ANKARA YILDIRIM BEYAZIT UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

SOLAR PV POWER CHARGE CONTROLLING SYSTEM WITH RESPECT TO REAL TIME SUN TRACKING INFORMATION TECHNIQUES

M.Sc. Thesis by

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M.Sc. THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **" SOLAR PV POWER CHARGE CONTROLLING SYSTEM WITH RESPECT TO REAL TIME SUN TRACKING INFORMATION TECHNIQUES "** completed by **DEEMAN NAJAT NAJM ALDAIN** under supervision of **ASSOC. PROF. Dr. SINAN KIVRAK** and **ASSIST. PROF. Dr. SAMEER ALGBURI** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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SOLAR PV POWER CHARGE CONTROLLING SYSTEM WITH RESPECT TO REAL TIME SUN TRACKING INFORMATION TECHNIQUES

ABSTRACT

This work focuses on power system modeling that awfully gives priorities to realize and store the maximum power radiated out of sun to feed a definite primary load. The power of the sun can be stored in different ways based on PV modules employed by renewable solar systems. The main challenge of this proposed idea is realizing the maximum sun power denoted as MPP (maximum power point) which is considered the most effective and energetic spot over power storage curves. MPPT indicates the maximum power point realized during a specific time. In accordance, a tracking system is employed in order to follow sun trajectory, direction, and the way of power radiation. Moreover, another point should be taken in to consideration that is the sun can feed the proposed load at day periods. However, the batteries are considered a most suitable solution for providing power at night periods. Hereby, the primary load gets the power from the sun directly at the day and indirectly at night based employed batteries. In addition, the temperature over the panel, the real time sun tracking information, the charge ratio in the employed batteries, and the strength of the wind are demonstrated over an LCD display. A GSM module based notification request is employed to direct the situation of the power system as an SMS through a specific phone number. Finally as a motivation, the energy of the solar system is considered as one of the power generation sources that are independent from petroleum and coal based energy resource. The main drawback with solar energy is conversion efficiency poorer and high installation cost. Hereby.

Keywords: Sun tracking, Real time systems, Solar panel physical conditions, Power system modules.

GERÇEK ZAMANIN GÜNEŞ İZLEME BİLGİ TEKNİKLERİ İLE SOLAR PV GÜÇ ŞARJ KONTROLLÜ SİSTEMİ

ÖZ

Bu çalışma , belirli birincil bir yükü beslemek için güneşten yayılan maksimum energy gerçekleştirme ve depolama öncelikleri veren güç sistemi modellemesine odaklanmaktadır. Güneşin gücü, yenilenebilir güneş sistemleri tarafından kullanılan PV modüllerine göre farklı yollarla depolanabilir. Bu önerilen fikrin ana zorluğu, güç depolama eğrileri üzerinde en etkili ve enerjik nokta olarak kabul edilen maksimum güneş gücünü MPP (maksimum güç noktası) olarak anlamaktır. MPPT, belirli bir süre boyunca gerçekleştirilen maksimum güç noktasını belirtir. Buna göre, güneş yörüngesini, yönünü ve güç radyasyonunun izini sürmek için bir izleme sistemi kullanılır. Dahası, güneşin önerdiği yükü gündüz besleyebileceği bir başka husus dikkate alınmalıdır. Bununla birlikte, piller gece periyotlarında güç sağlamak için en uygun çözüm olarak görülüyor. Burada, birincil yük doğrudan gündüz gücünü, aksine gece kullanılmış pillerde dolaylı olarak alır. Buna ek olarak, panel üzerindeki sıcaklık, gerçek zamanlı güneş izleme bilgileri, kullanılan pillerde şarj oranı ve rüzgarın kuvveti bir LCD ekran üzerinde gösterilir. Bir GSM modülüne dayalı bildirim talebi, güç sisteminin durumunu belirli bir telefon numarası yoluyla bir SMS olarak yönlendirmek için kullanılır. Nihayet bir motivasyon olarak, güneş sisteminin enerjisi, petrol ve kömür temelli enerji kaynaklarından bağımsız olan elektrik üretim kaynaklarından biri olarak düşünülür. Güneş enerjisindeki en büyük dezavantaj dönüşüm verimliliği daha düşük ve yüksek kurulum maliyetidir. Araştırmacılar, daha sağlam kontrol sistemleri gerçekleştirmek için kontrol mekanizması verimliliğini artırmak için bu alandan girmişlerdir. Bu nedenle, fotovoltaik şarj sisteminin toplam kurulum maliyeti düşer.

Anahtar Kelimeler: Güneş takibi, Gerçek zamanlı sistemler, Güneş panelleri fiziksel koşulları, Güç sistemi modülleri.

CONTENTS

NOMENCLATURE

Acronyms

AC	Alternative Current
ADC	Analog Digital Convertor
ALU	Arithmetic Logic Unit
C	Common
COM	Communication Po
CPU	Central Processing Unit
DC	Direct Current
DFU	Device firmware update
EEPROM	Electrically Erasable Programming Read Only Memory
En	Enable
FOCV	Fractional Open Circuit Current
FOCV	Fractional Open Circuit Voltage
GND	Ground
GSM	Global System for Mobile Communication
I/O	Input / Output
ICSP	In-Circuit Serial Programming
IDE	Integrated Development Environment
INC	Incremental Conductance
IOREF	Input Output voltage Reference
LCD	Liquid Crystal Display
LDR	Light Dependence Resistor
LED	Light Emitting Diode
MAC	Media Access Controller
MCU	Microcontroller
MISO	Master In Slave Out
MOSI	Master Out Slave In
MPPT	Maximum Power Point Tracking
NC	Normally Closed
NO	Normally Opened
O&P	Perturb and Observe
PIC	Programmable Integrated Circuit
PV	Photovoltaic Panel
PWM	Pulse Width Modulation
R/W	Read Write
RS	Register Select
RTC	Real Time Controller
RX	Receiver

SCK   Serial Clock
SCL   Serial Clock
SDA   Serial Data
SIM   Subscriber Identity Module
SMS   Short Message Service
SPI   Serial Peripheral Interface
SRAM Static Read Only Memory
SS   Slave Select
TWI   I – Two - C
TX   Transmitter
UNO   One in Italian Language
USB   Universal Serial Bus
VCC   Voltage at Common Collector
VDD   Voltage Drain Drain
VSS   Voltage Source Source

Subscripts

V   Voltage
V_{oc} Open circuit voltage
I   Current
I_{sc} Short-circuit current
V_{out} Output voltage
V_{in} Input voltage
R   Resistance

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CAPTER 1

INTRODUCTION

The demand for electricity and the way to produce power is considered as the most important needs for human being. The people nowadays are started using different kinds of power sources as fossil fuel, photovoltaic panels PV, wind recourses, hydroelectric power stations, etc. As the main concentration of this work, the photovoltaic panels are applied widely in several application such as charging the batteries, motor operators, light sources, machines and so on[1, 2]. The PV panels have got massive advantages as being treated freely maintenance and pollution. Whereas, they have some drawbacks and defects regarding their availability, design cost, low efficiency, and nonlinearity. The low energy conversion efficiency leads the cost of the system that works under PV panels' domination to be reduced in contrast the situation will be solved by assigning high level accurate sun power trackers to realize the maximum power point tracking (MPPT) the ensures the power realization in the worst cases [3]. The MPPT is the process that confirms the best utilization of PV panels. A MPPT, is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries. As mentioned, the power conversion efficiency of the solar systems is low and hence their impedance matching conditions need to be increased accordingly to increase the efficiency of the solar systems. The whole matter can be optimized by applying one of the numerous MPPT methods [4]. MPPT algorithms are vary due to simplicity, efficiency, tracking speed, sensor required and cost. It is seen that the V-I characteristics of the solar module is nonlinear and extremely affected by the solar irradiation and temperature. To maximize the output power of solar module, it has to be operated at fixed value of load resistance [5]. The complete motivation of the thesis is considered to realize the maximum power point tracking over the entire time of system operation. Hereby, such systems need to be equipped with sun tracking module to assign MPPT spot that leads the system to be always under the

government of weather conditions based sun light irradiance. As the steady state MPPT efficiency at deferent irradiation levels is a figure of merit of a PV inverter, MPP trackers have been under continuous improvement. Today a commercial PV inverter has an MPPT efficiency of about 99% over a wide range of irradiation conditions. However, until recently, tracking in variable environmental conditions received little attention from manufacturers [6]. It is worth mentioning that cloudy conditions can affect negatively on the MPPT tracking results and the amount of the produced power needed to charge system batteries with respect to any chosen MPPT algorithm [7]. Several researches have been presented recently to demonstrate the impact of the weather on the amount of the realized MPPT spot effectiveness [8]. The power variations can be rated around $20 - 100$ % by producing rectangular variation of the irradiation with respect to the required stabilization period between $1 - 5$ minutes for an intermediate level around $100 - 200$ms [7]. The Perturb and Observe denoted as O&P is one of the so called 'hill climbing' MPPT methods, which are based on the fact that, on the voltage-power characteristic, on the left of the MPPT the variation of the power against voltage $dP = dV > 0$, while on the right, $dP = dV < 0$ (see Fig.1). The main advantage of the P&O method is that it is easy to implement, it has low computational demand, and it is very generic, i.e. applicable for most systems, as it does not require any information about the PV array, but only the measured voltage and current [9]. Hereby, O&P nowadays is applied most often as the MPPT method [9, 10, 11]. The negative spot light of O&P technique is the oscillations over the MPPT in steady state situations that lead the tracking system to follow the wrong direction away from the MPPT active point under the fast radiation charge
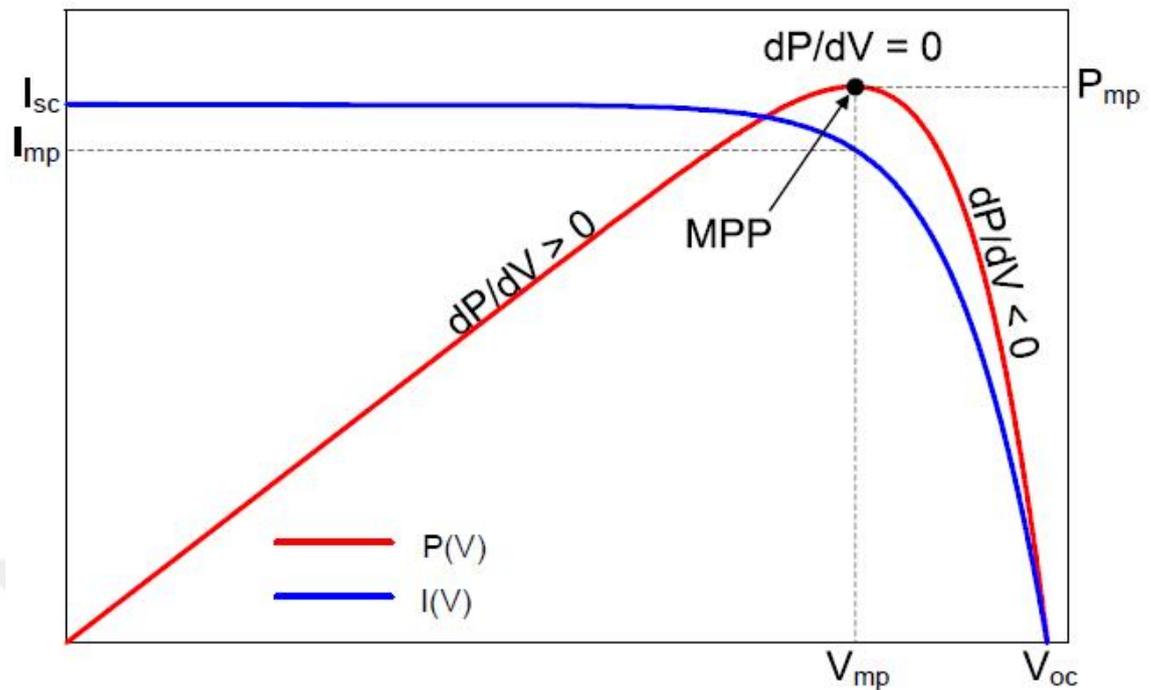
Figure1.1 V-I Relationship.

As was mentioned earlier, the O&P can track in the wrong direction under rapidly changing irradiation conditions. Irradiation can change relatively quickly due to weather conditions, e.g. passing clouds, and very fast changes (for small systems) corresponding to a variation of the rated power from 15% to 120% within 500ms, were reported [13]. Nevertheless, the probability of such fast irradiation changes is extremely low [8]. To surf for a little bit away from the power systems and sun tracking modules, it is intended to demonstrate the suitable active way to control and monitor the proposed system remotely by depending on the well-known Global System for Mobile communication kit. The kit is known as SIM900 GSM based Arduino microcontroller, which is the part that is treated as a shield hat for the microcontroller. The proposed power system information can be realized and monitored form far away with respect to notification request signal sent by a smart phone over a specific number to the power station site in order to be answered regularly and clarify system status periodically.

1.1 Research Objectives

Due to the necessity for high energy output of PV systems, the project develops high efficiency MPPT technique, appropriate for rapid changing operation Moreover , to implement the MPPT to control battery charging system for lead acid battery method. The proposed MPPT strategy also combines with a battery charging loop so that battery efficiently charge with less charging time and overall cost of reduced system.

1.2 Thesis Organization

This thesis is constructed of six chapters. Chapter (1) presents the information over the general power system and suitable ways to track the sun with respect to MPPT realization. Chapter (2) studies importance of the proposed microcontroller that is identified by Arduino microcontroller and clarifies its ports and sections in details. Chapter (3) shows the installation processes and the work methodology over the Arduino microcontroller and presents the components and the tests needed to complete the project. On addition, the chapter introduces the characteristics and specifications of the solar panels in details. Chapter (4) presents power system module, the connection scheme in reality and programing code in the form of algorithms. Chapter (5) discusses the results and makes comparisons between the theoretical and the practical results. Finally, chapter (6) presents and discusses the obtained results throughout the thesis and shows the practical analysis for the points that were lying under the challenges of the thesis.

1.3 Literature Review

Most of solar and renewable system researches nowadays give the priority to invent a robust sun tracking system based specific controller and confirm the results theoretically with respect to P-Spice or MATLAB programs [14]. The researchers prefer such systems to produce and control the power of the systems based on the charge of lead acid batteries with respect to their ages [15]. In addition, study the performance of the generated power based on PV panels with respect to various weather conditions [16]. The main idea of the proposed researches are considerably depended on the realization of the maximum power point MPP, which considered the

most effective challenge that the researches put in their mind [17, 18, 19]. Furthermore, there exists hybrid systems that don not take the tracking methodologies into account; however they can realize the maximum power point [20]. The problems that have appeared recently in specific geographical areas inspired new ideas specially to transport the electrical power to such places, hence it is proposed to track the motion of the sun in order to obtain the point that operates in maximum efficiency and gives maximum power in the knee of power realization curve between the current and the voltage [21]. The maximum power point realization technique is considered the tendency in a lot of papers knowing that presenting one optimum solution to clarify the methodology of such realization will be sufficient, such as based on MPP control using DC − DC convertor [22]. In addition, the employed battery charges can be controlled mainly depending on the maximum power point that is realized with respect to the PV system and specific circuit modelling methodology confirmed theoretically by using MATLAB simulation [14]. Renewable solar systems are considered the main argument in the proposed researches due to the flexibility of solar components that simplify system study from different sides, specially the photovoltaic modules (PV) that depends considerably on the amount of the irradiance of the sun over PV cell; to generate electricity based climate conditions in specific areas [16]. In solar systems, MPPT point tracking usually is considered the most persuasive challenge for most of the researches in the proposed field of study, that is the point the effects ultimately on conversion efficiency of the realized power [5]. It is worth mentioning that MPPT realization is not the sole challenge that should be taken into account, however the selection of a robust MPPT tracking and realization techniques are considered the most critical challenge that most of the researchers were struggling to reach the MPPT based effective methodology to increase power extraction by increasing the maximum power point [23]. Smart PV system model is identified to find out the maximum power point by controlling the tracking and the efficiency of the realized power as a feedback to improve the quality of the design [24]. In fact, it has been reached recently, that there exists new MPPT realization techniques is employed to maximize the power realized by the PV under any temperature and irradiations conditions [25]. Real time modelling systems are considered the main interest of the

our proposed thesis idea, however it is considered a little bit different than any other research works identified before such as study and prove the performance of the obtained MPPT experimentally and stimulatingly with respect to environmental changes regarding irradiation and temperature over PV systems [6]. As a result, it has been shown that there exists no power system as our proposed model, controls the MPPT under sun tracking model, realizes all the information needed to power system status remotely, and supervises the situation of the system periodically to report the urgent cases and the desired information as a notification to the mobile phone.

CHAPTER 2

SYSTEM DESCRIPTION

As a simple introduction, this chapter shows the main components that the proposed system stands over. The establishment of such a robust system aims to realize the maximum power coming out from the sun mainly by tracking the maximum power point MPPT that insures maximum power optimization. The tracking operation of the MPPT is not that easy, particularly if intended to follow the motion of the sun from four locations based on light sensor modules and linear actuators. Last but not least, the climate change situations over the whole system are modeled to report system's status in reality.

2.1 System layout

2.1.1 Solar Panel

This element is mainly employed in solar systems in order to handle with sun radiation effectively such that the incident sun light is converted to electricity due to the semiconductor materials employed in order to follow and achieve the observable fact (phenomena) that exposed in physics. The photovoltaic PV systems are constructed of solar panel with number of solar cells used to generate high electrical power from sunlight. The operation is considered a novel method since such a great systems put in charge to handle with the high grade degrees of the radiation coming from the sun. The procedure is unique phenomena due to following factors:

- Fixed solar panels without classical motions.
- No need for fuel.
- Lack of fluids and gases that might make problems in case of thermal solar systems.
- High sensitivity and response.
- Controlled easily in fair temperatures.
- Little maintenance required.
- The electricity is generated without pollution.
- Systems are made of well-known and profluent materials as silicon.

- Admired in wide world applications.
- High efficiency electric power convertor.

The input of the solar panel is employed in order to obtain the highest power from sun radiation in daily hours and along the month. We are aware that sun radiation is (hourly, daily, monthly, yearly) varied due to the rotation of the earth around the sun. Hereby, the power charged in the batteries by PV input is directly proportional with sun radiation all around the year.

2.1.2 Charge Controller

This work shows the typical implementation of the maximum power point MPPT using one of the unique techniques. Sun tracking systems based MPPT techniques are invented mainly in order to control the charge of system batteries. The charge control module and its implementation were dominated with respect to microcontroller program. In addition, the programming code shows the power realized by the sun in the form of Voltage V and current I that generate the amount of the power in each battery. Hereby, the realization of the power leads the charge ratio will be exposed in the display module alongside with rest of the power system parameters based on the State of charge with respect to the voltage.

It is worth mentioning that as soon as the components get ready, and the decision is taken regarding the MPPT algorithm employed in the system, the whole algorithm will be written by C++ compiler under the supervisor of Arduino IDE software.

2.1.3 Battery Charging Method

Battery life and performance are highly depends on method of charging. So, optimal charging pattern is required to increase lifespan of battery with less charging time. To charge lead-acid battery safe, faster and full charging, the manufacture recommended charge lead acid battery with four charging step [5, 26] that are called:

1) **Trickle charging:** The stage that the battery enters its complete discharging capacity.

2) **Constant current charging:** The step that first stage of battery charging reaches to its critical voltage then the charge will be in a constant current region.

3) **Constant voltage charging:** In this region battery charge up to charging current of battery fall below reestablished and voltage stay in the value of open circuit voltage Voc.

4) **Float charging:** The stage that is mainly used to avoid overcharging.

In stand-alone photovoltaic system, the electrical energy produced by the PV array cannot always be used when it is produced because the demand for energy does not always coincide with its production. Electrical storage batteries are commonly used in PV system [14]. The primary functions of a storage battery in a PV system are:

●**Energy Storage Capacity and Autonomy:** to store electrical energy when it is produced by the PV array and to supply energy to electrical loads as needed or on demand.

●**Voltage and Current Stabilization:** to supply power to electrical loads at stable voltages and currents, by suppressing or smoothing out transients that may occur in PV system.

●**Supply Surge Currents:** to supply surge or high peak operating currents to electrical loads or appliances.

2.1.4. Loads

The electrical load is an electrical component or portion of a circuit that consumes electric power. This is opposed to a power source, such as a battery or generator, which produces power. In electric power circuits examples of loads are appliances and lights. The term may also refer to the power consumed by a circuit.

2.2 Solar Photovoltaic Sensors and Tracking Devices

Compared to a fixed panel, a mobile PV panel driven by a solar tracker is kept under the best possible insolation for all positions of the Sun, as the light falls close to the geometric normal incidence angle. Automatic solar tracking systems (using light intensity sensing) may boost consistently the conversion efficiency of a PV panel,

thus in this way deriving more energy from the sun [27]. Most of researches in America have shown that the effectiveness of the solar tracking operation will be in summer season. Solar tracking systems are constructed of several types and can be classified according to several criteria. A first classification can be made depending on the number of rotation axes. Thus we can distinguish solar tracking systems with a rotation axis, respectively with two rotation axes. While, solar tracking operation in this work was done with respect to four directions.

2.3 Solar Photovoltaic Tracking Optimization Techniques

As we know power conversion efficiency of solar module very low. To increase efficiency of solar module proper impedance matching is required to increase efficiency of solar module. Hence, different types of MPPT techniques developed by researcher in the recent years. Methods used for MPPT are listed below [5]:-

- **Fractional open circuit voltage MPPT:** Fractional open circuit (FOCV) is considered as the easiest tracking way due to the change of sun light and the temperature in accordance with the change of MPPT. While, the technique is not able to track the exact MPPT point.

- **Fractional short circuit current MPPT:** This method also work on same principle of fractional open circuit voltage (FOCV). Similar to (FOCV) it is also not capable to track exact MPPT because it is also work on fixed value of current. Imp not change according to irradiation level and temperature changes.

- **Perturb and observe (P&O) MPPT:** Denoted as P&O and classified as one of the famous tracking MPPT tracking way. This algorithm works based on voltage and current sensing based used to track MPP. In this controller require calculation for power and voltage to track MPP. In this voltage is perturbed in one direction and if power is continuous to increase then algorithm keep on perturb in same direction.

- **Incremental conductance (INC) MPPT:** In this technique, the controller measures incremental change in module voltage and current to observe the effect of a power change [5]. This method requires more calculation but can track fast than perturb and observe algorithm (P&O) [28].

2.4 Remote Solar Photovoltaic Monitoring System

Generally, several systems need to be monitored by designing the suitable controller to supervise the behavior of a system. It is worth mentioning that the term system should always be linked with monitoring modules to insure the security and the safeness. While, there exist great challenges regarding the establishment of the remote monitoring systems with respect to the cost the module applicability. This work presents a new technique to monitor the proposed power system remotely so that system status is always under the control of the person who is in charge. The employed module in this work is SIM900 Arduino GSM module that is easily compatible with the friendly Arduino UNO microcontroller. The GSM module serves based on four frequencies specified by (850, 900, 1800, and 1900) MHz attached with services of voice, SMS, Data, and Fax respectively. Finally, it has to be mentioned that the connection methodology between the source and the destination in this work is under the supervision of 900 MHz frequency that is the reason leads to manage the information of the power system based on an SMS notification request by a specific phone number

2.5 Real-Time Online Solar Photovoltaic Monitoring

As the wide spreading of the cheap and reliable sensors compatible with different microcontrollers such as Raspberry Pi, PIC, Arduino, the researches and control designers are excited in order to reach the time of systems situations in the exact and real time. In this work, a study was occurred using temperature, humidity, and wind speed situations over power system environment. To be more specific, the temperature – humidity sensor is equipped on the panel in order to report the signal to the microcontroller addressed later to the display module. Besides, the remain part of the modules that realize the condition results in reality is the wind speed meter that is equipped near the base of the panel to demonstrate the strength of the wind in the power system location.

2.6 Arduino Uno Microcontroller

Arduino is an open source electronic board that supports both the hardware and software [29]. Arduino is considered the most typical microcontroller that deals with the input modules such as the sensors that transfers the realized data into the Arduino in order to take the suitable decision. Moreover, Arduino microcontroller deals with output modules and devices such as controlling the lights, motors, and the other actuators. The part responsible for controlling modules is equipped regularly on the board called (ATMEGA) that can be programmed by using Arduino IDE programing language. Arduino program is written by interfacing the board with computer in order to create programing user interface area to startup controlling tasks properly. Arduino Uno is a microcontroller works board based on ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started [30]. The term "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE). The Uno board and the versions of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board as shown in Figure2.1 is the first in a series of USB Arduino boards, and the reference model for the Arduino platform [31].

Figure2.1 Arduino Uno

Table2.1 Technical Specifications of Arduino UNO

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) for boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm

2.7 Programming

The Arduino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino Uno from the Tools → Board menu (according to the microcontroller on your board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno comes preprogrammed [31] with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

1) On Rev1 boards: connecting the solder jumper on the back of the board.
2) On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

2.8 Power

The Arduino Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector. The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Moreover, the power pins are as follows:

1) VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

2) VCC: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3) 3V3: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

4) GND: Ground pins.

5) IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V [31].

2.9 The Memory

The ATmega328 has 32 KB (with 0.5 KB occupied by the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

2.10. Atmega168/328-Arduino Pin Mapping

Note that this chart is for the DIP-package chip. The Arduino Mini is based upon a smaller physical IC package that includes two extra ADC pins, which are not available in the DIP-package Arduino implementations [31].
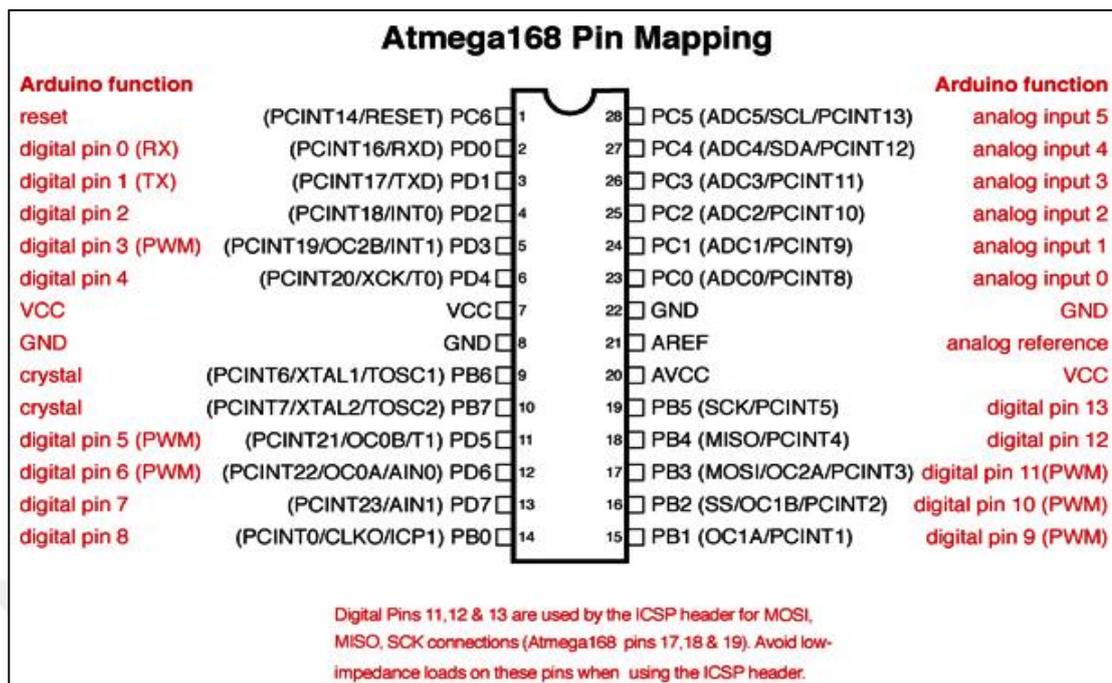
Figure2.2 Atmega168/328 Pin Mapping

In addition, some pins have specialized functions:

1) Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

2) External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

3) PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

4) SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

5) LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

6) TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

Arduino Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground

to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function.

2.11 Communication

Arduino Uno has a number of facilities for communicating with a computer, another Arduino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino Software identified by Integrated Development Environment (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows serial communication on any of the Uno's digital pins [31].

2.12 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino Software (IDE) uses this capability to allow you to upload code by simply pressing the upload button in the interface toolbar. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is

opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno board contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN" [31].

2.13 Atmega328/P Datasheet

The Atmel AVR core [32] combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers. The ATmega328/P provides the following features: 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6- channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main oscillator and the asynchronous timer continue to run.

Atmel offers the QTouch library for embedding capacitive touch buttons, sliders and wheels functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offers robust sensing and includes fully debounced reporting of touch keys and includes Adjacent Key Suppression (AKS) technology for unambiguous detection of key events. The easy-to-use QTouch Suite toolchain allows you to explore, develop and debug your own touch applications. The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328/P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications. The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits. The summary of the configuration can be modeled as shown in Figure2.3.
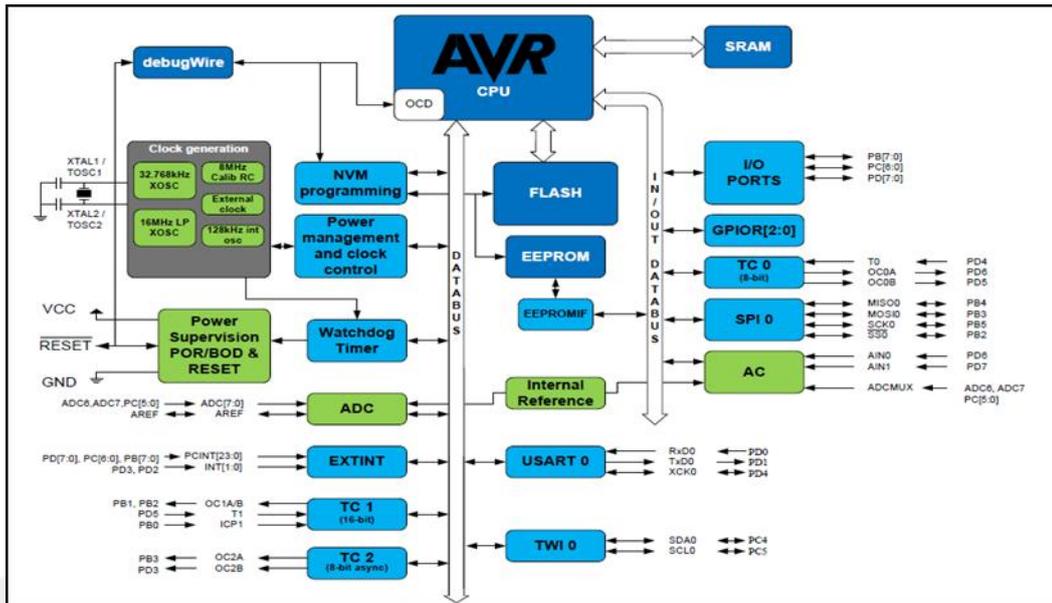
Figure2.3 The ATmega328/P Configuration

CHAPTER 3

MICROCONTROLLER SETUP PROCESSES

3.1 Getting Started With Arduino On Windows

Download the Arduino environment; get the latest version from the download page (http://arduino.cc/en/Main/Software). When the download finishes, unzip the downloaded file. Make sure to preserve the folder structure. Double click the folder to open it. There should be a few files and sub-folders inside.

3.2 Connection

The Arduino Uno automatically draws power from either the USB connection to the computer or an external power supply. Connect the Arduino board to your computer using the USB cable. The green power LED (labeled On) should light.

3.3 Drivers Installation

Installing drivers for the Arduino Uno with Windows8, Windows7, Vista, or XP:

1) Plug in your board and wait for Windows to begin its driver installation process. After a few moments, the process will fail, despite its best efforts.
2) Click on the Start Menu, and open up the Control Panel.
3) While in the Control Panel, navigate to System and Security. Next, click on System.
4) Once the System window is up, open the Device Manager.
5) Look under Ports (COM & LPT). You should see an open port named "Arduino UNO (COMxx)".
6) Right click on the "Arduino UNO (COMxx)" port and choose the "Update Driver Software" option.
7) Next, choose the "Browse my computer for Driver software" option.
8) Finally, navigate to and select the driver file named "arduino.inf", located in the "Drivers" folder of the Arduino Software download (not the "FTDI USB Drivers" sub-directory). If you are using an old version of the IDE (1.0.3 or older), choose the Uno's driver file named "Arduino UNO.inf".
9) Windows will finish up the driver installation from there.

When you connect the board, Windows should initiate the driver installation process (if you haven't used the computer with an Arduino board before). On Windows 8, 7 or Vista, the driver should be automatically downloaded and installed. You can check that the drivers have been installed by opening the Windows Device Manager (in the Hardware tab of System control panel). Look for a "USB Serial Port" in the Ports section; that's the Arduino board.

3.4 Launch The Arduiino Application

Double-click the Arduino application. (Note: if the Arduino software loads in the wrong language, you can change it in the preferences dialog. See the environment page (http://arduino.cc/en/Guide/Environment#languages) for details).

3.5 Getting Started With Arduino On Mac

Download the Arduino environment; get the latest version from the download page (http://arduino.cc/en/Main/Software). When the download is finished, double click the .zip file. This will expand the Arduino application.

3.6 Software Installation

Copy the Arduino application into the Applications folder (or elsewhere on your computer). No drivers are required to be installed.

3.7 The Connection Of The Board

The Arduino Uno automatically draws power from either the USB connection to the computer or an external power supply. Connect the Arduino board to your computer using the USB cable. The green power LED (labeled ON) should go on. A dialog box will appear telling you that a new network interface has been detected. Click "Network Preferences...", and when it opens, simply click "Apply". The Uno or Mega 2560 will show up as "Not Configured", but it's working properly. Quit System Preferences.

3.8 Ardunio Application

Double-click the Arduino application. Note: if the Arduino software loads in the wrong language, you can change it in the preferences dialog. See the environment page for (http://arduino.cc/en/Guide/Environment#languages).

3.9 Board Select

The operation needs to select the entry in the Tools > Board menu that corresponds to your Arduino as shown in Figure3.1.
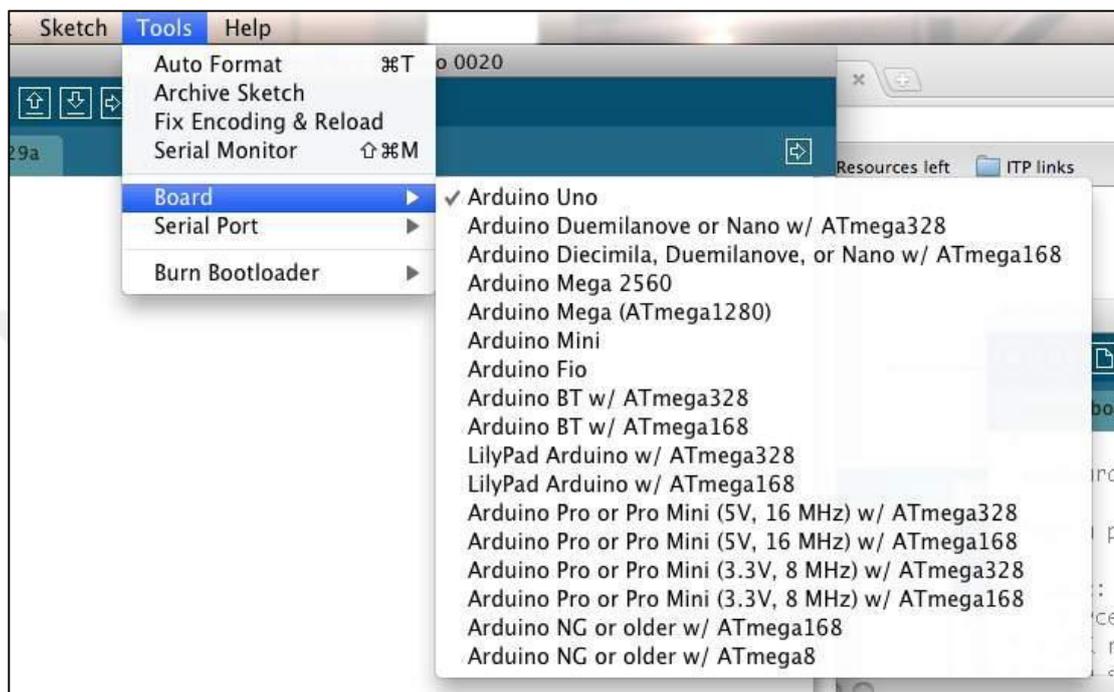
Figure3.1 Arduino IDE Program / Board Selection

3.10 Select Your Serial Port

Select the serial device of the Arduino board from the Tools > Serial Port menu as exposed in Figure3.2.Select the serial device of the Arduino board from the Tools | Serial Port menu. On Windows this is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu; the entry that disappears should be the Arduino board. Reconnect the board and select that serial port. On the Mac, this should be something with /dev/tty.usbmodem (for the Uno).
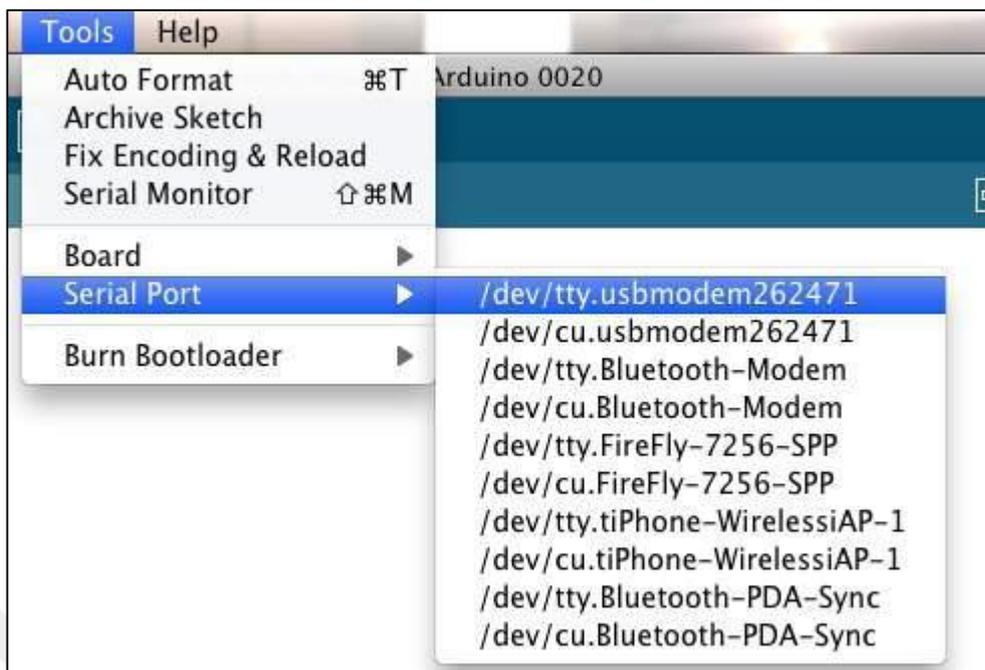
Figure3.2 Arduino IDE Program / Serial Port Selection

3.11 Upload The Program

Now, simply click the "Upload" button in the environment. Wait a few seconds - you should see the RX and TX LEDs on the board flashing. If the upload is successful, the message "Done uploading." will appear in the status bar. A few seconds after the upload finishes, you should see the pin 13 (L) LED on the board start to blink.

3.12 Arduino Microcontroller Work Principle

Analog input pins (A0-A5) that take-in analog values to be converted to be represented with a number range 0-1023 through an Analog to Digital Converter (ADC). ATmega328 chip 8-bit microcontroller that processes the sketch you programmed. Built-in LED on board LED to pin 13. Crystal Oscillator clock that has a frequency of 16MHz. DC Jack where the power source (AC-to-DC adapter or battery) should be connected. It is limited to input values between 6-20V but recommended to be around 7-12V. Digital I/O pins input and output pins (0-13) of which 6 of them (3, 5, 6, 9, 10 and 11) also provide PWM (Pulse Width Modulated) output by using the analogWrite() function. Pins (0 (RX) and 1 (TX)) are also used to transmit and receive serial data. ICSP Header pins for "In-Circuit Serial Programming" which is another method of programming. Indicator LED that lights

up when the board is connected to a power source. Power pins that can be used to supply a circuit with values VIN (voltage from DC Jack), 3.3V and 5V. For more simplicity, the parts of the microcontroller are clarified in Figure3.3.
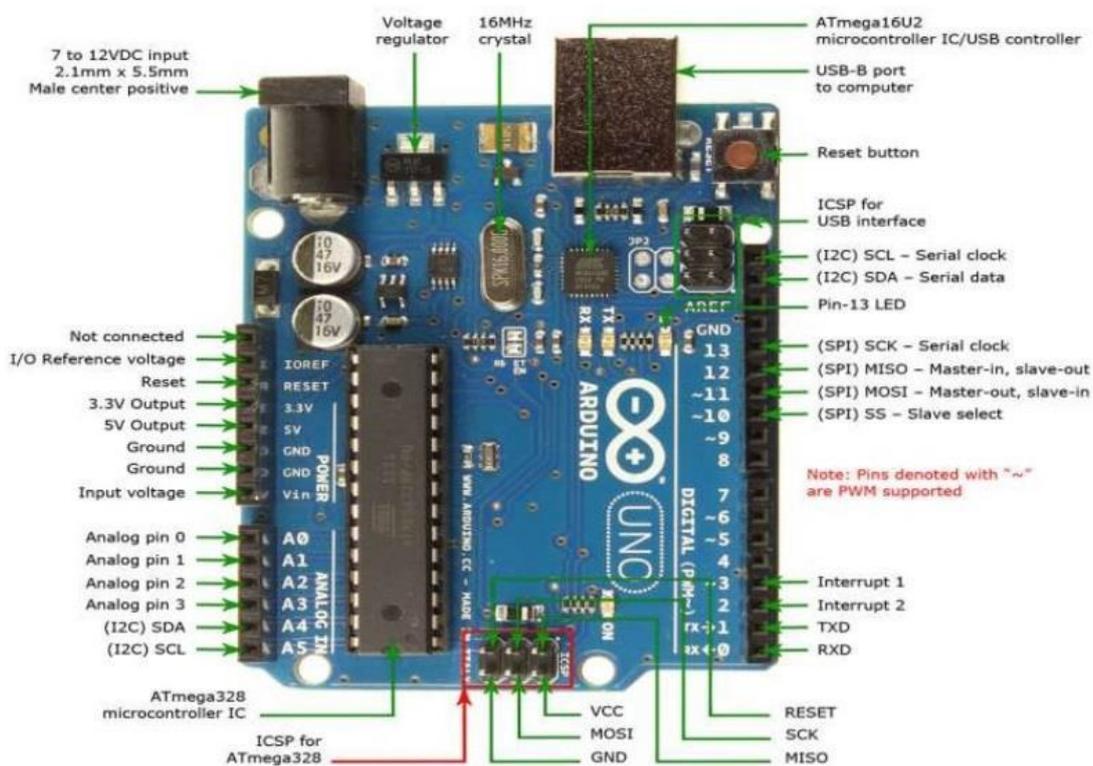
Figure3.3 The Parts Of Tthe Microcontroller

Reset Button, a button that is pressed whenever you need to restart the sketch programmed in the board. USB port allows the user to connect with a USB cable the board to a PC to upload sketches or provide a voltage supply to the board. This is also used for serial communication through the serial monitor from the Arduino software.

3.13 Integrated Development Environment(Ide)

Once the board is installed, it's time to open the Arduino IDE as shown in Figure3.4

It is fairly simple when compared to larger desktop C language development systems.

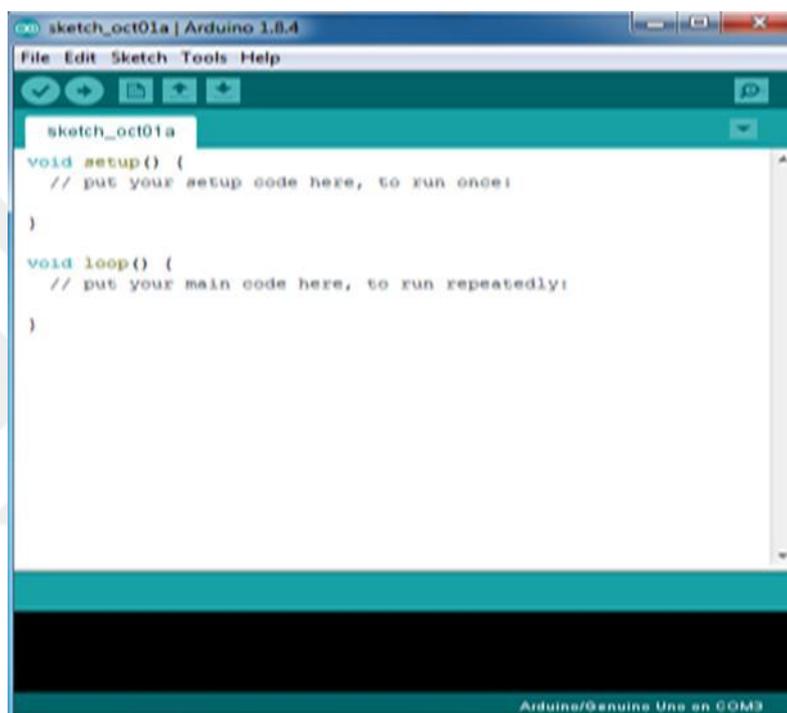**Figure3.4.** Arduino IDE Program / First Look

3.14 Digital Pins

The pins on the Arduino can be configured as either inputs or outputs. This document explains the functioning of the pins in those modes. While the title of this document refers to digital pins, it is important to note that vast majority of Arduino (Atmega) analog pins, may be configured, and used, in exactly the same manner as digital pins [33].

3.15 Pins Configuratiopn As Input-Pullup

There are 20K pullup resistors built into the Atmega chip that can be accessed from software. These built-in pullup resistors are accessed by setting the pinMode() as INPUT_PULLUP. This effectively inverts the behavior of the INPUT mode, where HIGH means the sensor is off, and LOW means the sensor is on. The value of this pullup depends on the microcontroller used. On most AVR-based boards, the value is guaranteed to be between 20kΩ and 50kΩ. On the Arduino Due, it is between 50kΩ and 150kΩ. For the exact value, consult the datasheet of the microcontroller on your board. When connecting a sensor to a pin configured with INPUT_PULLUP, the other end should be connected to ground. In the case of a simple switch, this causes the pin to read HIGH when the switch is open, and LOW when the switch is pressed. The pullup resistors provide enough current to dimly light an LED connected to a pin that has been configured as an input. If LEDs in a project seem to be working, but very dimly, this is likely what is going on. The pullup resistors are controlled by the same registers (internal chip memory locations) that control whether a pin is HIGH or LOW. Consequently, a pin that is configured to have pullup resistors turned on when the pin is an INPUT, will have the pin configured as HIGH if the pin is then switched to an OUTPUT with pinMode(). This works in the other direction as well, and an output pin that is left in a HIGH state will have the pullup resistors set if switched to an input with pinMode() [33]. It is possible to configure the internal pull-ups in the following manner:

```
digitalWrite(pin, HIGH);
digitalWrite(pin, LOW);
```

3.16 Pins Configuration As Output

Pins configured as OUTPUT with pinMode() are said to be in a low-impedance state. This means that they can provide a substantial amount of current to other circuits. Atmega pins can source (provide positive current) or sink (provide negative current) up to 40 mA (milliamps) of current to other devices/circuits. This is enough current to brightly light up an LED or run many sensors [33]. For example,

```
pinMode(pin, OUTPUT);
digitalWrite(pin, HIGH);
digitalWrite(pin, LOW);
```

3.17 Analog To Digital Converter

The Atmega controllers used for the Arduino contain an onboard 6 channel analog-to-digital (A/D) converter. The converter has 10 bit resolution, returning integers from 0 to 1023. While the main function of the analog pins for most Arduino users is to read analog sensors, the analog pins also have all the functionality of general purpose input/output (GPIO) pins (the same as digital pins 0 - 13). Consequently, if a user needs more general purpose input output pins, and all the analog pins are not in use, the analog pins may be used for GPIO [34].

3.18 Pin Mapping

The analog pins can be used identically to the digital pins, using the aliases A0 (for analog input 0), A1, etc. For example, the code would look like this to set analog pin 0 to an output, and to set it ;

```
pinMode(A0, OUTPUT);
digitalWrite(A0, HIGH);
```

3.19 Pullup resistors

The analog pins also have pullup resistors [34], which work identically to pullup resistors on the digital pins. They are enabled by issuing a command such as

digitalWrite(A0, HIGH);

3.20 Handling With Project Components

3.20.1 Blinking Led Light

Connect the positive terminal of your light emitting diode LED into pin 13 on Arduino Uno board then complete you circuit by connecting the other terminal to a 220 ohm resistor and lead the other part of the resistor to the GND pin on Arduino as exposed in Figure3.5.
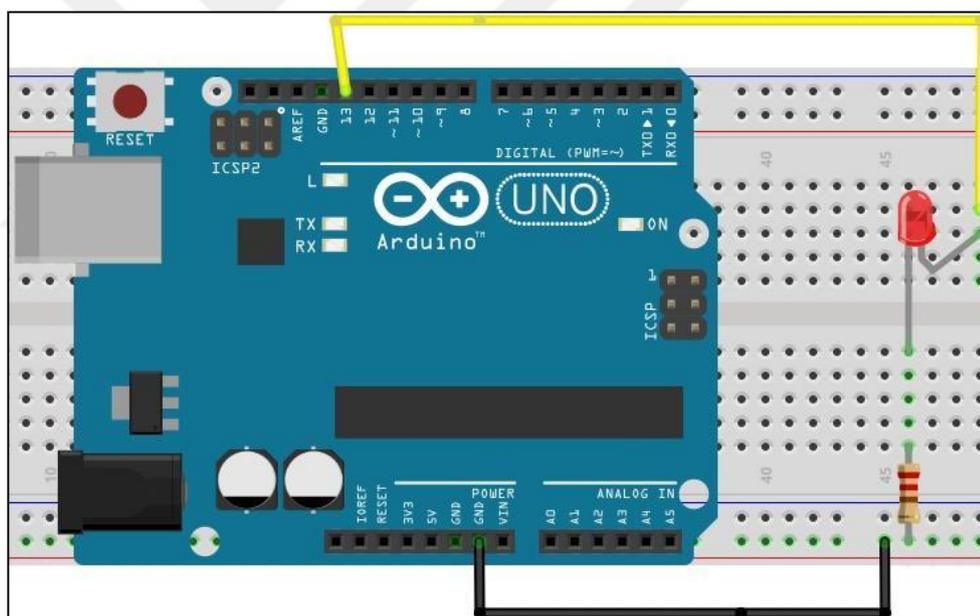

Figure3.5. Blinking Experiment Based Arduino UNO

THE PROGRAMING CODE
int led = 13;
void setup() {
pinMode(led, OUTPUT);}
void loop() {

```
 digitalWrite(led, HIGH);
 delay(1000);
 digitalWrite(led, LOW);
delay(1000);
}
```

3.20.2 Microcontroller Analog Pin Dominatiation

The analogRead command will not work correctly if a pin has been previously set to an output, so if this is the case, set it back to an input before using analogRead. Similarly if the pin has been set to HIGH as an output, the pullup resistor will be set, when switched back to an input [34]. The Atmega datasheet also cautions against switching analog pins in close temporal proximity to making A/D readings (analogRead) on other analog pins. This can cause electrical noise and introduce jitter in the analog system. It may be desirable, after manipulating analog pins (in digital mode), to add a short delay before using analogRead to read other analog pins.

In this example, we use a variable resistor (a potentiometer or a photoresistor), we read its value using one analog input of an Arduino board and we change the blink rate of the built-in LED accordingly. The resistor's analog value is read as a voltage because this is how the analog inputs work [35].

HARDWARE REQUIRED
1) Arduino or Genuino Board Figure3.6

2) Potentiometer or
3) 10K ohm photoresistor and 10K ohm resistor
4) built-in LED on pin 13 or
5) 220 ohm resistor and red LED
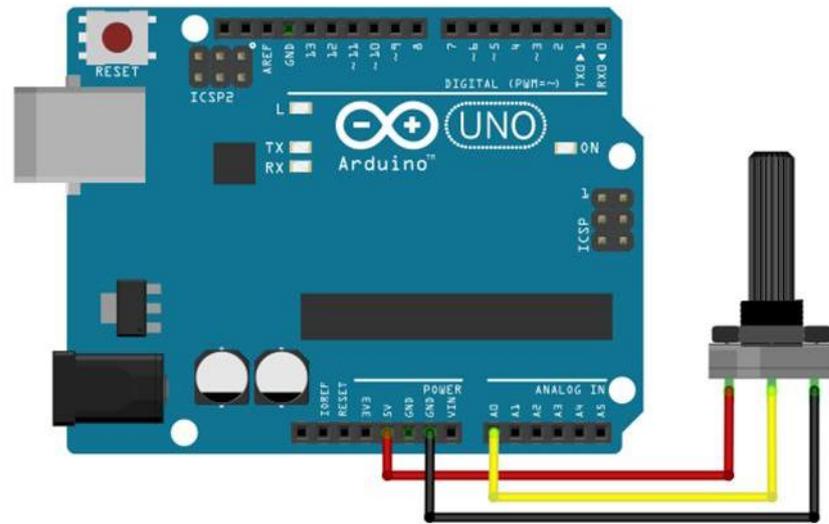
Figure3.6 Arduino Board Analog Pin Domination Based Potentiameter

Based another example, it is possible to use the board's built in LED attached to pin 13. To use an additional LED, attach its longer leg (the positive leg, or anode), to digital pin 13 in series with the 220 ohm resistor, and it's shorter leg (the negative leg, or cathode) to the ground (GND) pin next to pin 13 as demonstrated in Figure3.7.
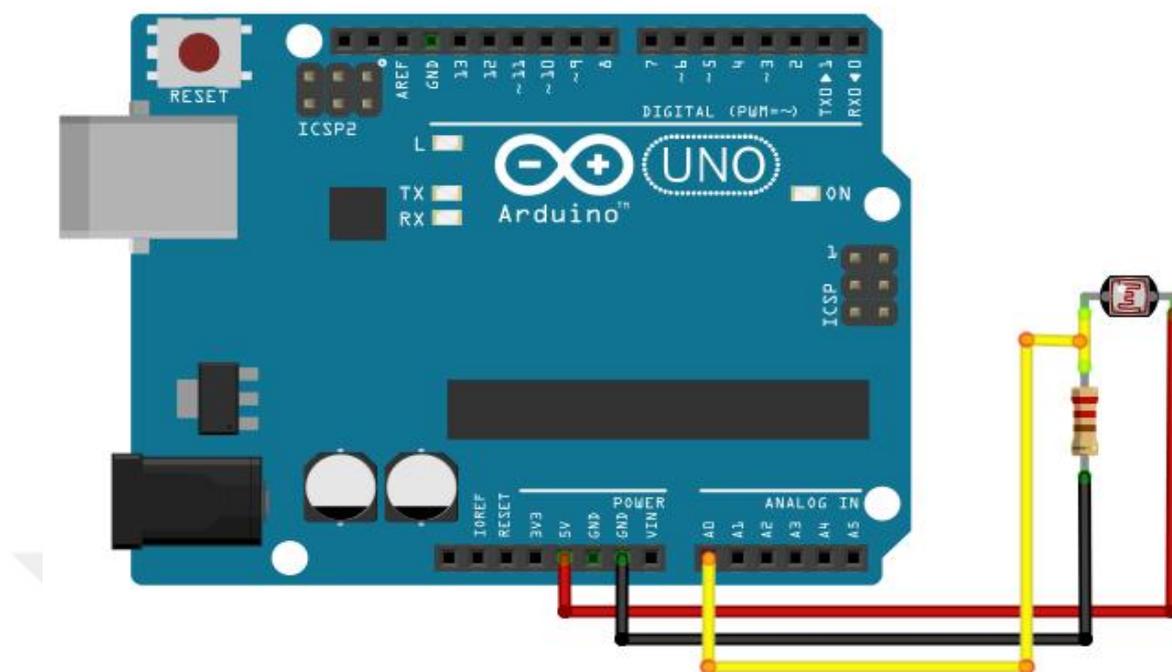
Figure3.7 Arduino Board Analog Pin Domination Based LDR

The circuit based on a photoresistor uses a resistor divider to allow the high impedence Analog input to measure the voltage as exposed in the Figure.16. These inputs do not draw almost any current, therefore by Ohm's law the voltage measured on the other end of a resistor connected to 5V is always 5V, regardless the resistor's value. To get a voltage proportional to the photoresistor value, a resistor divider is necessary. This circuit uses a variable resistor, a fixed resistor and the measurement point is in the middle of the resistors. The voltage measured (Vout) follows this formula:

$$Vout=Vin*(R2/(R1+R2))$$

where Vin is 5V, R2 is 10k ohm and R1 is the photoresistor value that ranges from 1M ohm in darkness to 10k ohm in daylight (10 lumen) and less than 1k ohm in bright light or sunlight (>100 lumen) [35].

THE CODE

```
const int sensorPin = A0;
int ledPin = 13;
 int sensorValue = 0;
 void setup() {
 pinMode(ledPin, OUTPUT);}
void loop() {
sensorValue = analogRead(sensorPin);
digitalWrite(ledPin, HIGH);
delay(sensorValue);
digitalWrite(ledPin, LOW);
delay(sensorValue);}
```

3.20.3 Arduino Photocell Sensor

The photoresistor shown in Figure3.8 or light-dependent resistor (LDR), or photocell is a resistor whose resistance will decrease when incident light intensity increase; in other words, it exhibits photoconductivity. A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance [36].

Figure3.8 Photo Resistor Shape LDR

The single photoresistor might be useless since you will need the digital signal according to the brightness. Hereby, the following sensor shape in Figure3.9 is invented in order to realize and employ whatever analog or digital signal according to the application.

Figure3.9 Photo Resistor Shape LDR

SPECIFICATIONS

- Uses high quality Photo resistor.

- Employed voltage: 3.3~5V.Analog Data: The VALUE of the light (0 to 1023) with more light giving lower numbers.

- Digital Data: A LOW signal when the light is brighter than the set point.

- Uses wide voltage LM393 comparator that has good waveform.

- The output current >= 15mA, can directly light LED.

- Uses adjustable potentiometer to adjust the sensitivity.

- Uses two M2.5 mounting holes.

This module is very sensitive to ambient light, and is very suitable for detecting brightness of ambient light.

When the ambient light intensity is lower than the predefined threshold, the output signal is high. When the light intensity reaches or exceeds the threshold, the signal output is low. See Figure 3.10
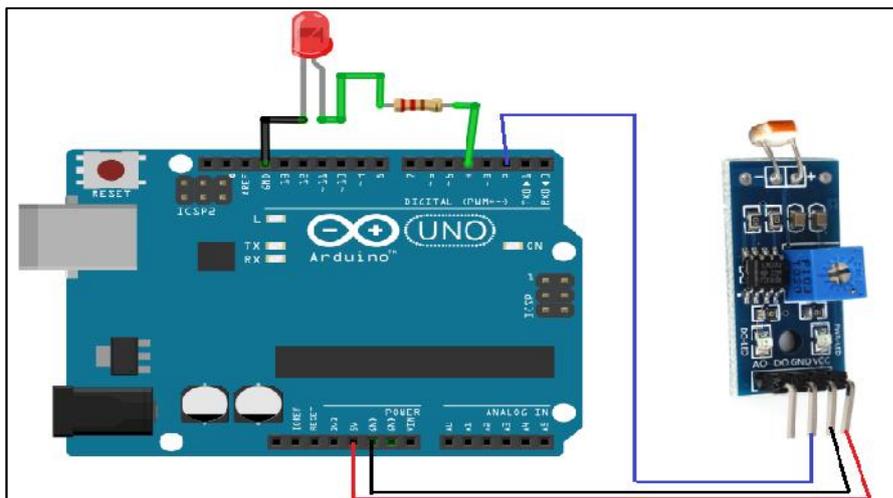
Figure3.10 Photocell Sensor Connection Scheme

The circuit shown above in Figure.26, demonstrates a simple connection scheme using the presented photocell sensor to control an LED light based light radiation falling over the photo resistor attached to the top of the proposed module.

The LED light is connected to the digital pin4 of Arduino Uno controller. Whereas the digital pin of the proposed photocell module is connected to pin 2 of Arduino in order to out the signal along from the module based light radiation strength accordingly. Finally photocell module is excited via the 5v, GND of Arduino to Vcc and GND to the photocell module respectively.

THE CODE

```
int photocellpin = 2;
int photocellstate = 0;
int ledpin = 4;
void setup() {
pinMode(photocellstate, INPUT);
pinMode(ledpin, OUTPUT);
}
void loop() {
photocellstate = digitalRead(photocellpin);
if(photocellstate == HIGH) {
digitalWrite(ledpin, HIGH); }
else if(photocellstate == LOW) {
```

3.20.4 Temperature And Humidity Sensor

Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output [37]. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connected to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost effectiveness.see Figue 3.11.
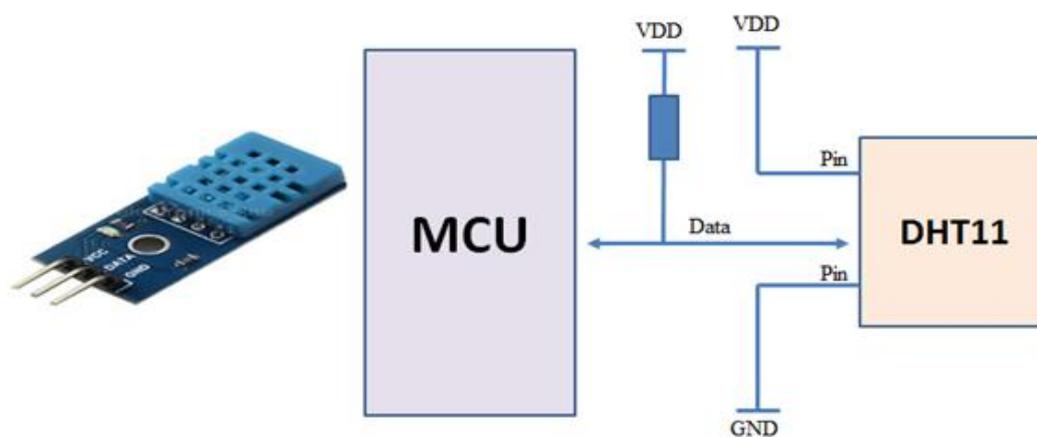
Figure3.11 Temperature / Humidity Sensor DHT11

The DHT11 element shown in Figure3.11 is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programs in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

DHT Sensor Sectors

1) Power And Pin

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

2) Communication Process

Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms. Data consists of decimal and integral parts. A complete data transmission is 40bit, and the sensor sends higher data bit first. Data format: 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is right, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data.

3) Overall Communication Process

When MCU sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for MCU completing the start signal. Once it is completed, DHT11 sends a response signal of 40-bit data that include the relative humidity and temperature information to MCU. Users can choose to collect (read) some data. Without the start signal from MCU, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the low-power-consumption mode until it receives a start signal from MCU again.

4) DHT Responses to MCU

Once DHT detects the start signal, it will send out a low-voltage-level response signal, which lasts 80us. Then the programmer of DHT sets Data Single-bus voltage level from low to high and keeps it for 80us for DHT's preparation for sending data. When DATA Single-Bus is at the low voltage level, this means that DHT is sending the response signal. Once DHT sent out the response signal, it pulls up voltage and keeps it for 80us and prepares for data transmission. When DHT is sending data to

MCU, every bit of data begins with the 50us low-voltage-level and the length of the following high-voltage-level signal determines whether data bit is "0" or "1" [37].

DHT sensor measures both temperature (Tmp) and (Hum) and hands the readings over the LCD display. The sensor consists of 3 terminals (VCC, DATA, GND) knowing that the data pin of the sensor acts well when mapped with digital Arduino Uno pins. The connection scheme of the sensor is followed as shown in the Figure.30, such that, the VCC terminal of the sensor is connected to the 5V of Arduino board, the data is chosen to be connected to the digital pin 5 of Arduino Uno, and the GND terminal of the sensor is connected to the GND pin of Arduino Uno board as shown in fig which created by Fritzing Sketch.
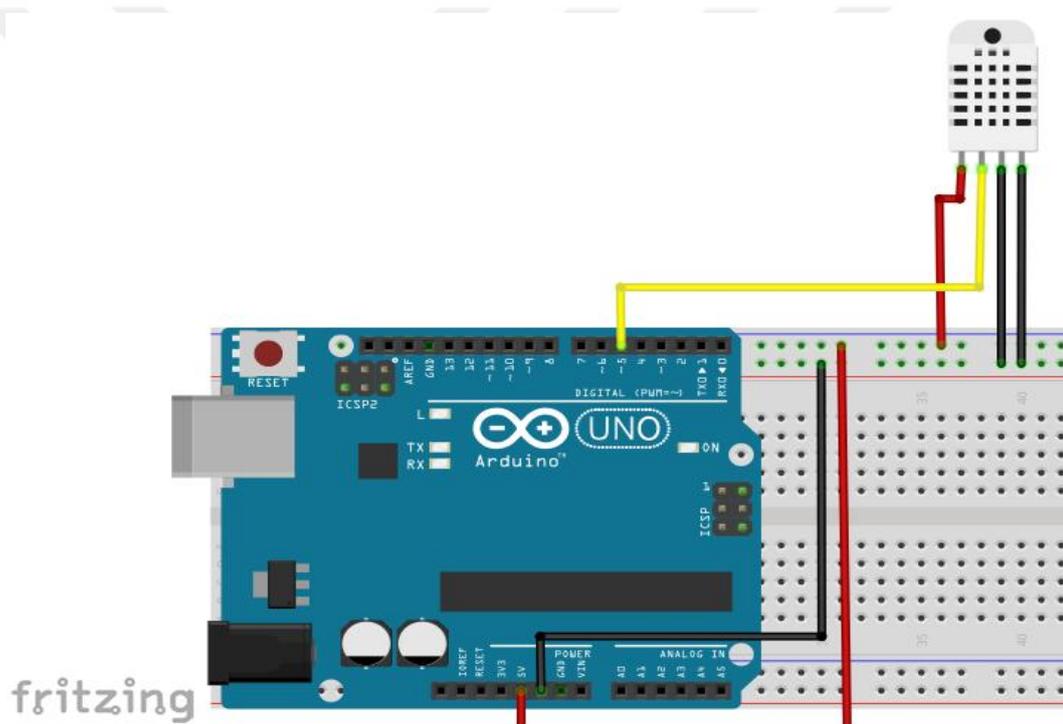
Figure3.12 DHT11 Connection SchemeIn The System

The code sketch based Arduino IDE program is written depending on the connection scheme of DHT sensor with Arduino Uno board that shown in Figure.3.13, is expressed as follows:

THE CODE

```
#include "DHT.h"
#define DHTPIN 5
```

```
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
void setup(){
  Serial.begin(9600); }
void loop() {
int h = dht.readHumidity();
int t = dht.readTemperature();
if(isnan(t) || isnan(h)) {
Serial.println("FAILED TO READ FROM DHT"); }
else {
Serial.print ("Temp = ");
Serial.print (t);
Serial.print (" C");
Serial.print ("Hum = ");
Serial.print (h);
Serial.print (" %"); }}
```

3.20.5 The Liquidcrystal Lcd Display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and indoor and outdoor signage. Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones. LCD screens are also used on consumer electronics products such as DVD players, video game devices and clocks. LCD screens have replaced heavy, bulky cathode ray tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD

Screens available in sizes ranging from tiny digital watches to huge[38].

The LiquidCrystal library allows you to control LCD displays that are compatible with the Hitachi HD44780 driver. There are many of them out there, and you can usually tell them by the 16-pin interface [38]. The example sketch in Figure3.13 prints "Hello World!" to the LCD and shows the time in seconds since the Arduino was reset.

Figure3.13 LCD Model Example Sketch

The display is considered the spot light of the project that demonstrates several data synchronously over 16 columns and 2 rows. LCD display has 16 pins illustrated as shown in Table3.1.

Table3.1 Interface Pin Configuration

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7		DB0
8		DB1
9		DB2
10		DB3
11	8-bit data pins	DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

The connection scheme of the proposed project regarding LCD display is attached such that pin1 of the LCD to the GND of the Arduino board, pin2 to the Vcc of the Arduino, pin3 to the middle pin of the potentiometer to control LCD light intensity, pin4 is proposed to be attached to pin7 of Arduino, pin5 to Arduino GND, pin6 is attached to pin8 of Arduino, (pin7, pin8, pin9, pin10) which refer to the first 4-bit data pins are not needed, the other 4-bit pins denoted as (pin11, pin12, pin13, pin14) are attached to (pin9, pin10, pin11, pin12) of the Arduino respectively. Last but not least, the last two LCD pins identified by the numbers pin15 and pin16 are connected to Vcc and GND of Arduino board respectively as shown in the Figure3.14.
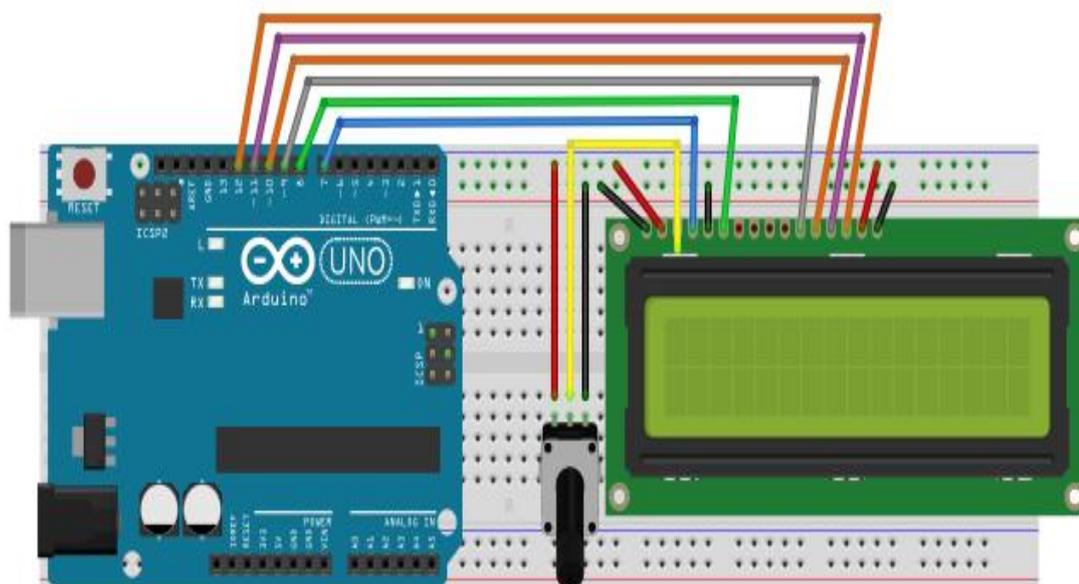
Figure3.14 LCD Connection Scheme Details

The code sketch based Arduino IDE program and LiquidCrystal lcd library is written depending on the connection scheme of the LCD display with Arduino Uno board that shown in Figure3.15, is given as follows:

THE CODE

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 8, 9, 10, 11, 12);
void setup(){
lcd.begin(16, 2);
lcd.print("Hello World");}
```

3.20.6 Wind Speed Meter-Anemometer

An anemometer demonstrated in Figure3.15 is a device used for measuring wind speed, and is a common weather station instrument. This well-made anemometer is designed to sit outside and measure wind speed with ease. To use, connect the black wire to a common ground between anemometer and Arduino microcontroller, the red wire to 7-24VDC (we used 9V with success) and measure the analog voltage on the yellow wire. The voltage will range from 0.4V (0 m/s wind) up to 2.0V (for 32.4m/s wind speed). That's it! The sensor is rugged, and easy to mount. The cable can easily disconnect with a few twists and has a weatherproof connector [39, 40].

Figure3.15 Anemometer Module In Reality

Technical Details
Dimensions:
- Height (base to center): 105mm / 4.1"
- Center out to Cup: 102mm / 4"
- Arm Length: 70mm / 2.8"
- Weight: 111.8g

Wire Dimensions:
- Wire Length: 99cm / 39"
- Plug Length: 30mm / 1.2"
- Diameter (thickness): 4.8mm / 0.2"

Specifications

- Output: 0.4V to 2V
- Testing Range: 0.5m/s to 50m/s
- Start wind speed: 0.2 m/s
- Resolution: 0.1m/s
- Accuracy: Worst case 1 meter/s

Connector Details:

Pin 1 - Power (red wire), Pin 2 - Ground (black wire), Pin 3 - Signal (yellow wire), Pin 4 (blue wire) which generates very low current, is neglected (not connected) [39, 40].

Wind speed meter generates the other third ultimate side of weather station attributes in this project. It is employed in order to measure, store, and demonstrate the wind speed in (*mph*) of a local specific location. Moreover, the Arduino code is proposed to show up the maximum wind speed measured lastly such that if the wind blown up hardly in a specific moment, the max value of the wind that time is stored and shown in the part assigned to measure the peak point of the wind. The peak value of the wind differs from time to time depending on the maximum wind strength which is proposed to be stored in the proposed database system and shown alongside over LCD display as long as there exists no greater read than the last value. The working principle of the proposed wind speed sensor depends considerably on the construction of this tidy anemometer. See Figure 3. 16.
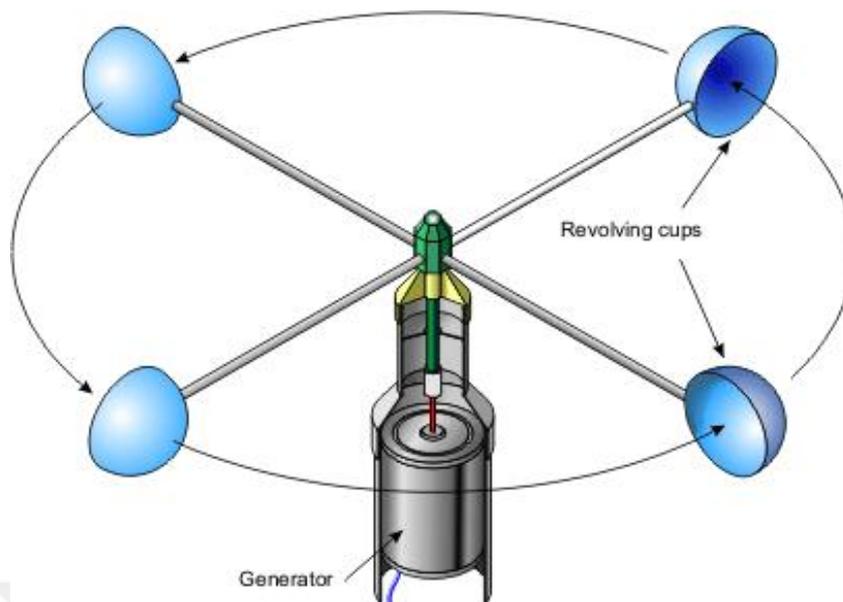
Figure3.16 The Interior Structure Of The Anemometer

The interior structure of the device is constructed of a DC motor that works in synchronous with the revolving cups rotation as shown in Figure.32. The rotation of the revolving cups gives a synchronous moving to the DC motor due the pole combination between the motor and the Hub which carries the cups. As a reminder about the characteristic of a DC motor, the motion and the energy are reverse proportional, that means the motor can generate mechanical rotation/motion if it is provided by power, and can work as a voltage generator if the rotor excited by mechanical motion. Hereby, the wind speed sensor attached to the analog pin of employed Arduino board. The output terminals of the anemometer consist of three wires identified by red, black, and yellow color. As an important point, the proposed anemometer needs external separated power (battery) in a range of (9-12) Volt. The red terminal wire is attached to the positive terminal of the battery, the black wire alongside with Arduino GND are attached to the negative terminal of the battery, and the yellow terminal wire is attached to the analog pin A1 of the Arduino board as shown in Figure3.17. The amount of voltage generated by the rotation of the cups is handed up to the analog pin of the Arduino and hence the wind speed is calculated based on some formulas represented by Arduino IDE code.
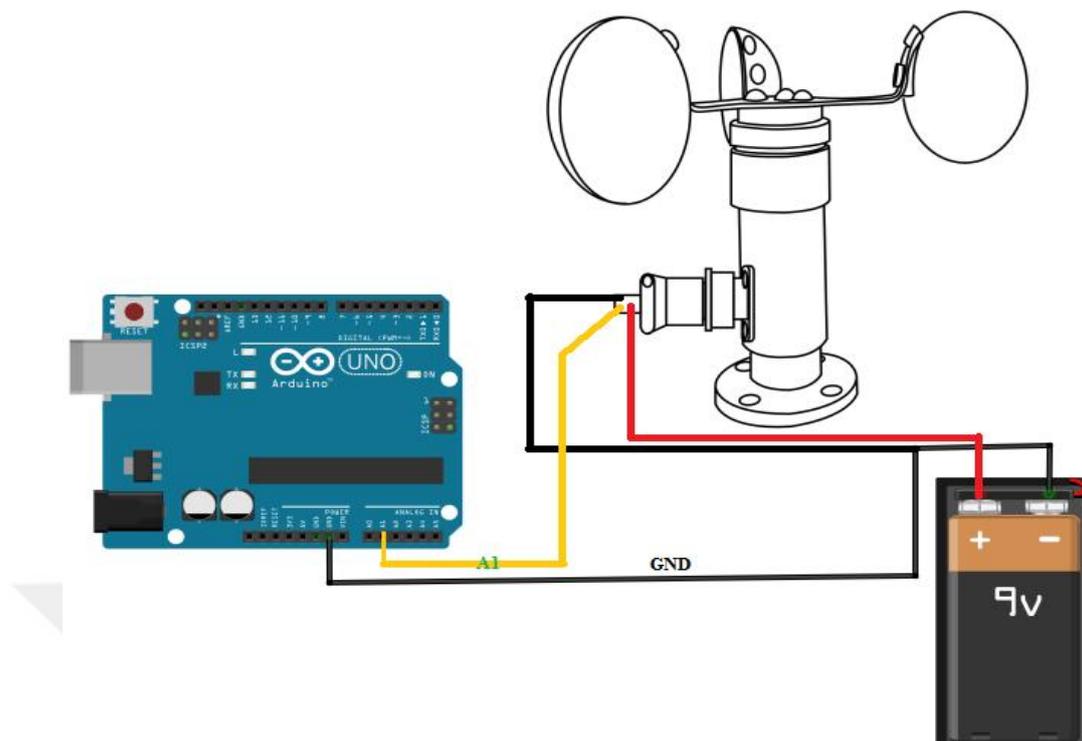
Figure3.17 Anemometer Connection Scheme

THE CODE
```
int serial_in;
double x = 0;
double y = 0;
const int sensorPin = A1;
int sensorValue = 0;
float sensorVoltage = 0;
int windSpeed = 0;
float voltageConversionConstant = 0.004882814;
int sensorDelay = 1000;
float voltageMin = 0.03;
float windSpeedMin = 0;
float voltageMax = 1.25;
float windSpeedMax = 32;
void setup(){
Serial.begin(9600);}
void loop(){
sensorValue = analogRead(sensorPin);
sensorVoltage = sensorValue * voltageConversionConstant;
if (sensorVoltage <= voltageMin){
windSpeed = 0;}
else{ windSpeed = ((sensorVoltage -voltageMin)*windSpeedMax/(voltageMax -
voltageMin));}
```

```
x = windSpeed;
if (x >= y){y = x;}
else {y = y;}
Serial.print("Voltage: ");
Serial.print(sensorVoltage);
Serial.print("\t");
Serial.print("Wind speed: ");
Serial.print(windSpeed);
Serial.println("Max=");
Serial.println(y);
delay(sensorDelay);
}
```

3.20.7 Limit Swith

The term limit is given to such switches in order to cut power when tripped to prevent over-run. The limit switch type that is used in the project is called snap action limit switch. The switch is designed to satisfy wide industrial applications due to its availability in heavy duty metal. The limit switch is suitable for the work based separated contacts application to switch high current and potential necessities with galvanic ally for switching based different polarities in a given circuit. The contacts of the switch can be treated independently with respect to mechanism connectivity that is excited by EN confirmation. Finally, the switch shown in Fig3.19 can sense the action from different areas based 360o so that a tiny contact can cut the power accordingly [41].
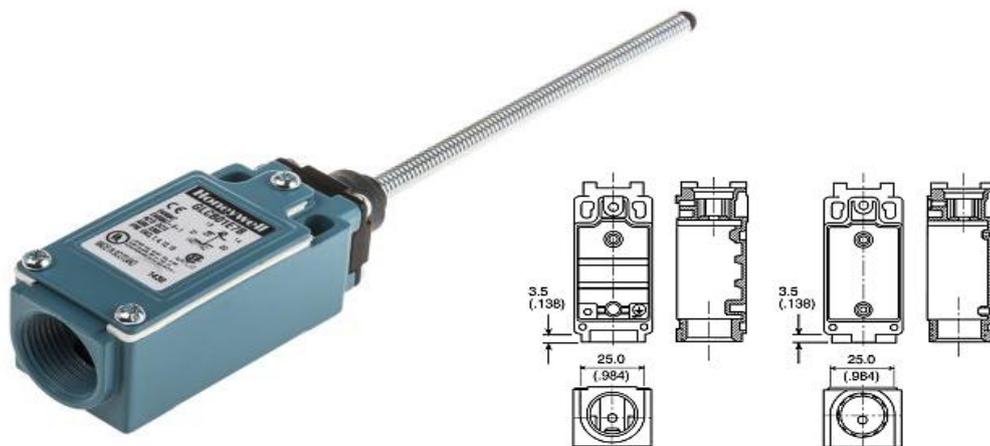
Figure3.18 Snap Action limit Switch

The specification of the proposed snap action limit switch is exposed for more details as shown in Table3.2

Table3.2 Snap Action limit Switch Sspecifications

Actuator Type	Coil Spring
Maximum Current	10 A
Housing Material	Die Cast Zinc
Maximum AC Voltage	300 V
Maximum DC Voltage	300 V
Contact Type	Snap Action
Length	68.5 mm
Width	30.5 mm
Minimum Life	10 000 000 Cycles
Max Operating Temp	+ 85ºC
Depth	26.35 mm
Dimensions	184 × 30.5 × 30 mm
Min Operating Temp	-40ºC

Photocell sensor is considered the main controller media that activates the relay by feeding its signal pin by 5V from Arduino Uno digital pin. The other side of the relay can be either attached to DC voltage or to AC voltage particularly in case of dealing with AC voltage to activate huge applications based AC. This project involves high voltage that causes serious injury. Hence, all necessary precautions should be taken in to consideration and all power to the circuit should be turned OFF before working over.

The relay consists of three input terminals and three output terminals. The input terminals are constructed of VCC connected to the VCC of Arduino, GND connected to the GND of Arduino and the signal to any digital pin of Arduino (pin 8). The output terminals are constructed of normally open (ON) connected directly to one of satellite receiver positioner terminals, the common (C) is connected directly to the other satellite receiver positioner terminals.

The output of the positioner is connected to the terminals of the linear actuator in order to be controlled based on the amount of the light falling over the LDR. Finally, the normally closed (NC) terminal of the relay is initially left up. The relay module is activated by the reading signal coming out of the photocell. For more clarity, the light strength applied over photocell component will excite the system and give PWM digital pulse equals to 0. In the other hand, as light strength decreases to a specific level, the photocell will be excited and give PWM digital pulse equal to 1.

The digital signals identified by (0 & 1) control the light bulb such that the changing over phenomena between ON / OFF states occurs regularly as shown in Figure 3.19. The digital signal 0 means by the photocell that light strength falling over LDR is higher. Whereas, the digital signal 1 means that the light is decreased than the specific range and hence the relay can easily control the linear actuator depending on the LDR module with respect to the employed positioner.
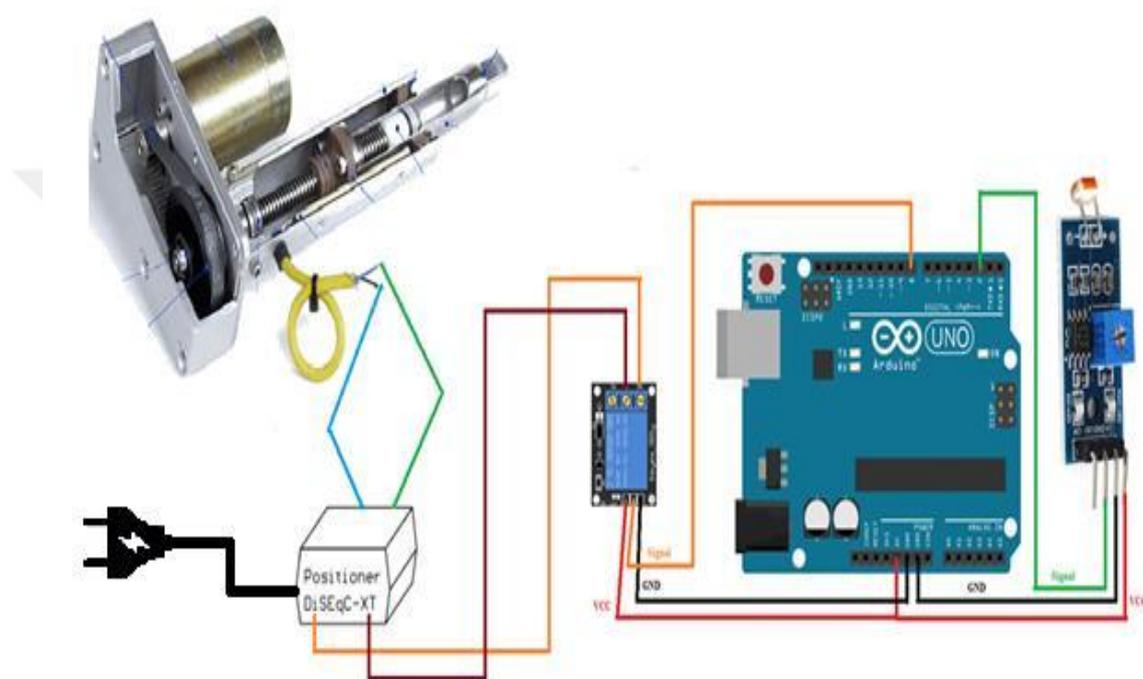
Figure3.19 Relay Module Connection Scheme Based LDR Domination

3.21 Arduino SIM900-GSM Shield

The specified weather station and power system information are ordered and managed in order to be sent via Arduino GSM shield module. The employed GSM in the proposed module is identified by SIM900 Arduino GSM shield, which is also called Quad − Band GSM/ GPRS unit. It is worth mentioning that the proposed SIM900 GSM module shown in Fig.6 can work over four frequencies specified by (850 MHz, 900 MHz, 1800 MHz, 1900 MHz) in order to provide (Voice, SMS, Data, Fax) services respectively with inconsiderable power consumption [42].

The standard proposed system uses SMS service; hence, 900 MHz frequency is put in charge. The GSM modem is modeled to be worked normally when provided with 3 − 5 Volt external power, which makes the modem to be interfaced competently

with several friendly microcontrollers such as (Raspberry Pi, PIC, and Arduino). In addition, Tx / Rx symbol rate of SIM900 GSM modem is specified between 9600 – 115200 bit / second, which makes SMS or Data acknowledgment broadcasting through the mobile phone more applicable.

Figure3.20 Arduino GSM Shield Module

```
THE CODE
#include "SIM900.h"
#include "sms.h"
#include "SoftwareSerial.h"
#include "sms.h"
SMSGSM sms;
int led = 13;
boolean started=false;
char smsbuffer[160];
char n[20];
int inc=10;
void setup()  {
Serial.begin(9600);
Serial.println("GSM Shield testing.");
if (gsm.begin(2400)){
Serial.println("READY");
started=true;
pinMode(led, OUTPUT);   }
else Serial.println("\nstatus=IDLE");
if(started){
delsms();   } };
void loop() {
```

```
int pos=0;
if(started){
pos=sms.IsSMSPresent(SMS_ALL);
if(pos){
Serial.println("IsSMSPresent at pos ");
Serial.println(pos);
sms.GetSMS(pos,n,smsbuffer,100);
Serial.println(n);
Serial.println(smsbuffer);
if(!strcmp(smsbuffer,"ON")==0){
Serial.println("led is on");
digitalWrite(led, HIGH); }
else if(!strcmp(smsbuffer,"OFF")==0) {
Serial.println("led is off");
digitalWrite(led, LOW);  }
else if(!strcmp(smsbuffer,"STATUS")==0){
if(digitalRead(led)==1)
{sms.SendSMS("Enter phone number here", "led is on");}}
else  if(digitalRead(led)==0)
{sms.SendSMS("Enter phone number here ", "led is off");} }
delsms(); } } };
void delsms(){
Serial.println("delsms");
for (int i=0; i<10; i++){
int pos=sms.IsSMSPresent(SMS_ALL);
if (pos!=0){
Serial.print("\nFind SMS at the pos ");
Serial.println(pos);
if (sms.DeleteSMS(pos)==1){
Serial.print("\nDeleted SMS at the pos ");
Serial.println(pos);  }
else {
Serial.print("\nCant del SMS at the pos ");
Serial.println(pos); }}}}
```

3.22 Linear Actuator Motor

The actuator type that is employed in this project is called super duty linear actuator. These actuators can be used in place of pneumatics or hydraulics. The super duty linear actuators are driven by high torque brushed DC gear motors coupled to a ball-screw to create a low friction linear drive. The ball-screw provides efficient linear

thrust that can handle loads in both the pushing and pulling orientation. The linear actuators can handle an incredible amount of static load and will hold position even when power is removed. Each actuator has a built-in potentiometer which can be used for positioning feedback if your application requires. Figure3.21 shows the aluminum and steel construction with full metal drive gears that ensures tremendous durability and reliability.
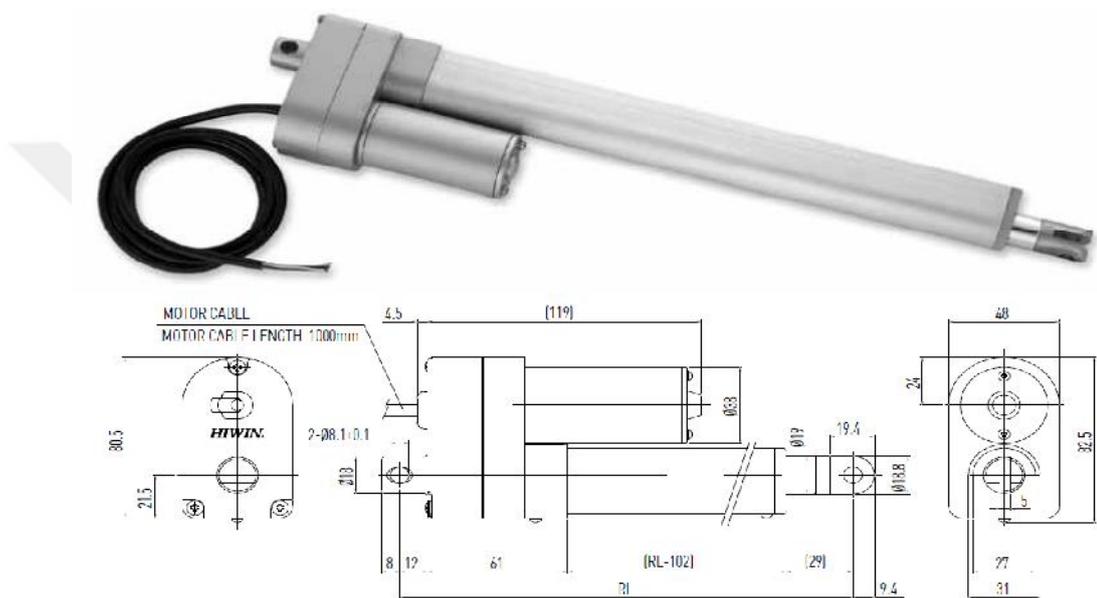
Figure3.21 Super Duty linear Actuator

For more details, the specifications of the proposed linear actuator motor [43] are demonstrated as shown in Table 3.3.

Table3.3 Linear Actuator Specifications

Screw Type	ACME		
Weight	1.27 kg		
Protection	IP54		
Working Temp	+5ºC ~ 40ºC		
Supply Voltage	24 VDC	12 VDC	5 VDC
The Output	High level 24 VDC	High level 12 VDC	TTL
	Low level0.2V/40mA PNP*	Low level0.2V/40mA PNP*	
	PS. Open collector		

3.23 Photo Voltaic Module

The element is mainly employed in solar systems in order to handle with sun radiation effectively such that the incident sun light is converted to electricity due to the semiconductor materials employed in order to follow and achieve the observable fact (phenomena) that exposed in physics. The photovoltaic systems are constructed of solar panel with number of solar cells used to generate high electrical power from sunlight. The operation is considered a novel method since such a great systems put in charge to handle with the high grade degrees of the radiation coming from the sun. The procedure is unique phenomena due to the following factors:

1) Fixed solar panels without classical motions.
2) No need for fuel.
3) Lack of fluids and gases that might make problems in case of thermal solar systems.
4) High sensitivity and response.
5) Controlled easily in moderate temperatures.
6) Little maintenance required.
7) The electricity is generated without pollution.
8) Systems are made of well-known and pro fluent materials as silicon.
9) Admired in wide world applications.
10) High efficiency electric power convertor.

A photovoltaic module is a group of cells, wired in series. The electrical output from a single cell is small; so multiple cells are connected in series and encapsulated (usually behind glass) to form a module. PV modules are thus the principle building blocks of a PV system, and any number of modules can be connected to give the desired electrical output in a PV array or system. This modular structure is a considerable advantage of PV systems, because new panels can be added to an existing system as and when required.

Figure3.22 PV Module Structer
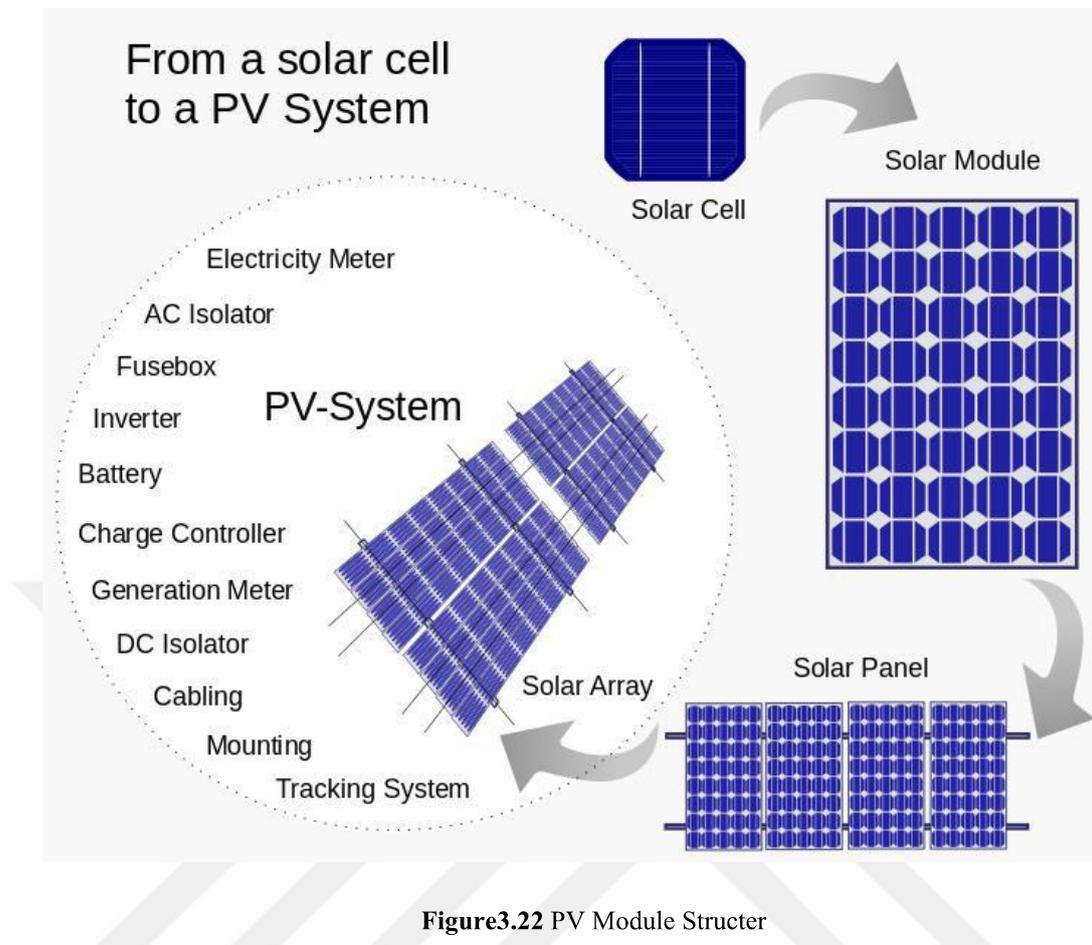
There are four advanced thin film technologies for making PV modules. Their names are derived from the active cell materials:

1) Cadmium telluride (CdTe),

2) Copper indium dis elenide (CIS),

3) Amorphous silicon (a-Si)

4) Thin film silicon (thin film-Si).

Amorphous silicon is in commercial production while the other three technologies are slowly reaching the market. Thin film modules are made directly on the substrate, without the need for the intermediate solar cell fabrication step.

3.24 Photo Voltaic Module Performance

The total energy output wattage of a photovoltaic module equals its output voltage multiplied by its operating current. Unlike voltage sources such as batteries which

produce current at relatively constant voltage, photovoltaic modules may produce current over a wide range of voltages.

The output characteristics of a module are characterized by a performance curve called an I-V Curve which shows the relation between current and voltage output. An example is shown in Figure 3.23 Voltage (V) is plotted along the horizontal axis while Current (I) is plotted along the vertical axis. Typical I-V curves are given for the conditions of 1000 watts per square meter of sunlight and 25degrees C (77 degrees F) cell temperature. 1000 watts per square meter is often referred to as one 'Peak Sun.' There are three significant points of interest on the I-V curve:

- **Maximum Power Point (MPP)**: is labelled Vmp, Imp on the I-V curve. This is the operating point at which the maximum output will be produced by the module at operating conditions indicated above.

- **The Open circuit Voltage**: (Voc) - is the maximum potential voltage achieved when no current is being drawn from the module. As shown by the figure the open circuit voltage (VOC) occurs when there is no current passing through the cell.

$$V\ (at\ I = 0) =\ V_{oc}$$

VOC is also the maximum voltage difference across the cell for a forward-bias sweep in the power quadrant.

$$V_{oc} =\ V_{MAX}\ for\ forward - bias\ power\ quadrant$$

- **The Short Circuit Current**, **(Isc)**: Is the maximum current output which could be reached by the module under the conditions of a circuit with no resistance. The short circuit current ISC corresponds to the short circuit condition when the impedance is low and is calculated when the voltage equals 0.

$$I\ (at\ V = 0) =\ I_{SC}$$

I$_{SC}$ occurs at the beginning of the forward-bias sweep and is the maximum current value in the power quadrant. For an ideal cell, this maximum current value is the total current produced in the solar cell by photon excitation.

$$I_{SC} =\ I_{MAX}\ = I_{\varsigma}\ for\ forward - bias\ power\ quadrant$$
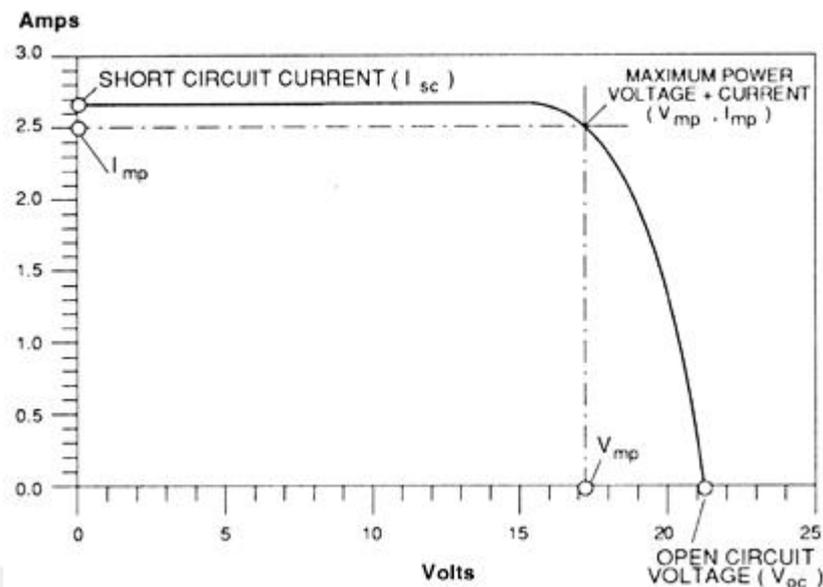
Figure3.23 Ideal Cell Characteristic

Factors Affecting PV Module Perfomace

- **Load Resistance:** A load or battery will determine at what voltage the module will operate. For example, in a nominal 12 volt battery system, the battery voltage is usually between 11.5 and 14 volts. In order for the battery to charge, the modules must operate at slightly higher voltage than the battery. If a load's resistance is well matched to a module's I-V curve, the module will operate at or near the maximum power point, resulting in the highest possible efficiency. As the load resistance increases, causing the photovoltaic module to operate at a voltage higher than the maximum power point, module efficiency decreases. Efficiency also decreases at voltages less than at the maximum power point.

- **Intensity of Sunlight:** A photovoltaic module's output is proportionally affected by the intensity of solar radiation to which it is exposed. More intense sunlight will result in greater module output. Lower sunlight levels result in lower current output. Voltage is not changed appreciably by variations of sunlight intensity.

- **Cell Temperature:** Photovoltaic modules operate less efficiently at higher cell temperatures. The operating voltage drops with increasing cell temperature heat Figure 3.24, in this case may be thought of as an electrical resistance to flow of electrons. Effective current output may be significantly reduced decreased if the maximum power point of a module or array shifts to a much lower voltage than

the operating voltage of the load. Generally a module will lose approximately 0.5 % efficiency per degree centigrade of temperature rise between 80 and 90 degrees C [47].
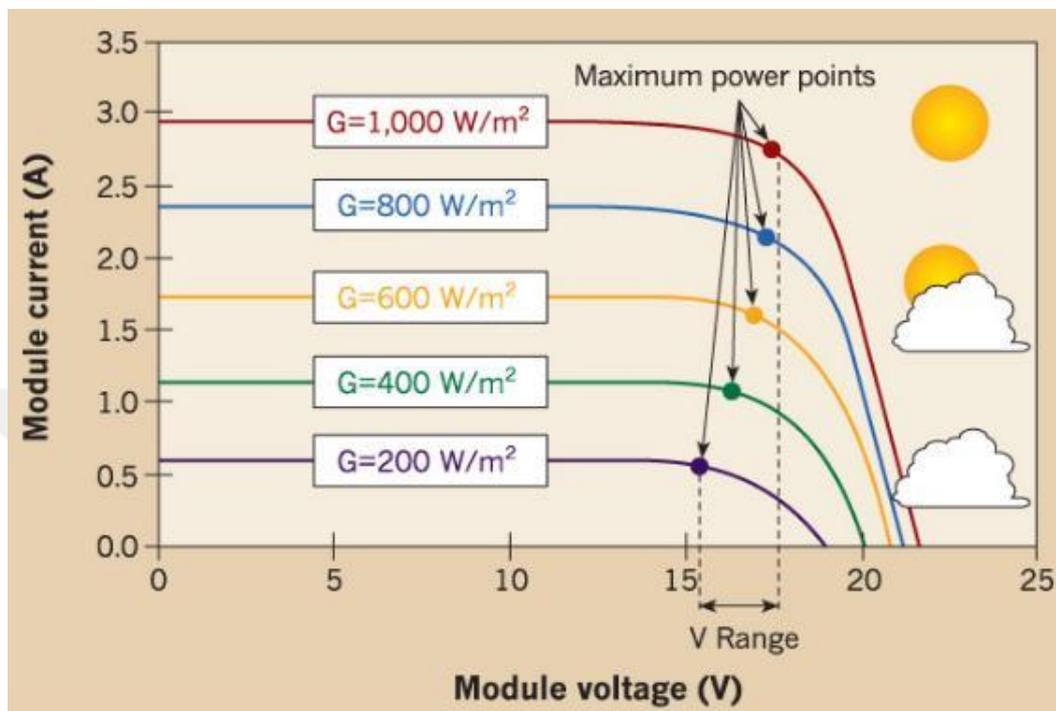
Figure3.24 The Effect of Temperature On The Performance

- **Shading:** Even partial shading of photovoltaic modules will result in dramatic reduction of module's output. One completely shaded cell can reduce this module's output by as much as 80%. The effect of partial shading of three cells cuts the modules output in half when operating at 15 volts.

3.25 Photovoltaic System Sizing

Sizing a photovoltaic system for a stand-alone photovoltaic power system involves a five step process which will allow the photovoltaic system designer or user to accurately size a system based on users projected needs, goals and budget. These steps are:

1) Estimating The Electric Load
2) Sizing and Specifying An Inverter
3) Sizing and Specifying Batteries

4) Sizing and Specifying An Array

5) Specifying A Controller

3.26 Photo voltaic System Sizing Instruction

The first task for any photovoltaic system design is to determine the system load. This load estimate is one of the key factors in the design and cost of the stand-alone PV system. If the loads vary significantly on a seasonal basis or are of a critical nature the peak load values are used.

The following steps are followed for Electric Load Estimation:

- Identify each load and the number of hours of use per day. Enter the load current in amperes and the operating voltage for each load and calculate the power demand. The power demand is the product of the current and the voltage. List the ac loads at the top of the worksheet and dc loads, at the bottom. A power conditioning unit (PCU) is required for ac loads. A PCU, commonly called an inverter, adds complexity to a system and causes a 10-15 percent loss of power because of the efficiency of converting dc power to 28 ac power. If only a small percentage of the loads require ac power, it may be better to replace those devices with ones that use dc power.

- Group the loads by type and operating voltage and sum the Power demand for each group. The recommended voltage of the standalone PV system will be determined by considering this information.

- After selecting the system voltage, calculate the total daily ampere hours required at this voltage. The load determination is straightforward the power requirements of any electrical device that will be included in the system are calculated and multiplied by the amount of time that specific appliances will operate each day. The power required by an appliance can be measured or obtained from manufacturer's data sheets. However, the amount of time the appliance will be used per day, week, or month must be estimated. For residential systems (and many others) the hours of use can be controlled by the system owner. The design should consider energy conserving substitutes for items that are used often. Large and/or variable loads are determined and if they can be eliminated or changed to operate from another power source. Fluorescent lamps should be used in place of

incandescent lamps. They provide the same light levels with much lower power demand. Dc appliances considered to avoid the loss in the dc/ac power conversion process. DC lights and appliances usually cost more, but are more efficient and last longer. The number of ac appliances available is greater but efficiencies are usually lower because these appliances are designed for use on an "infinite" utility power supply.

3.27 Batteries

Batteries chemically store direct current electrical energy for later use, during periods of cloudy weather and when a portable power source is desired. Since a photovoltaic system's power output varies throughout any given day, the battery storage system can provide a relatively constant power source, even when the photovoltaic system is disconnected for repair and maintenance or producing minimal power in periods of reduced insolation.

A battery's efficient lifetime depends on the technology and the way the battery is used - significantly on the number of 'cycles' (complete full battery charge and discharge) that they undergo.

Manufacturers generally give an expected lifetime in years and/or in 'charge-discharge cycles'. For example:

• 'Life expectancy = 10 years or 10,000 cycles, whichever is the sooner'

Lithium-ion batteries last longer than lead-acid: you may see a 10-year lifetime expectancy claimed and this is improving all the time.

Normally the battery storage system will monitor the battery performance and should give you an indication when your batteries need replacing.

Some battery system manufacturers operate a battery leasing and/or replacement scheme for worn-out batteries and arrange for the safe disposal/recycling of the battery.

The batteries in a solar PV storage system work like any rechargeable battery: they charge direct current (DC) from an external source (e.g. your solar PV system) and discharge DC when energy is required.[44].

For lead-acid batteries, shallow cycle batteries are discharged no more than 25% of rated capacity on a daily basis, and up to 80% over the period of autonomy. They are designed to produce high energy over a short period of time, with longer autonomy periods. The term autonomy denotes the length of time during which a PV-battery system can provide energy to the load without energy from the photovoltaic array. [45].

CHAPTER 4

PROPOSED SYSTEM MODULE

In this chapter, we focus on power system modeling that awfully gives priorities to realize and store the maximum power radiated out of sun to feed a definite primary load. The power of the sun can be stored in different ways based on PV modules employed by renewable solar systems. The main challenge of this proposed idea is realizing the maximum sun power denoted by MPPT (maximum power point) which is considered the most effective and energetic spot over power storage curves.

The MPPT indicates the maximum power point realized during a specific time. In accordance, a tracking system is employed in order to follow sun trajectory, direction, and the way of power radiation. Moreover, another point should be taken in to consideration that is the sun can feed the proposed load at day periods. However, the batteries are considered a most suitable solution for providing power at night periods. Hereby, the primary load gets the power from the sun directly at the day and indirectly at night based on the employed batteries. In addition, the temperature over the panel, the real time sun tracking information, the charge ratio in the employed batteries, and the strength of the wind are demonstrated over an LCD display. Finally, a GSM module based notification request is employed to direct the situation of the power system as an SMS through a specific phone number. Finally, it has to be mentioned that the whole system is controlled by modular supervisor technology, which means there exist a main supervisor employed to dominate the tasks of the sub controlled modules.

4.1 Proposed Idea

The connection methodology was implemented based on two independent microcontrollers identified by MCU1 and MCU2, which they are dominated by a main Modular supervisor denoted by (S) as exposed in Figue4.1
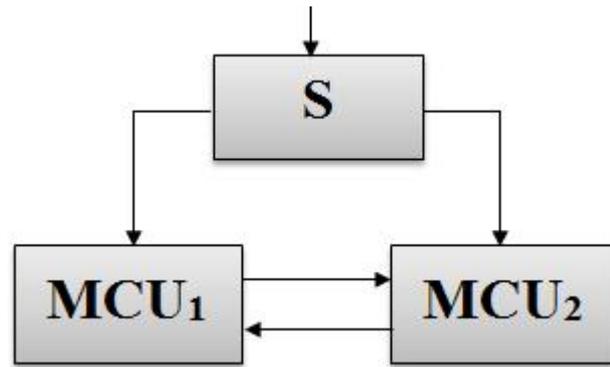
Figure4.1 Modular Supervisor Concept

This independency based the microcontrollers was proposed due to the need for larger number of pins and in order to specify the programing code that govern sun tracking mechanism and the meteorological conditions over solar panel separately. The first Arduino microcontroller denoted as MCU1 is put in charge to control two linear actuators identified by M1 and M2 as shown in Figure4.2.
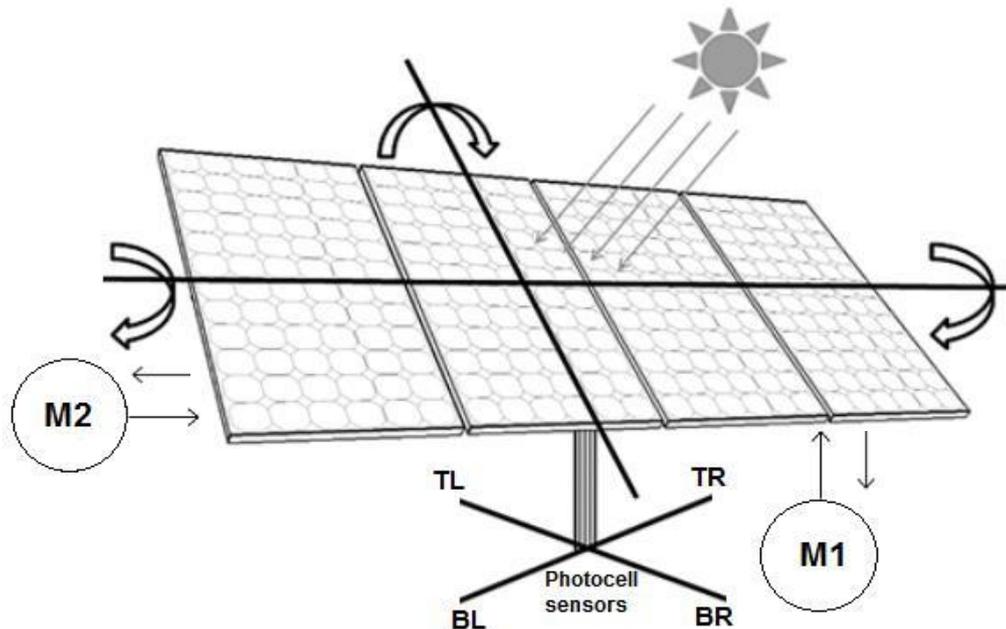
Figure 4.2 Solar Panel Combination With LDR Sensors And Motors

The location of the photocell sensors in the real module was equipped on the upper side of the panel but the genuine place omitted in for clarity. Generally, the proposed

photocell sensors are equipped over the solar panel in order to face sun light radiations from top left TL, top right TR, bottom left BL, and bottom right BR. The motors M1 & M2 are controlled by MCU1 based the photocell sensors with respect to sun radiation strength. Moreover, the motors are responsible of moving the panel horizontally based M1 or vertically based M2 to specify the highest h1, h2, and h3 as shown in Figure4.3.
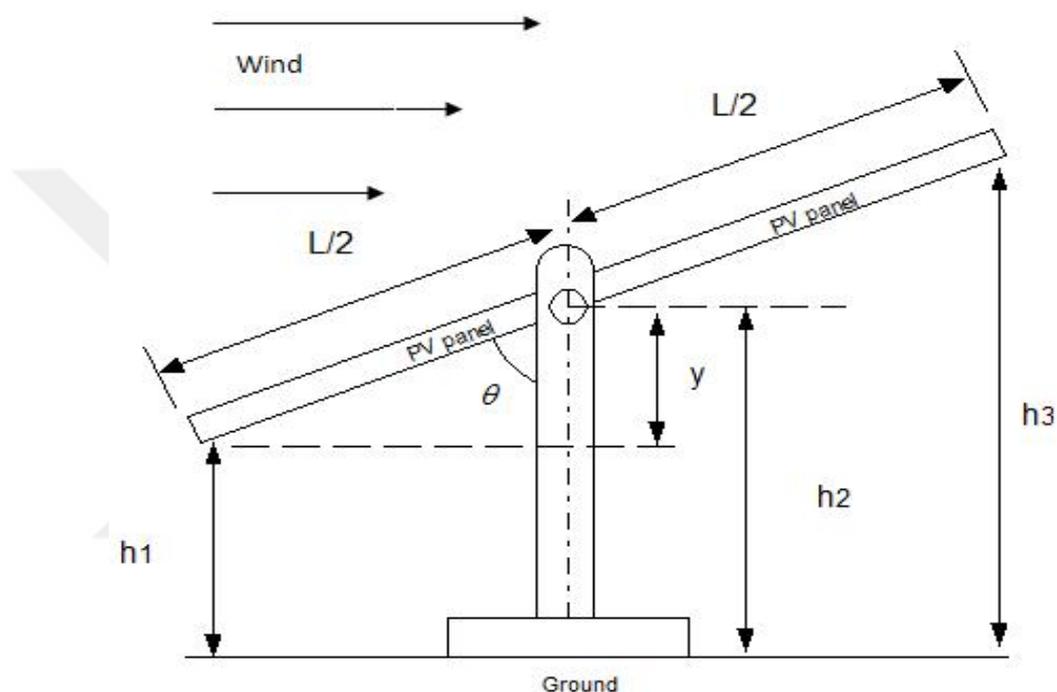
Figure4.3. Solar Panel Pmotion

There exist several motors compatible with Arduino microcontroller such as Servo motor and DC motor, etc. However, the suitable choice based motor modules will be the servo motors due to their abilities to be rotating in degrees. On the other hand, such a motor is not that tough to hold and move the heavy solar panel that is employed in the project. Accordingly, linear actuators are employed in order to move the panel up, down or left, right and the limit switches are used to specify the maximum rotation range of the motors M1 & M2 instead of dealing with motor rotation based degrees as the servo motors. Hereby, four limit switches denoted as

Lm1, Lm2, Lm3and Lm4, were connected as shown in Fig4.4 to specify the four directions accurately.
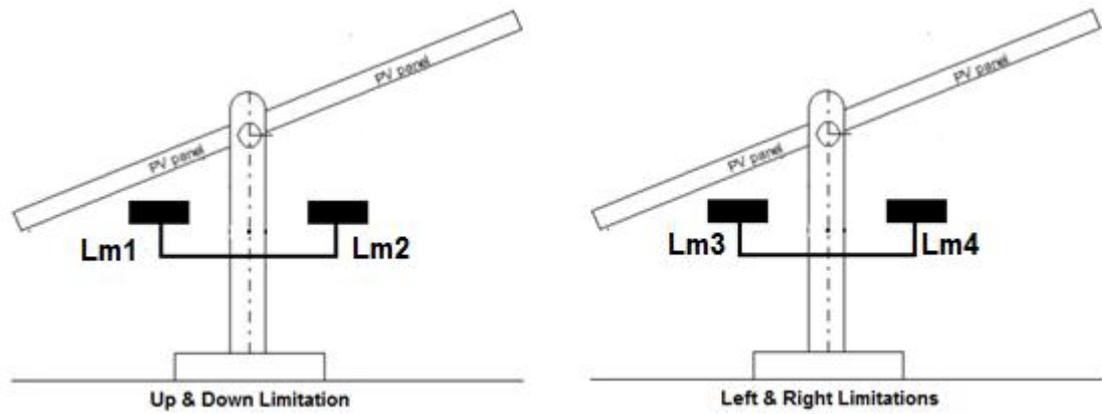

Fig4.4. Panel Based Lm Structure For Two Side Views

For more simplifications, the connection methodology of the power elements based MCU1 is converted into blocks and demonstrated as shown in Figure 4.5.
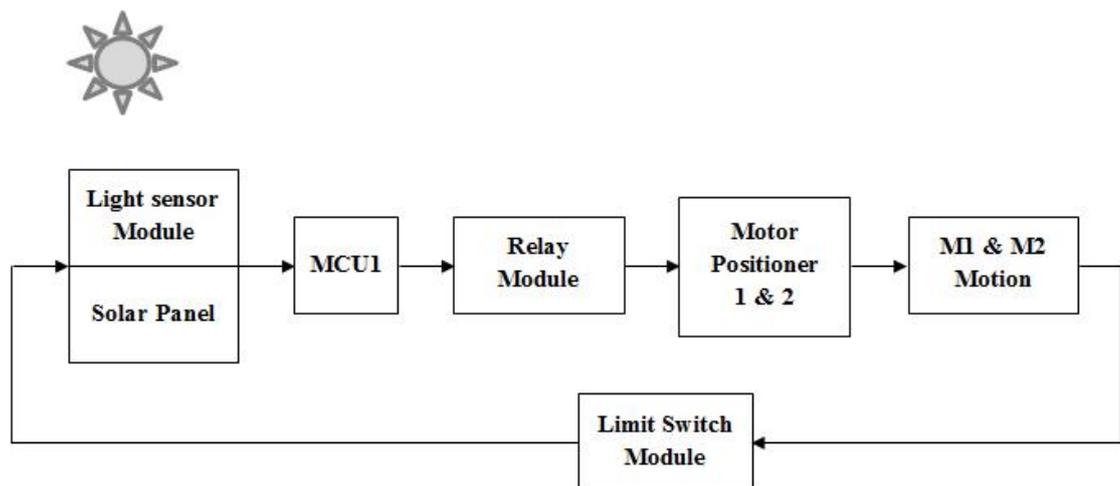

Figure4.5 Components Connection Based MCU1

4.2 System Components Combination

As mentioned before that there exist a main modular supervisor dominates the tasks given to the sub controllers MCU1 and MCU2. Accordingly, it is intended to separate the description of each MCU working methodology.

4.2.1 Working Principle Based MCU1

The working principle based MCU1 starts from the light sensors that are synchronized directly with solar panel motion. It is worth mentioning that the sensor that gets more light intensity with respect to *TL, TR, BL, BR* will be the ultimate coordinator to report a given situation to MCU1 in order to take the right decision to move the actuators either vertically or horizontally. The motion mechanism of the actuators is synchronized with motor controller called positioner. There exist two positioners denoted by *pos1 pos2* to control M1 and M2 respectively. The high voltage requirement of $18V_{dc}$ that the actuators need and the microcontroller cannot supply led to use relay modules in order to deal with higher voltages supplied by the Ac source of the positioners. For more clarity, the connection module is demonstrated in Figure4.6.
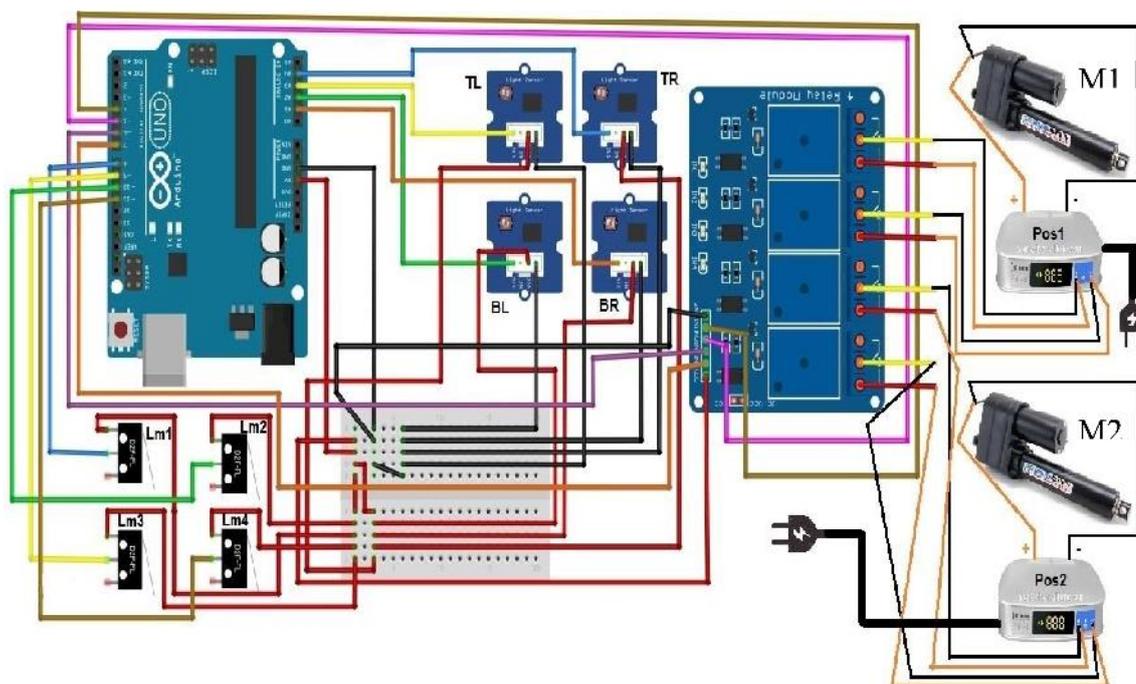

Figure4.6 MCU1 Components Connection

4.2.2 Working Principle Based MCU2

The second microcontroller unit MCU2 is employed to show the information regarding physical situation over the solar panel. The physical situation attributes are chosen to be concentrated on demonstrating the temperature T, humidity H and the speed pf the wind W in the proposed power system established location. Hereby, DHT sensor and wind speed meter modules are put in charge to perform the tasks ordered by MCU2 in synchronous with MCU1 under the domination of the coordinating supervisor (S). It is worth mentioning that the proposed system module can provide real time information about the system status based on the SIM900 GSM module employed in the system as the hierarchical connection of the components based MCU2 shown in Figure4.7.
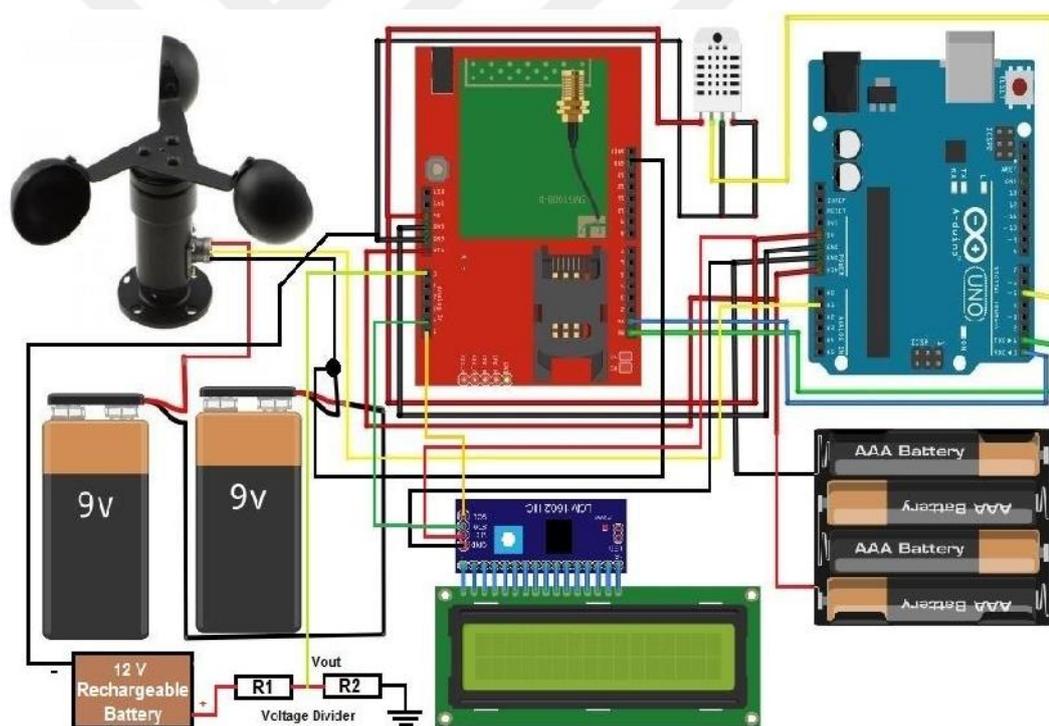
Figure 4.7 Hierarchical Connection Based MCU2

As shown in Figure4.7, the display module was interfaced with I2C connector module in order to shrink the pins that are connected to microcontroller. As a background, Arduino microcontroller generally deals with $0 - 5$ V for both inputs and outputs that is the reason which effects on the compatibility between the 12 V

rechargeable battery and Arduino board. Hereby, the compatibility issues will be solved by applying voltage divider rule depending on the connection shown in Figure4.8.
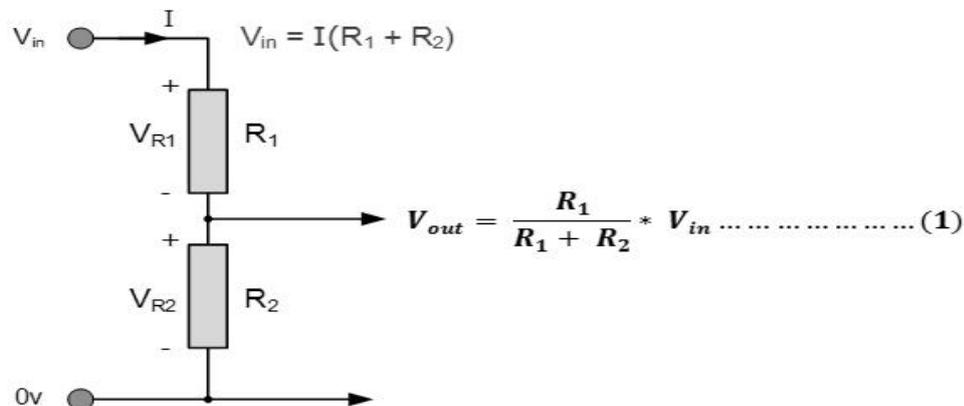
Figure 4.8 Voltage Divider Operation

The formula in equation (1) sets the voltage down in order to map the 12 V of the rechargeable unit to 5 V. As mentioned before, there exists a relational connection between MCU1 and MCU2 based on the presence of the common rechargeable unit. The term common is given to the storage unit for being the parallel connector between sun tracking system and it's physical circumstances with respect to MCU1 and MCU2 respectively. However, the whole connection based the coordinating supervisor principle is omitted for more clarity.

It is worth mentioning that the mapping methodology applied to convert the $12 - 5$ V was processed nominally based on the programing code by formally linking each specific voltage to its corresponding charge ratio in percentage [46] as shown in Table 4.1.

Table4.1 State Of Charge With Respect to The Voltage

Voltage (V)	State of charge (%)
12.63	100
12.54	90
12.45	80
12.39	75
12.27	60
12.18	50
11.97	25
11.76	No charge

It has to be mentioned that the proposed project tracks the motion of the sun in order to obtain MPPT spot that increases the maximum efficiency of a given system that realizes the knee of power realization curve between the current I_{mp} and the voltage V_{mp} as shown in Figure 4.9.

Figure4.9 Maximum Power Point MPPT Relational Curve
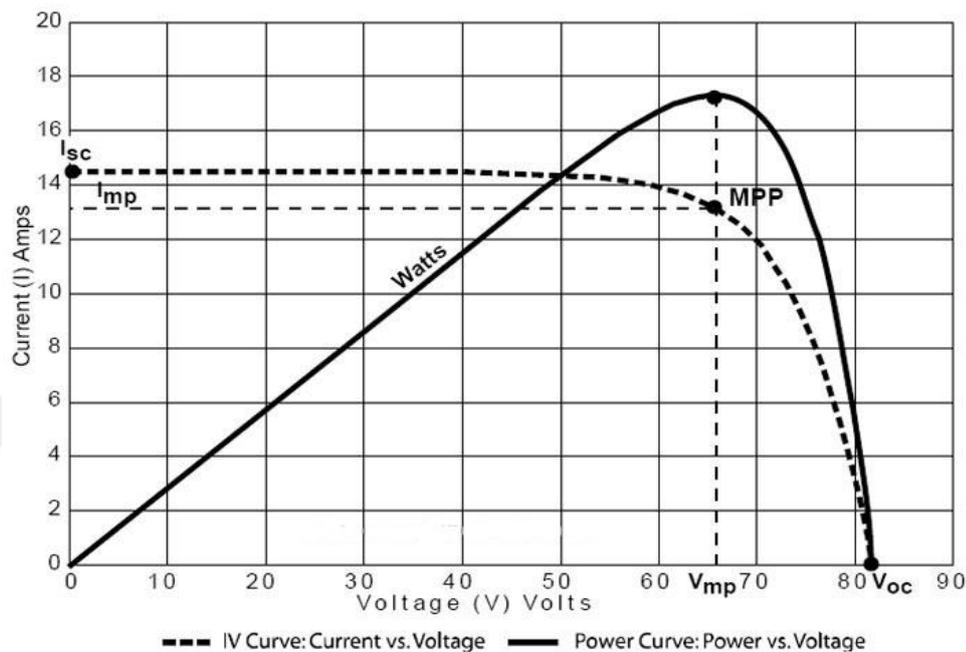
Finally, the information of the system such as the temperature – humidity on the panel, the wind speed in the proposed location and the charging ratio of the storage unit can be transferred remotely to any specific phone number by notification SMS request included with "*STATUS*" word as the diagram unveiled in Figure4.10
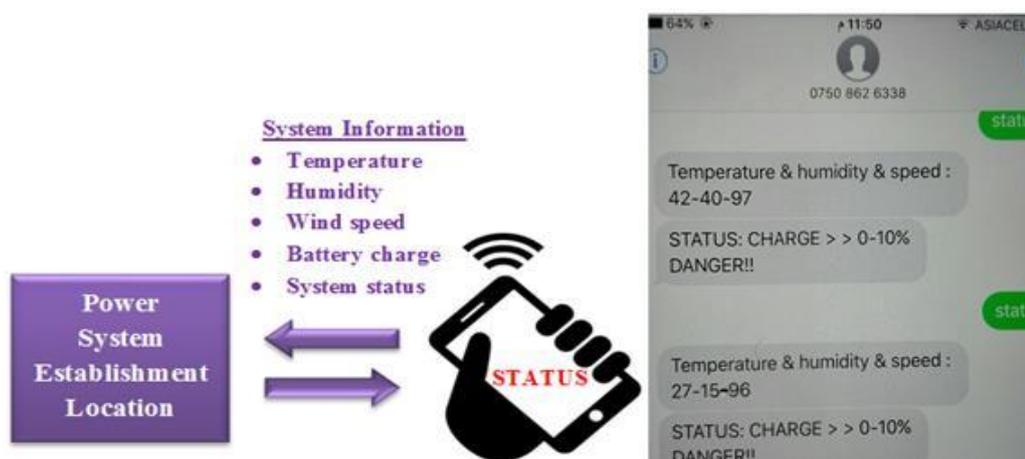
Figure4.10 Data Transfer Center Diagram

CHAPTER 5

5.1 Results

The project's installations were completed inside the university laboratories as shown in Figure5.1 and Figure 5.2 .

Before establishing our system on the   roof of Al-Kitab university, the following main parts were checked inside the university labs:

The projects four optical sensors were checked in the labs using ordinary lamp instead the sun light. The movement of the linear actuator motors depending on Light intensity on each sensor was observed and the two motors movements to the four directions were limited by limit switches. Finally, the information of the system such as the temperature – humidity on the panel, the wind speed in the proposed location and the charging ratio of the storage unit were transferred remotely to any specific phone number by tification SMS with "STATUS"

Figure5.1 System Installation In The University Laboratory
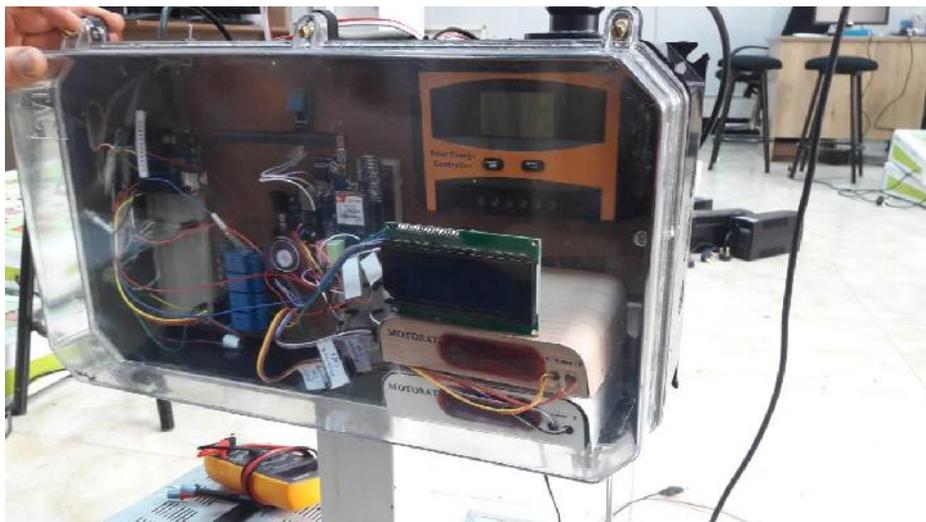
Figure5.2 System Installation In The University Laboratory

The system equipment was installed on the university roof as shown in Figure5.3. Data

transferred (temperature, humidity, wind speed and chagrin batteries) were recorded

in 1/1/2018 for 24 hours and placed in the Table5.1.

Figure5.3 The Project is Established On The University Roof.

Table5.1 Collected Data Transferred to Remote Place Mobile

Time	Temperature Cº	Humidity %	Wind Speed Km / Hour	Battery Charging %
00	10	80%	15	45
01	10	80%	14	45
02	10	81%	14	45
03	10	82%	13	40
04	10	83%	13	35
05	10	85%	12	35
06	10	85%	12	35
07	9	87%	12	45
08	9	91%	13	45
09	10	86%	14	55
10	10	82%	15	70
11	11	80%	16	75
12	11	78%	17	85
13	11	75%	18	85
14	12	74%	19	95
15	12	75%	19	100
16	12	72%	17	100
17	11	72%	14	100
18	12	66%	12	95
19	11	69%	10	95
20	11	70%	14	85
21	10	68%	13	70
22	10	70%	15	55
23	10	69%	14	45

5.2 Arduino code in words

Code 1 – Solar

```
////////MOTORS////////

const int mr=9;
const int ml=2;
const int mt=3;
const int md=4;

/////LIMITED SWITCH////
```

```
const int limitm11=5;
const int limitm12=6;
const int limitm21=7;
const int limitm22=8;

/////Assigning LDRs/////

int ldrtopl = A0;
int ldrtopr = A1;
int ldrbotl = A2;
int ldrbotr = A3;

void setup ()
{
pinMode(mr,OUTPUT);
pinMode(ml,OUTPUT);
pinMode(mt,OUTPUT);
pinMode(md,OUTPUT);

pinMode(limitm11,INPUT);
pinMode(limitm12,INPUT);
pinMode(limitm21,INPUT);
pinMode(limitm22,INPUT);
delay(500);
}

void loop()
{
  //////CAPUCARING ANALOG VALUES OF EACH LDR////

  int topl = analogRead(ldrtopl);
  int topr = analogRead(ldrtopr);
  int botl = analogRead(ldrbotl);
  int botr = analogRead(ldrbotr);

  ///////// CALCULATION AVERAGE/////////
  int avgtop = (topl + topr) / 2; //average of top LDRs
  int avgbot = (botl + botr) / 2; //average of bottom LDRs
  int avgleft = (topl + botl) / 2; //average of left LDRs
  int avgright = (topr + botr) / 2; //average of right LDRs

/////////////// left/right///////////////


 if (avgleft > avgright)
  {
if(digitalRead(limitm22)==LOW)
{
```

```
   digitalWrite(ml,HIGH);
}
else if(digitalRead(limitm22)==HIGH)
{
  digitalWrite(ml,LOW);
}
 }
else if (avgleft < avgright)
  {
if(digitalRead(limitm21)==LOW)
{
  digitalWrite(mr,HIGH);
}
else if(digitalRead(limitm21)==HIGH)
{
  digitalWrite(mr,LOW);
}
 }
else if(avgleft == avgright)
{
 digitalWrite(mr,LOW);
 digitalWrite(ml,LOW);
}

/////////////// TOP/DOWN////////////////
 if(digitalRead(mr)==LOW&&digitalRead(ml)==LOW)
 {
  if (avgtop < avgbot)
  {
if(digitalRead(limitm12)==LOW)
{
  digitalWrite(md,HIGH);

}
else if(digitalRead(limitm12)==HIGH)
{
  digitalWrite(md,LOW);

}
 }
else if (avgtop > avgbot)
  {
if(digitalRead(limitm11)==LOW)
{
  digitalWrite(mt,HIGH);
}
else if(digitalRead(limitm11)==HIGH)
{
```

```
   digitalWrite(mt,LOW);
}
  }
else if(avgtop == avgbot)
{
 digitalWrite(mt,LOW);
 digitalWrite(md,LOW);
}
}
```

Code 2 – Sun

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(8, 9, 10, 11, 12, 13);
int voltpin=A0;
int val;
float voltread;
floa
t I;

void setup() {
  // put your setup code here, to run once:
lcd.begin(16, 2);
lcd.print("SYSTEM IS ON");
val=0;
delay(1000);
}
  voltread=((val)/1023.0)*5.0*14.53/4.67;// resistance ratio =14.3/4.6

void loop() {
  // put your main code here, to run repeatedly:
  val= analogRead(voltpin);//  0 >> 1023 (5v)
  I = voltread/14.53; // mA

  // LCD FIRST RAW//
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("V=");
  lcd.print(voltread);

  lcd.setCursor(7, 0);
  lcd.print("I=");
  lcd.print(I);
  lcd.print("mA");

  lcd.setCursor(0, 1);
  if(voltread>=10.5&&voltread<=12.6)
  {
```

```
/*10%*/ if(voltread<=11.3){lcd.print("0-10% DANGER!!");}
/*20%*/ else if(voltread>=11.3&&voltread<=11.6){lcd.print("10-20%");}
/*30%*/ else if(voltread>=11.6&&voltread<=11.8){lcd.print("20-30%");}
/*40%*/ else if(voltread>=11.8&&voltread<=11.9){lcd.print("30-40%");}
/*50%*/ else if(voltread>=11.9&&voltread<=12.1){lcd.print("40-50%");}
/*60%*/ else if(voltread>=12.1&&voltread<=12.2){lcd.print("50-60%");}
/*70%*/ else if(voltread>=12.2&&voltread<=12.3){lcd.print("60-70%");}
/*80%*/ else if(voltread>=12.3&&voltread<=12.4){lcd.print("70-80%");}
/*90%*/ else if(voltread>=12.4&&voltread<=12.5){lcd.print("80-90%");}
/*100%*/ else if(voltread>=12.5&&voltread<=12.6){lcd.print("90-100%");}
} else if(voltread<10.5){lcd.print("BAT DANGER!!");}

  delay(1000);

}
```

Code 3 – Wind – Temp

```
#include "SIM900.h"
#include <SoftwareSerial.h>
// #include "inetGSM.h"
#include "sms.h"
#include "DHT.h"
#define DHTPIN 5
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
SMSGSM sms;
int numdata;
boolean started=false;
char smsbuffer[160];
char Mittente[20];
char string[160];
int serial_in;
int z = 0;
double x = 0;
double y = 0;
const int sensorPin = A1;
int sensorValue = 0;
float sensorVoltage = 0;
int windSpeed = 0;
float voltageConversionConstant = 0.004882814;
int sensorDelay = 1000;

float voltageMin = 0.03;
float windSpeedMin = 0;

float voltageMax = 1.25;
float windSpeedMax = 32;
```

```
void setup()
{
  Serial.begin(9600);
  Serial.println("SMS");
///////// pinMode(led, OUTPUT);
///////// digitalWrite(led, LOW);
  // initialization
  if ( gsm.begin(2400) )
  {
    Serial.println("STATUS =ok");
    started=true;
  }
  else
    Serial.println("STATUS =FAILED");
};


boolean SerialRead(char s[])
{
  int i=0;
  if (Serial.available() > 0)
  {
    while (Serial.available() > 0)
    {
      s[i]=Serial.read();
      delay(10);
      i++;
    }
  }
  s[i]='\0';
  return (i!=0);
}


void loop()
{
sensorValue = analogRead(sensorPin);
sensorVoltage = sensorValue * voltageConversionConstant;
if (sensorVoltage <= voltageMin)
{
  windSpeed = 0;
}
else

{
  windSpeed = ((sensorVoltage - voltageMin)*windSpeedMax/(voltageMax -
voltageMin)*2.23694);
```

```
}
x = windSpeed;
  if (x >= y)
  {
  y = x;
  }
  else
  {
  y = y;
  z = y;
  }

 int h = dht.readHumidity();
int t = dht.readTemperature();
 sprintf(string,"Temperature & humidity&speed : %d-%d-%d", t, h,windSpeed  );
  char inSerial[50];
  char position;
  if (started)
  {

// Serial.println(h);
        //       Serial.println(t);


    // -- Righe commentate poichè utilizzate per nei test
    // strcpy(Mittente,"3380000000");
    // if (SerialRead(smsbuffer))
    // ----------------------------------------------------
    // Legge se ci sono messaggi disponibili sulla SIM Card
    // e li visualizza sul Serial Monitor.
    position = sms.IsSMSPresent(SMS_ALL); // Valore da 1..20
    if (position)
    {
     // Leggo il messaggio SMS e stabilisco chi sia il mittente
     sms.GetSMS(position, Mittente, smsbuffer, 160);
     Serial.print("Comando Recive [tel. "+String(Mittente)+String("]: ") +
String(smsbuffer));
     if (strcmp(smsbuffer,"weather")==0)
     {
                   sms.SendSMS(Mittente, string);

//     }
//     else if (strcmp(smsbuffer,"charge")==0)
//     {
//
   /*10%*/ if(voltread<=11.3){sms.SendSMS(Mittente, "STATUS: CHARGE > > 0-
10% DANGER!!");}
```

```
    /*20*/ else if(voltread>=11.3&&voltread<=11.6){sms.SendSMS(Mittente,
"CHARGE > > 10-20%");}
    /*30%*/ else if(voltread>=11.6&&voltread<=11.8){sms.SendSMS(Mittente,
"CHARGE > > 20-30%");}
    /*40%*/ else if(voltread>=11.8&&voltread<=11.9){sms.SendSMS(Mittente,
"CHARGE > > 30-40%");}
    /*50%*/ else if(voltread>=11.9&&voltread<=12.1){sms.SendSMS(Mittente,
"CHARGE > > 40-50%");}
    /*60%*/ else if(voltread>=12.1&&voltread<=12.2){sms.SendSMS(Mittente,
"CHARGE > > 50-60%");}
    /*70%*/ else if(voltread>=12.2&&voltread<=12.3){sms.SendSMS(Mittente,
"CHARGE > > 60-70%");}
    /*80%*/ else if(voltread>=12.3&&voltread<=12.4){sms.SendSMS(Mittente,
"CHARGE > > 70-80%");}
    /*90%*/ else if(voltread>=12.4&&voltread<=12.5){sms.SendSMS(Mittente,
"CHARGE > > 80-90%");}
    /*100%*/ else if(voltread>=12.5&&voltread<=12.6){sms.SendSMS(Mittente,
"CHARGE > > 90-100%");}
  } else if(voltread<10.5){sms.SendSMS(Mittente, "BAT DANGER!!");}
//////////////////////////


    else
      Serial.println(" => non riconosciuto!");
    sms.DeleteSMS(position); // Elimina l'SMS appena analizzato
   }
  delay(1000);    delay(1000);
 }
};
```

CHAPTER 6

CONCLUSION AND FUTURE WORKS

6.1 Conclusions

This work presents a robust four directional sun tracking system in order to follow the movement of the sun based on full axis coordination. For more clarity, it is intended to present the results as follows:

1. The technique realizes design novelty due to the active concentration on sun tracking from four directions so that a tiny variation in the coordination of the sun can lead the controller to change PV panel allocation correspondingly.

2. The working principle of the system depends inconstantly on sun radiation, hence power saving will be existed due to cut system operation off for the rest of night.

3. The entire system was equipped by several weather sensing modules to clarify the physical conditions of the proposed power system with respect to system establishment location.

4. The physical situation of the system is transferred remotely using the GSM module depending on notification request from any specific phone number.

5. Data handover costs are economically inexpensive due to the complete dependency on notification request.

6. The center of data transfer is managed freely so that a given specific phone number can be provided by the required information concerning system status.

7. Finally, the proposed power system realizes the maximum power point MPPT knee spot depending on the V_{mp} and I_{mp} correspondingly.

6.2 Future Works

We suggest the following future works:

1. Modeling, Simulation and Control of solar power system using Matlab.

2. Design of a Low-cost Solar Tracking Photo-Voltaic (PV) Module and Wind Turbine Combination System.

3. Improving the efficiency of solar photovoltaic power system.

4. Optimum design of hybrid solar, wind and diesel generator.

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TOPICS OF INTEREST

- Realizing the maximum sun power denoted as MPP