino board...

At the time of writing this page, the most recent version of the Arduino IDE is 1.8.10. The look is pretty much the same on every platform (Windows, Mac, and Linux). The following image shows the initial screen that appears when launching the IDE.

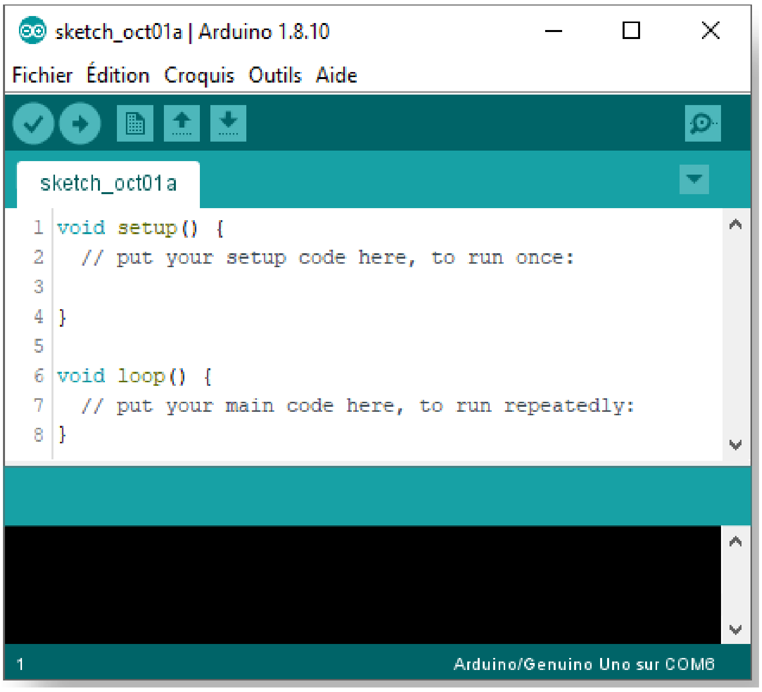

Figure 2: The main screen of the Arduino IDE at startup

3.3.4. The key features of Arduino IDE are:

The main features of the Arduino IDE are:

1) Analog or digital input signals can be read by the Arduino board and converted to outputs that can be connected to the cloud or used in many other ways.

2) Your board can be controlled via the Arduino IDE by sending commands to its microcontroller over the internet.

3) Unlike previous programmable boards, Arduino uses a USB cable to load new programs onto the board.

4) A simplified version of C++ is used in the Arduino IDE to make it easier to learn.

5) Additionally, Arduino provides a standard from factor that breaks down the functionality of a microcontroller into more accessible package.

3.4PRESENTATION:

Proteus Professional is a software suite for electronics. Developed by Lab center Electronics, the software included in Proteus Professional allows CAD (Computer Aided Construction) in the electronic field. Two main software make up this software suite: (ISIS, ARES, PROSPICE) and VSM. This software suite is well known in the field of electronics. Many companies and training organizations (including high schools and universities) use this software suite. Besides the popularity of the tool, Proteus Professional has other advantages

-Pack containing software that is easy and quick to understand and use

-Excellent technical support

-Virtual prototype creation tool helps reduce hardware and software costs when designing a projectISIS.

The ISIS software from Proteus Professional is mainly known for editing electrical diagrams. In addition, the software also makes it possible to simulate these diagrams, which makes it possible to detect certain errors from the design stage. Indirectly, the electrical circuits designed with this software can be used in documentation because the software makes it possible to control the majority of the graphic aspect of the circuits.

ARES

The ARES software is an editing and routing tool that perfectly complements ISIS. An electrical diagram produced on ISIS can then be easily imported on ARES to create the PCB (Printed circuit board) of the electronic card. Although PCB editing is more efficient when done manually, this software allows for automatic component placement and automatic routing.

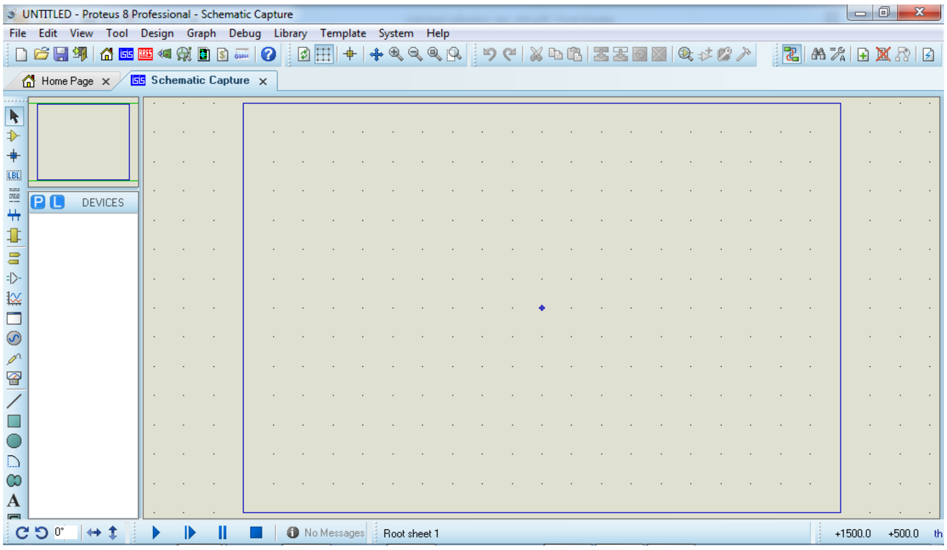

Figure 3: PRESENTATION

3.5 Choice of sensors

In order to facilitate the connection between the Arduino board on one side and the solar panel and battery on the other side, the appropriate sensors should be chosen [18].

3.5.1 Choice of voltage sensor

The voltage sensor is used to reduce the PV voltage to another voltage between (Vd) [0, 5] which can be supported by Arduino, because Arduino cannot read the voltage more than 5 V, so the voltage divider circuit shown in Figure 4was used.

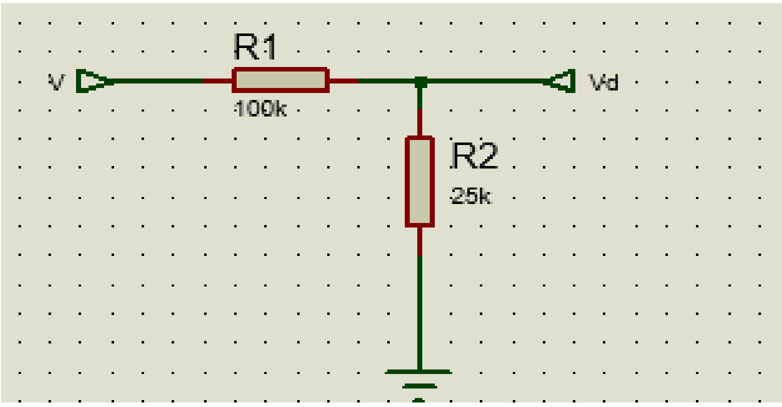

Figure 4 : Choice of voltage sensor

La conception des résistances R1 et R2 se fait comme suit :

$$V_{AD0} = \frac{R_2}{R_1 + R_1} * V_{PV} \qquad (3.1)$$

Since the voltage range of the PV panel (V) is [0, 21.1], the voltage ratio of the divider must be less than or equal to 0.23 in order to simplify the choice of resistors, a voltage ratio of a divider equal to 0.2 was selected. In addition and in order to minimize the loss of energy (such as the voltmeter) the resistors must be of great values. Therefore, one chooses

$$R_2 = R_1 \times 0.23 \quad (3.2)$$

Where R5 is chosen with a value equal to 25kΩ and R6 is selected with a value equal to 100kΩ.

3.5.2Current sensor choice:

The current sensor is used to provide the Arduino with the current image of the PV panel. In this study, we design a current sensor as shown in Figure 3.4. The design of this sensor consists of putting a resistor (R13) between the panel and the charge as shown in Figure 5 so that the current that passes through this resistor is the PV current. So the subtract or circuit of the operational amplifier is used to calculate the voltage at the terminals of this resistor, and this voltage is supplied to the Arduino in order to obtain the value of the PV the current of the panel.Note that R13 must be small in order to minimize energy loss.

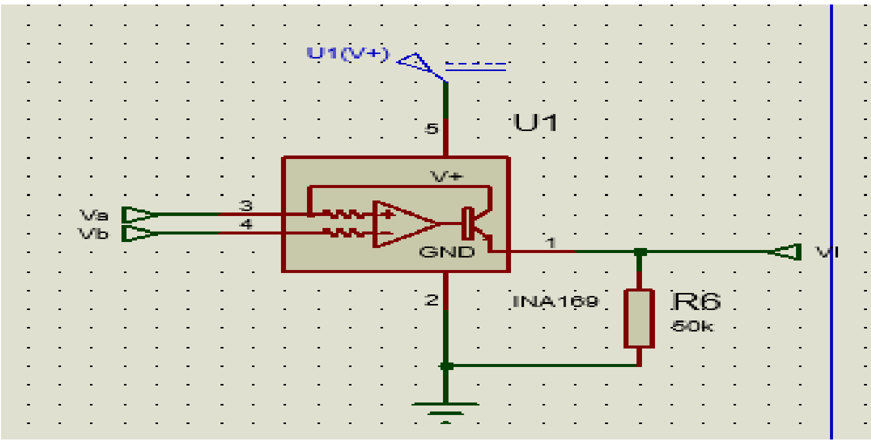

Figure 5 : Operational amplifier subtractor circuit

3.6 SIMULATION RESULTS

3.6.1System Design in Proteus Software

Photovoltaic voltage and current can be monitored remotely by leveraging wireless communication technology. The Proteus model of the PV panel is placed in a sub-circle, and is then connected to the Arduino panel that acquires load through the Boost adapter. Photovoltaic voltage and current through voltage and current sensors, PV, voltage and photovoltaic current are displayed on Numerical Output Display

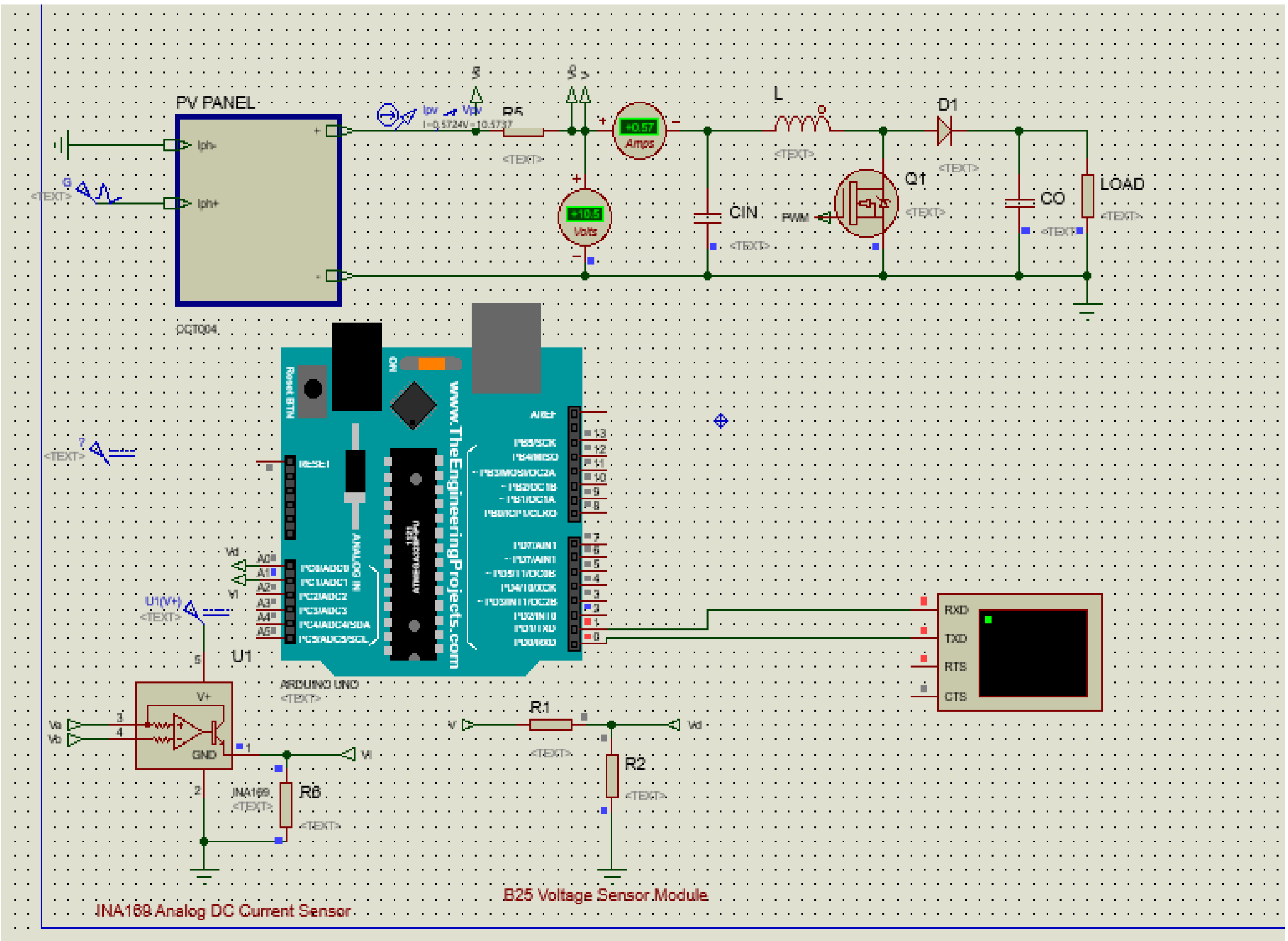

Figure 6: Schematic of PV system design in Proteus software.

3.6.2PROTEUS OUTPUT ANALYSIS

The evaluation of proposed System communication performance frameworks by tracking the state of the microgrid. The state space parameters used in simulation and used chosen from experimental setup.

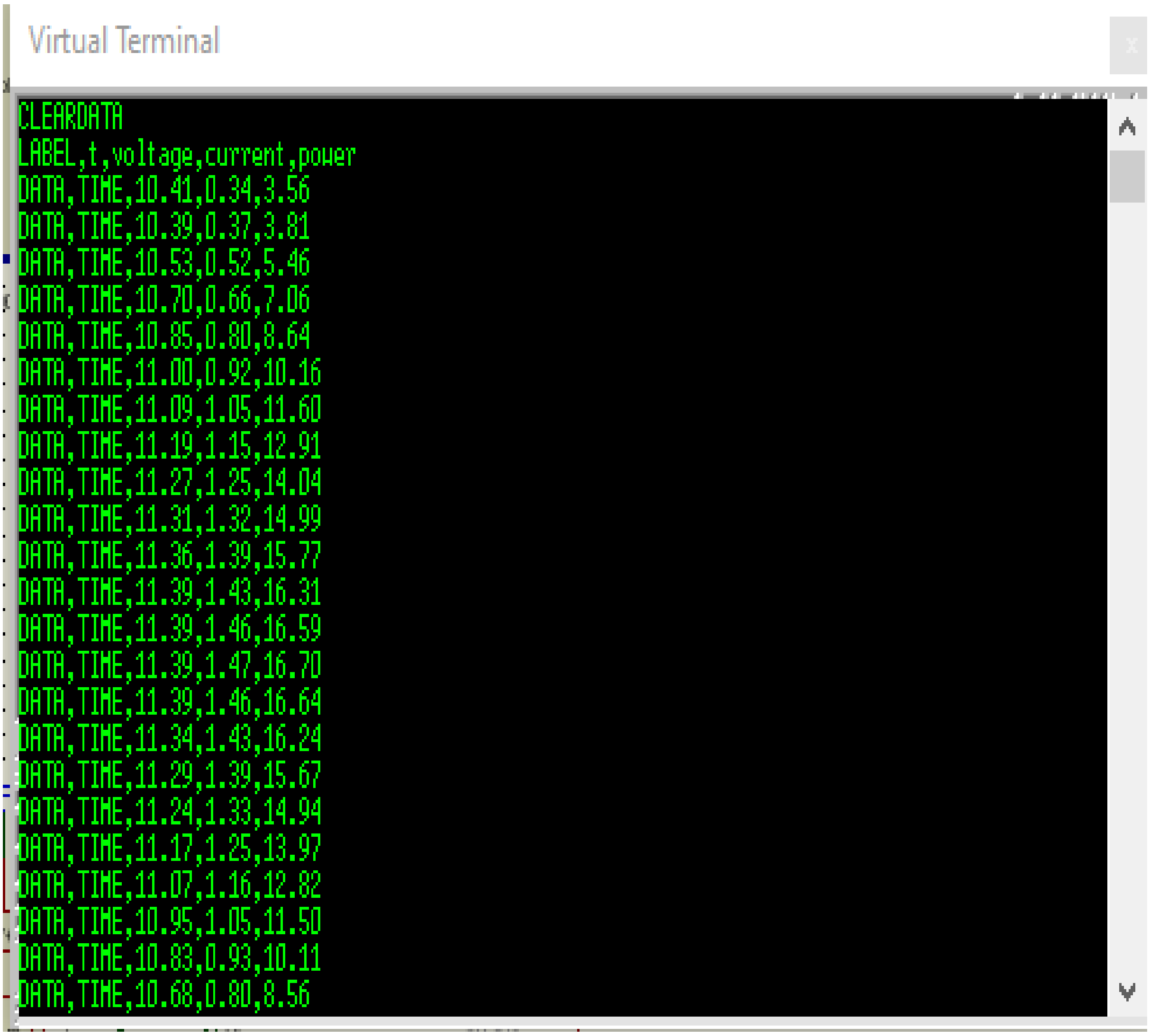

Figure7: Numerical Output Display

3.6.3 Experimental Results

Create Excel report files and view all this data and the dynamic system behavior in real time. This toolkit translates into a robust modelling, an advanced simulation incorporating system with regard to solar resource, local weathe

	A				
1	voltage	28	9,8	55	0
2	10,41	29	8,97	56	0
3	10,39	30	4,57	57	0
4	10,53	31	0	58	0
5	10,7	32	0	59	0
6	10,85	33	0	60	0
7	11	34	0	61	1,42
8	11,09	35	0	62	6,11
9	11,19	36	0	63	10,31
10	11,27	37	0	64	10,51
11	11,31	38	0	65	10,7
12	11,36	39	0	66	10,87
13	11,39	40	0	67	11
14	11,39	41	0	68	11,09
15	11,39	42	0	69	11,19
16	11,39	43	0	70	11,27
17	11,34	44	0	71	11,34
18	11,29	45	0	72	11,36
19	11,24	46	0	73	11,39
20	11,17	47	0	74	11,41
21	11,07	48	0	75	11,41
22	10,95	49	0	76	11,39
23	10,83	50	0	77	11,36
24	10,68	51	0	78	11,31
25	10,53	52	0	79	11,24
26	10,34	53	0	80	11,17
27	10,12	54	0	81	11,07
28	9,8	55	0	82	10,97

Figure 8: Excel report of PV voltage.

The results of a monitoring test for voltage of PV panel are presented in the Figure below. From the experimental results

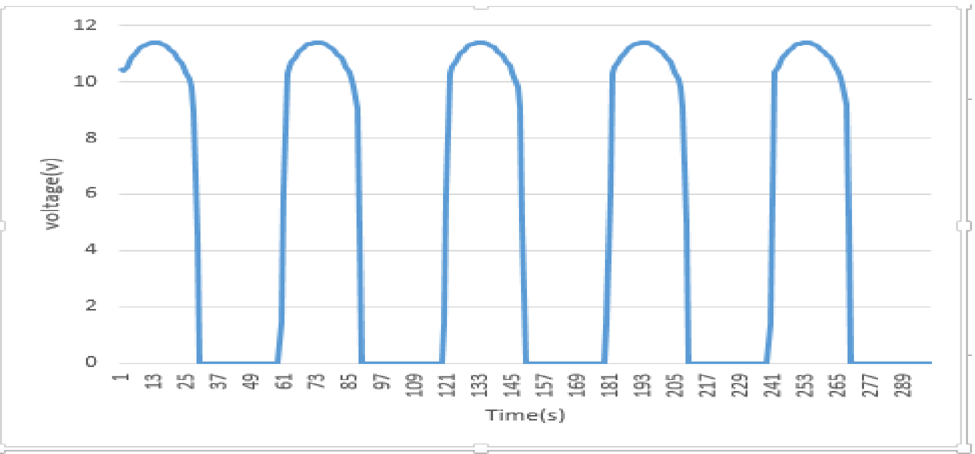

Figure 9: Monitoring voltage of PV panel

1	current	29	0,7	57	0
2	0,34	30	0	58	0
3	0,37	31	0	59	0
4	0,52	32	0	60	0
5	0,66	33	0	61	0,09
6	0,8	34	0	62	0,22
7	0,92	35	0	63	0,37
8	1,05	36	0	64	0,51
9	1,15	37	0	65	0,66
10	1,25	38	0	66	0,8
11	1,32	39	0	67	0,92
12	1,39	40	0	68	1,04
13	1,43	41	0	69	1,15
14	1,46	42	0	70	1,25
15	1,47	43	0	71	1,32
16	1,46	44	0	72	1,38
17	1,43	45	0	73	1,43
18	1,39	46	0	74	1,46
19	1,33	47	0	75	1,47
20	1,25	48	0	76	1,46
21	1,16	49	0	77	1,43
22	1,05	50	0	78	1,39
23	0,93	51	0	79	1,33
24	0,8	52	0	80	1,25
25	0,66	53	0	81	1,16
26	0,52	54	0	82	1,05
27	0,37	55	0	83	0,93
28	0,22	56	0	84	0,8

Figure 10 : Excel report of PV current

The results of a monitoring test for current of PV panel are presented in the Figure below. From the experimental results.

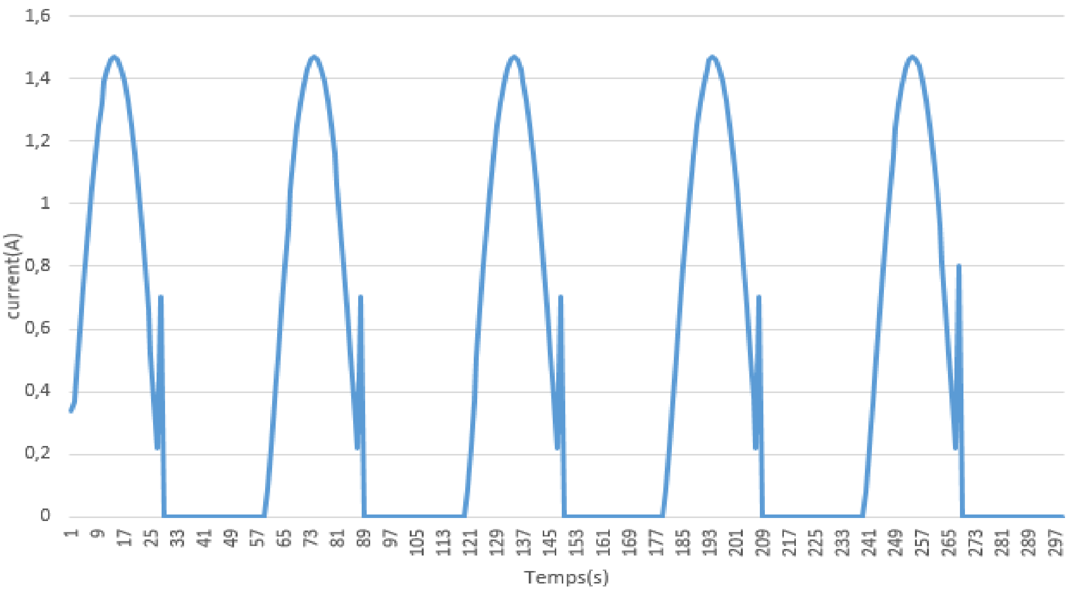

Figure11: Monitoring current of PV panel

1	power	29	0,61	57	0
2	3,56	30	0	58	0
3	3,81	31	0	59	0
4	5,46	32	0	60	0
5	7,06	33	0	61	0,12
6	8,64	34	0	62	1,37
7	10,16	35	0	63	3,78
8	11,6	36	0	64	5,39
9	12,91	37	0	65	7,06
10	14,04	38	0	66	8,66
11	14,99	39	0	67	10,16
12	15,77	40	0	68	11,55
13	16,31	41	0	69	12,91
14	16,59	42	0	70	14,04
15	16,7	43	0	71	15,02
16	16,64	44	0	72	15,72
17	16,24	45	0	73	16,31
18	15,67	46	0	74	16,62
19	14,94	47	0	75	16,73
20	13,97	48	0	76	16,64
21	12,82	49	0	77	16,27
22	11,5	50	0	78	15,76
23	10,11	51	0	79	14,94
24	8,56	52	0	80	13,97
25	7	53	0	81	12,82
26	5,41	54	0	82	11,58
27	3,76	55	0	83	10,13
28	2,11	56	0	84	8,58

Figure 12: Excel report of PV power

The results of a monitoring test for power of PV panel are presented in the Figure below. From the experimental results.

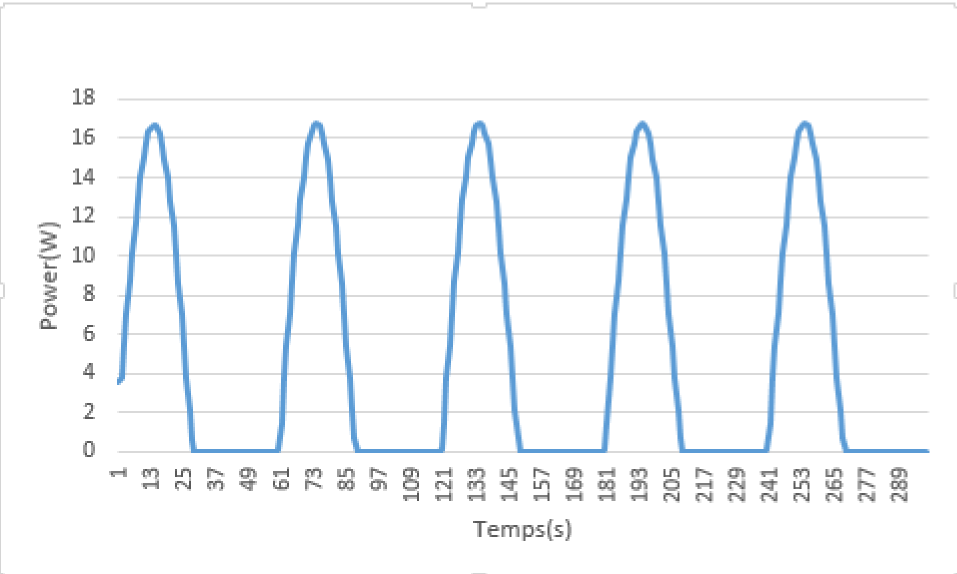

Figure 13: Monitoring power of PV panel

	Time	Maximum	Minimum
voltage	1s-289s	11.93	0.0
current	1s-289s	1.30	0.0
power	1s-289s	17.30	0.0

Table 2: The results we get.

3.7 Arduino program code:

The Arduino UNO board provides an easy way to communicate with a computer or other microcontroller.ATMega328 microcontroller for Arduino UNO The board provides serial UART TTL (5V) communication. 10. Integrated circuits The ATmega8U2 on the board connects this serial communication from the Arduino UNO's serial port to the computer's USB port, which appears as a virtual COM port in the PLX-DAQ window. Embedded program code On an Arduino UNO board that allows acquisition the measurement data of the photovoltaic panel from the sensor and sent to PLX-DAQ spreadsheet, as follows:

sketch_jun11a §

```
/*initialization function*/

void setup() {
//serial connection setup
//opens serial port, sets data rate to 9600 bps
Serial.begin(9600);
//clear all data that's been place in already
Serial.println("CLEARDATA");
//define the column headings (PLX-DAQ command)
Serial.println("LABEL,t,voltage,current,power");
}
/*the main code*/
void loop() {
//measuring voltage using "B25 0 to 25V" Voltage Sensor
//measuring current using "INA169" Current Sensor
//reading of the current and voltage from sensors
float voltage = analogRead(A0)*5*5.0/1023;      //PV panel voltage
float current = analogRead(A1)*5.0/1023;      //PV panel current
float power = voltage*current;                //PV panel power

//allows the serial port to send data to Excel in real-time
Serial.print("DATA,TIME,"); // PLX-DAQ command
Serial.print(voltage);     //send the voltage to serial port
Serial.print(",");
Serial.print(current);     //send the current to serial port
Serial.print(",");
Serial.println(power);   //send the power to serial port
delay(1000); //wait 1s before repeating
}
```

Figure 14: code Arduino

3.8 Conclusion

In this chapter, details of the different components of an Arduino are provided. The component specification and component selection criteria for an Arduino are explained a suitable analog measurement interface board for the Arduino prototype has been The implementation of these PV generator models, in ISIS PROTEUS for simulation to collect real-time data from solar panels. From the top, the Volta study imported real- time solar panels from the PLX-DAQ application into the Excel spreadsheet.

General Conclusion

General Conclusion

This work contributes to the characterization or monitoring of photovoltaic systems will always be done in three stages: the collection of information (current, voltage.)

The first part, we studied the internet of things, and we studied generalities on PV system,
Then we present models of literature of the necessary components in our study such as from (photovoltaic field, regulator, DC-DC converters).
We have explained in detail the important role of the purchasing system and the choice of Arduino UNO board.
We have also managed to create Excel report files and view all this data and the dynamic behavior of the system in real time,

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