

# Solar based wireless E-vehicle charging with Solar Traking

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## Abstract:

Solar panel research and development has been around for many years, in recent times they have become more popular as a means of primary power generation. Since the sun's energy is an unlimited energy resource, it has the potential to become the main source of energy in the future. All other forms of energy can be indirectly sourced back to the sun and solar movements. The main objective of our project is to find the most efficient geometry possible for a solar panel, in order to maximize the energy generated for a given base area and to store the energy and to deliver the stored energy to wireless transmitter coil by converting the direct current to alternating current and the E vehicle consist of receiver coil and the power received is rectified to convert it in to Dc and stores the power in to E vehicle battery

**Keywords:** EV charging, Wireless charging, Solartracking and Charging, Onroad Charging

## 1 Introduction:

### 1.1 Problem Statement:

Due to the dependence on fossil fuels as an energy source, and the inefficiency of alternate sources, our goal is to design a 3-dimensional solar panel that offers a better energy generation and efficiency than the basic rectangular-shaped solar panel. The sun is a moving source, and therefore the amount of sunlight and the angles of approach are always changing. The most efficient position for a solar panel will always be ninety degrees, or perpendicular, to the rays of sunlight. We have come up with three possible geometries that will give us this maximum absorption at all times: a dome, a parabolic bowl, and a pyramid. Since our design will be portable, we will be able to reach remote areas that either do not have an energy source, or cannot afford one.

Basic wireless transfer operation involves the transmission of energy from a transmitter to a receiver via oscillating magnetic field. The operation starts by converting direct current (DC) supplied by a power source to high frequency alternating current (AC) using specific designed of electronic circuit built together with transmitter. The AC current excite a wire coil in the transmitter that induce a magnetic field. When a receiver coil is placed within vicinity of the magnetic field, the field can energize an alternating current in the receiver coil. Electronic circuit in the receiver converts back the AC current into DC current which turn to usable power.

A secondary input into our design will be the use of reflectors. By implementing mirrors between the solar cells and/or around the panel itself, the stray sunlight that bounces off the panel can be reflected back to the solar cells where it will be absorbed and utilized, hence increasing absorption of sunlight energy.

Within the last 20 years, environmental impact has been a major consideration in the design and manufacturing fields worldwide. “Going green” has become a world-renowned slogan that influences many decisions in our everyday life. Since the first working plant in the 1980s, Photovoltaic Solar plants have become more abundant, especially in Europe, where ¾ of the worlds’ solar plants are based . In order to reduce the dependence on fossil fuels, implement cleaner energy, and reduce electricity costs, we must focus on alternate energy sources, mainly solar. The sun’s energy is an unlimited resource, and when harvested efficiently, has the potential to become our primary energy source. In our design, we plan to advance the methods of solar energy intake by testing alternate geometries to maximize energy generation and efficiency of the panel.

There are many countries, and entire regions that either do not have a reliable energy source or cannot afford one. Parts of Central America and Africa for example, that experience a year round supply of hot climate and sunshine, can focus on solar energy as a means of power. The 3-dimensional solar panel is designed to be portable with the absence of a solar tracker and can easily reach remote areas and provide a cheap, efficient energy source that will solve this crisis.

**1.2 Solar Analysis:**

**1.3 Solar Time:**

In order to design a solar panel that will generate the maximum amount of usable energy, a prediction must be made in which direction the sunrays will point relative to a given location [18]. The position of the sunrays is essential to collecting the maximum amount of solar radiation. This is why solar time is of great importance for solar energy generation. Solar time is a different concept than the commonly known local time or local clock time. The true solar time is measured by observing the motion of the sun, whereas, local time varies due to time zones and daylight savings. The position of the sun can be determined by using the hour angle equation, given below.

$$\omega_s = (ST - 12) \times 15^\circ \text{ [23]}$$

$$\omega_s = \text{Hour Angle } [^\circ]$$

$$ST = \text{Solar Time}$$

The hour angle is 0° at solar noon, when the sun is at its highest in the sky and pointing directly south. Every hour away from solar noon corresponds to an angular motion of the sun, since the sun rotates about 15° every hour in a 24 hour day. Thus, in the morning before solar noon the hour angle should be negative and after solar noon it should be positive [18]. Table 4 below shows the time of the day with the corresponding hour angle.

**Table 1 - Time of the day with corresponding Hour Angle**

Time of the day		Hour Angle
[Hours]		[Degrees]
<b>7.00</b>	<b>AM</b>	-75
<b>8.00</b>	<b>AM</b>	-60
<b>9.00</b>	<b>AM</b>	-45
<b>10.00</b>	<b>AM</b>	-30
<b>11.00</b>	<b>AM</b>	-15
<b>12.00</b>	<b>PM</b>	0
<b>13.00</b>	<b>PM</b>	15

14.00	PM	30
15.00	PM	45
16.00	PM	60
17.00	PM	75
18.00	PM	90
19.00	PM	105

### 1.4 Solar Power Generation:

Calculating the absorption of the solar panel is a process that goes through many steps. The wavelength, band gap and energy of the sunlight, the angle of incidence, the solar cell material and efficiency are all aspects that must be considered. The band gap is the minimum amount of energy required for an electron to break free of its bound state. It determines how much energy is generated. When the energy of a photon is equal to or greater than the band gap of the material, the photon is absorbed by the material and excites an electron into the conduction band. Photovoltaic energy is based on the energy generated by these photons. Materials with a high absorption coefficient are able to absorb photons more easily. The diagram below shows the absorption coefficients of multiple materials including silicon (Si), which is our chosen cell material. Absorption coefficient ( $\alpha$ ) is calculated using the following formula:

$$\alpha = \frac{4\pi k}{\lambda} [22]$$

$\alpha$  = absorption coefficient

k = Boltzmann's constant

$\lambda$  = wavelength

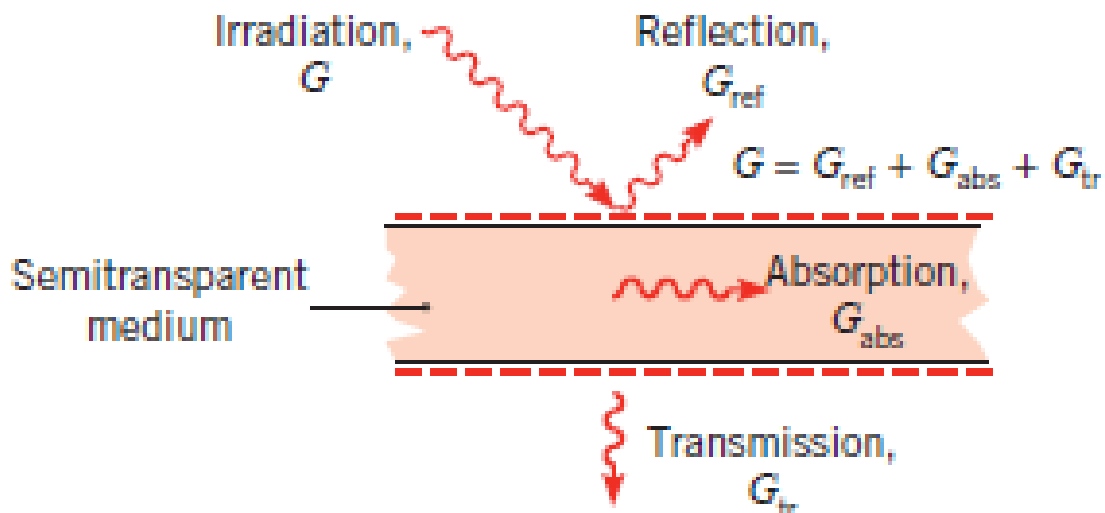
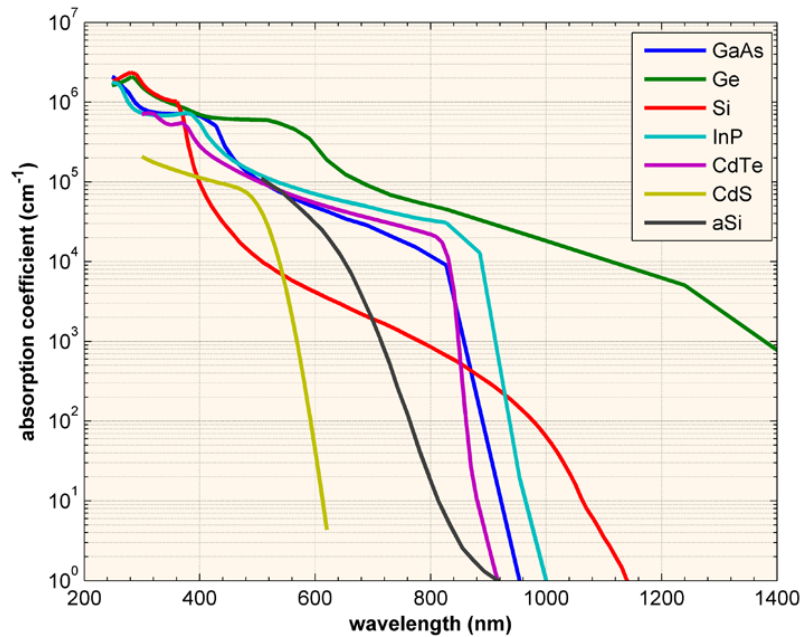


Figure 1 - Absorption and Reflection of irradiation for a semitransparent medium [24].



**Figure - Absorption Coefficient [22]**

Figure 15 above shows that the absorption coefficient strongly depends on the wavelength.

The absorption coefficient determines how much light is absorbed, and in turn gives us the generation rate of electrons. The intensity of light ( $I$ ) is calculated by:

$$I = I_0 e^{-\alpha x} \quad [22]$$

$I$  = light intensity

$\alpha$  = absorption coefficient

$x$  = distance into material

$I_0$  = light intensity at top surface

Generation rate is greatest at the surface of the material, as that is where the light is absorbed, but since the light absorbed has numerous wavelengths, generation rate ( $G$ ) must be calculated for each one:

$$G = \alpha N_0 e^{-\alpha x} \quad [22]$$

$G$  = generation rate

$N_0$  = photon flux at surface

$\alpha$  = absorption coefficient

$x$  = distance into material

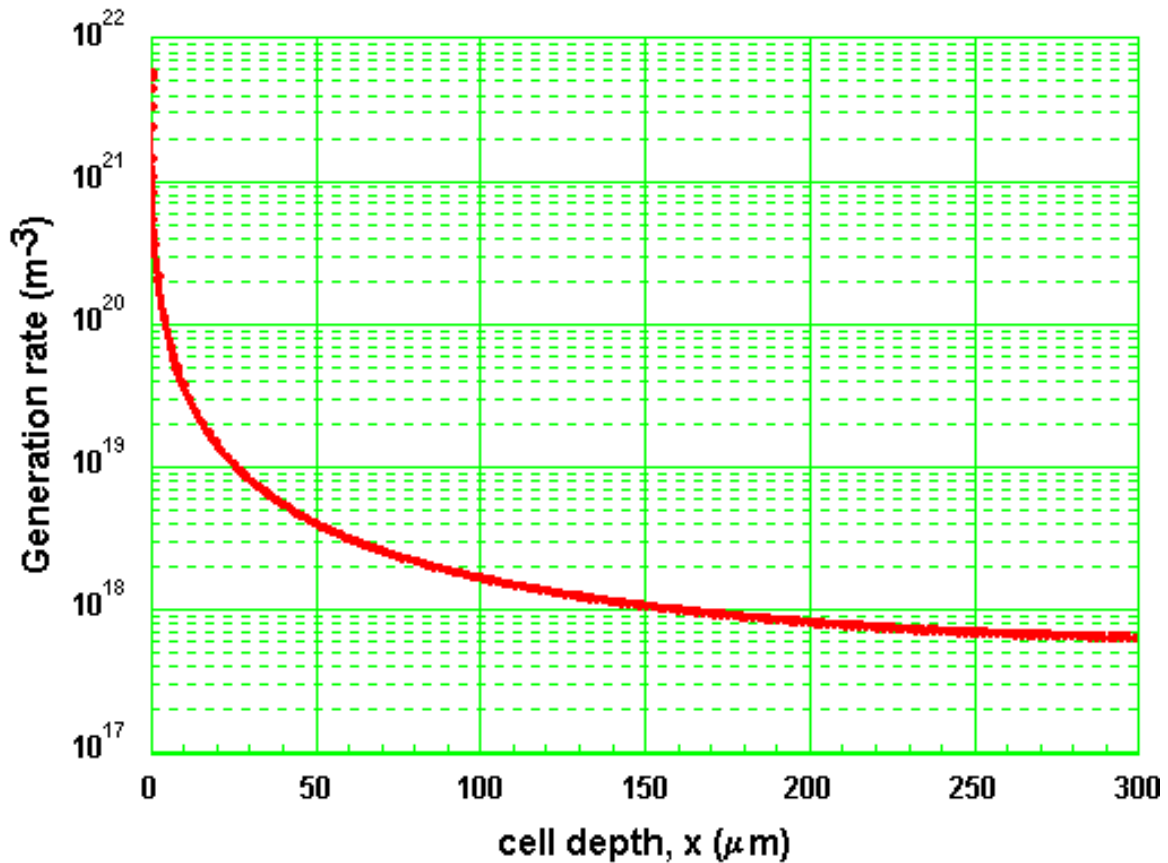


Figure - Generation rate at Depths 0-300 μm [22]

Solar radiation is absorbed in two ways by the photovoltaic cell: the first is absorption from the direct sunlight, and the second is absorption due to blackbody radiation of the earth. The area surrounding the solar cell is heated by the sun, and also reflected rays make up the secondary absorption. The absorption from the sun is:

$$\varphi_{Sun}(E_G, \infty, 0, T_{Sun}) = Cf \frac{2\pi}{h^3 c^2} \int_{E_G}^{\infty} \frac{E^2}{\exp\left(\frac{E}{kT_{Sun}}\right) - 1} dE$$

The absorption from the black body radiation is:

$$\varphi_{Earth}(E_G, \infty, 0, T_{Earth}) = (1 - Cf) \frac{2\pi}{h^3 c^2} \int_{E_G}^{\infty} \frac{E^2}{\exp\left(\frac{E}{kT_{Earth}}\right) - 1} dE$$

Therefore, total absorption is given by:

$$\begin{aligned} \varphi_1 &= \varphi_{Sun}(E_G, \infty, 0, T_{Sun}) - \varphi_{Earth}(E_G, \infty, 0, T_{Earth}) = \\ &= Cf \frac{2\pi}{h^3 c^2} \int_{E_G}^{\infty} \frac{E^2}{\exp\left(\frac{E}{kT_{Sun}}\right) - 1} dE - (1 - Cf) \frac{2\pi}{h^3 c^2} \int_{E_G}^{\infty} \frac{E^2}{\exp\left(\frac{E}{kT_{Earth}}\right) - 1} dE \end{aligned}$$

C = capacitance

ν = frequency

h = Planck's constant

c = speed of light

E<sub>G</sub> = band gap

E = energy

k = Boltzmann's constant

T<sub>Sun</sub> = temperature of sun

It is important to estimate the amount of useable energy generated by the 3 dimensional solar panel. Sunray radiation is different for various locations on earth and as such, the following equation will be used to calculate the total energy in a given day for such a location:

$$E = \sum_{k=1}^{24/\Delta t} P_k \cdot \Delta t \quad [1]$$

E = Energy [kWh/day]  
 Δt = time step [hrs]  
 P<sub>k</sub> = Total Power Generated  
 k = solar time step

For calculating the total energy generated by the 3 dimensional solar panel for a specific period, the energies generated for each day and period must be summed together.

The power generation term can be calculated using the equation:

$$P_k = P_k^{(0)} + P_k^{(1)} + \dots + P_k^{(m)} + \dots \quad [1]$$

m = number of light ray reflections

Furthermore, the terms P<sub>k</sub><sup>(0)</sup> and P<sub>k</sub><sup>(1)</sup> can be expanded and thus become:

$$\begin{aligned} P_k^{(0)} &= \sum_{l=1}^N I_k \cdot \eta_l \cdot A_{l,eff} [1 - R_l(\theta_{l,k})] \cos(\theta_{l,k}) \quad [1] \\ P_k^{(1)} &= \sum_{l=1}^N \{ [I_k \cdot \eta_l \cdot A_{l,eff} R_l(\theta_{l,k}) \cos(\theta_{l,k})] \cdot \eta_s [1 - R_s(\alpha_{ls,k})] \} \quad [1] \end{aligned}$$

I<sub>k</sub> = incident energy flux from the sun  
 k = time step  
 A<sub>l,eff</sub> = unshaded area of solar cell  
 l = l<sup>th</sup> number solar cell  
 R<sub>l</sub> = reflectivity

$$\begin{aligned} \theta_{l,k} &= \text{angle of incidence} \\ \eta_s &= \text{solar cell efficiency} \\ \alpha_{ls,k} &= \text{angle of incidence with reflected ray} \end{aligned}$$

The first bracket in the  $P_k^{(1)}$  term illustrates the power generated after the absorption of direct sunlight. In the second bracket mirror reflections of sunlight are absorbed by the solar cells according to the given efficiency.

### 1.5 Solar Cell Parameters:

Solar cell parameters are essential to understanding the power output of such a cell. The solar cell used in this project is a 3x6 inch “string ribbon” polycrystalline cell, as seen in Figure 17 below.



**Figure - Actual Solar Cell used in this project**

The silicon substrate is pulled in a ribbon rather than cast. In this section various solar cell parameters will be calculated to determine the efficiency of the solar cell. Solar cell efficiency is the ratio of the input energy from the sun to the output energy of the solar panel. It is dependent on the sunlight intensity and the solar cell’s temperature. The efficiency of a solar cell is determined as the fraction of incident power, which is converted to electricity [22]:

$$\begin{aligned} P_{max} &= V_{oc} I_{sc} FF \quad [22] \\ \eta &= \frac{V_{oc} I_{sc} FF}{P_{in}} \quad [22] \end{aligned}$$

- $P_{max}$  = maximum power
- $P_{in}$  = input power
- $V_{oc}$  = open-circuit voltage
- $I_{sc}$  = short-circuit current
- $FF$  = fill factor
- $\eta$  = efficiency

Before calculating the solar cell efficiency, a few necessary variables must be determined, such as: the open-circuit voltage, the short-circuit current, fill factor and the input power. The short circuit current is directly measured from the solar cell. Theoretically, this current is the maximum current through the solar cell when the voltage across the cell is zero, hence the name “short-circuit” current. The short-circuit current; measured directly from the cell itself is 3.285 Amps.

The maximum available voltage from the solar cell is known as the open-circuit voltage. This occurs when the current through the cell is zero. Measure directly from the solar cell, the open-circuit voltage is 0.553 Volts. A commonly used equation to calculate the open-circuit voltage is given by:

$$V_{oc} = \frac{nkT}{q} \ln \left( \frac{I_L}{I_o} + 1 \right) \quad [22]$$

$I_o$  = dark saturation current [A]

$q$  = elementary charge =  $1.602176565 \times 10^{-19}$  coulombs

$k$  = Boltzmann constant =  $1.3806488 \times 10^{-23}$  J/K

$T$  = temperature [K]

$n$  = ideality factor = 1

$I_L = I_{sc}$  = light generated current [A]

Even though the open-circuit voltage and the short-circuit current are known, the power output from the solar cell is still zero. This is where the fill factor plays an essential role. Together with the open-circuit voltage and the short-circuit current, the maximum power can be determined from the cell. Fill factor is simply defined as the ratio of maximum power of the cell to the maximum voltage and current. A commonly used equation for the calculation of the fill factor is given by:

$$FF = \frac{v_{oc} - \ln(v_{oc} + 0.72)}{v_{oc} + 1} \quad [22]$$

$v_{oc}$  = normalized  $V_{oc} = \frac{qV_{oc}}{nkT}$

$$v_{oc} = \frac{qV_{oc}}{nkT} = \frac{(0.553)(1.602176565 \times 10^{-19})}{(1)(1.3806488 \times 10^{-23})(350)} = 18.335 \text{ Volts}$$

$$FF = \frac{18.335 - \ln(0.553 + 0.72)}{18.335 + 1} \cong 0.936$$

The efficiency of the cell can now be determined using the short-circuit current, open-circuit voltage, and fill factor found previously. An assumption for the input power will be made, where  $P_{in} = 1000W/m^2$  or  $100mW/cm^2$ .

$$A_{solar\ cell} = 3 \times 6 \text{ in} = 24 \text{ in}^2 = 0.01548384 \text{ m}^2$$

$$P_{in(solar\ cell)} = 0.01548384 \text{ m}^2 \left( \frac{1000W}{1m^2} \right) = 15.48384 \text{ W}$$

$$\eta = \frac{V_{oc} I_{sc} FF}{P_{in}} = \frac{(0.553)(3.285)(0.936)}{15.48384} \times 100 \cong 11\%$$

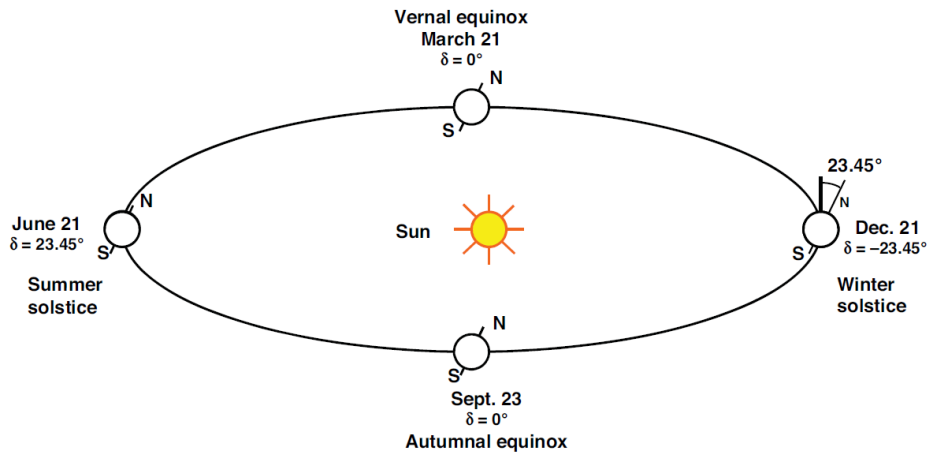
## 1.6 Design Analysis:

### 1.7 Sun’s Position:

The sun’s position and location are crucial variables when designing any type of photovoltaic module. It is for this reason that special attention will be given to the sun’s path over the course of a day. Research has shown that the earth rotates around the sun every 365 days in an elliptical orbit. Also, the



earth rotates around its own axis once every 24 hours. The axis of the earth is neither horizontal nor vertical, but at a slight angle of  $23.45^\circ$  relative to the earth's elliptical path around the sun. Figure shows that the earth's axis is inclined towards the sun during the summer and in the winter it is inclined away from the sun. The inclination of the earth's axis during the summer and winter period is referred to as the solar declination ( $\delta$ ). This simply means that the amount of solar radiation received in a given time period is not constant and is mostly determined by the latitude ( $\phi$ ) of a given location as well as the solar declination.



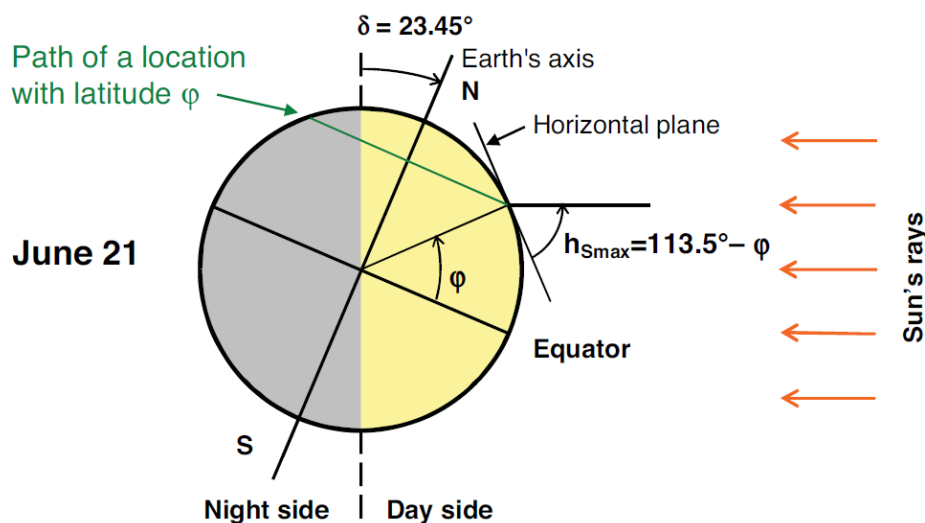
**Figure - Earth's orbit around the sun and axis orientation in 365 days [23]**

Figure depicts the earth's position around the sun during the 365 days. Also, the solar declination can be seen clearly at each major season. To calculate the declination angle, the following equation is used:

$$\delta = 23.45^\circ \sin \left[ \frac{360}{365} (d - 81) \right]$$

$\delta$  = declination angle [ $^\circ$ ]

d = day of the year with Jan. 1 as (d = 1)



**Figure – The Solar Declination angle for a specific location**

Figure above shows the solar declination for the Summer solstice for a location with latitude  $\varphi$ . The highest elevation of the sun for the Summer solstice is calculated using the following equation:

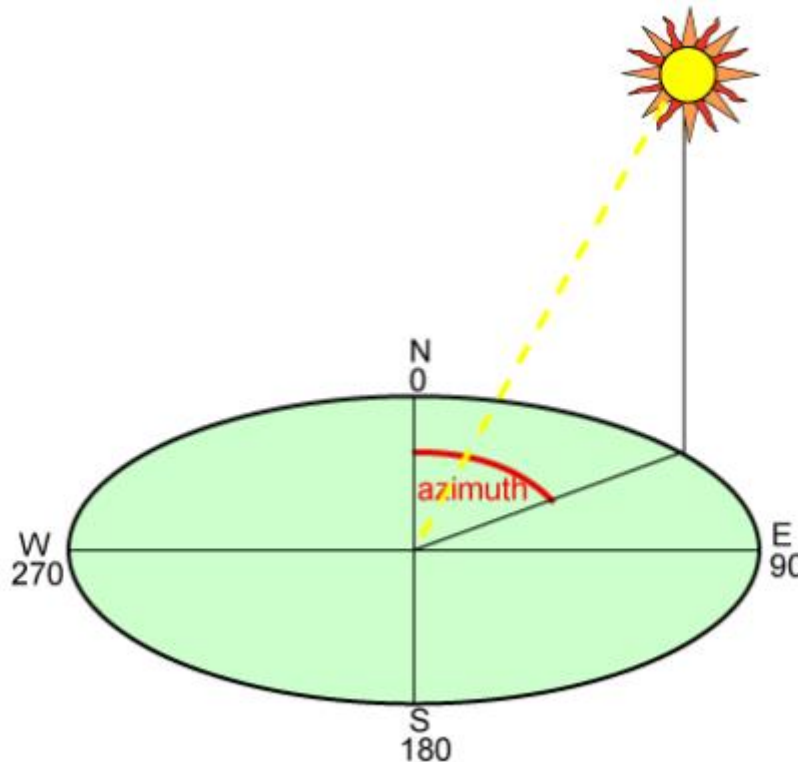
$$h_{s_{max}} = 113.5^\circ - \varphi$$

$h_{s_{max}}$  = Maximum Elevation  
 $\varphi$  = Latitude

The direction from which sunlight reaches the earth is another essential component in photovoltaic design and placement. This can be determined by calculating the azimuth angle, which determines the direction of the sun and is given by the following equation:

$$\gamma = \cos^{-1} \left[ \frac{\sin(\delta) \cos(\varphi) - \cos(\delta) \sin(\varphi) \cos(\omega_s)}{\cos(h_s)} \right] \quad [22]$$

$\gamma$  = azimuth angle  
 $\delta$  = solar declination  
 $\varphi$  = latitude  
 $\omega_s$  = hour angle  
 $h_s$  = elevation



**Figure - Azimuth Angle of the sun [22].**

At exactly 12.00, solar noon, the sun is facing directly south in the northern hemisphere and directly north in the southern hemisphere. The azimuth angle changes throughout a 24 hour day. When the sun rises in the east the azimuth angle is  $90^\circ$  and when it sets in the west the angle is  $270^\circ$  as seen in Figure .

The angular height is an additional variable that can contribute to the sun’s position throughout the day. This is known as the elevation angle and it measures the angular height of the sun from the horizontal. The following equation is used to obtain the elevation angle:

$$\alpha = \sin^{-1}[\sin \delta \sin \varphi + \cos \delta \cos \varphi \cos \omega_s]$$

$\alpha$  = elevation angle [°]  
 $\delta$  = declination angle [°]  
 $\varphi$  = latitude of location [°]

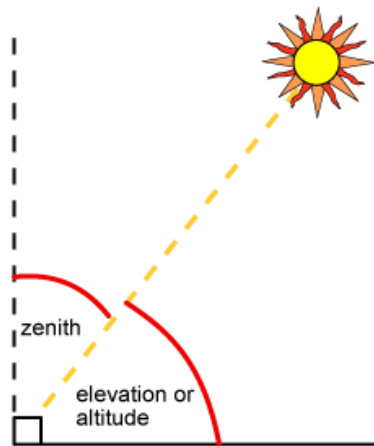
The elevation angle depends on the latitude of a specific location and varies throughout the day. At solar noon, the elevation angle is at its maximum and at sunrise the elevation is at its minimum.

Another frequently used angle to indicate the sun’s position is the zenith angle. Unlike the elevation angle, which is measured between the sun and the horizontal, the zenith angle is measured between the sun and the vertical. The following equation is used to calculate the zenith angle:

$$\zeta = 90^\circ - \alpha$$

$\zeta$  = zenith angle [°]  
 $\alpha$  = elevation angle [°]

Figure below shows a clear graphical illustration of both the elevation and zenith angle.



**Figure - Elevation and Zenith Angle**

Table below depicts all the calculated angles with respect to each hour of a solar day.

**Table - The Sun' Position Calculations**

Sun's Position for each Hour Angle				
Time of the day	Hour Angle	Elevation Angle	Zenith Angle	Azimuth Angle
[Hours]	[Degrees]	[Degrees]	[Degrees]	[Degrees]
7.00 AM	-75	14.548	75.452	94.415
8.00 AM	-60	27.915	62.085	101.710
9.00 AM	-45	40.880	49.120	110.870
10.00 AM	-30	52.886	37.114	124.117
11.00 AM	-15	62.537	27.463	145.895
12.00 PM	0	66.630	23.370	180.000

13.00	PM	15	62.537	27.463	145.895
14.00	PM	30	52.886	37.114	124.117
15.00	PM	45	40.880	49.120	110.870
16.00	PM	60	27.915	62.085	101.710
17.00	PM	75	14.548	75.452	94.415
18.00	PM	90	1.052	88.948	87.823
19.00	PM	105	-12.385	102.385	81.137

For the calculations in Table we need to first calculate the declination angle for Miami, Florida. The day of the year (d) must be established. Since the test day was on March 28, the day of the year is 87. The declination angle for March 28 is as follows:

$$\delta = 23.45^\circ \sin \left[ \frac{360}{365} (87 - 81) \right] = 2.418^\circ$$

**WIRELESS POWER TRASFER:**

Wireless power is one of the new terms that define this century. In the age of mobility, the need for wireless power transfer (WPT) is growing fast. There are several approaches for transferring the electric power wirelessly. In this paper, different methodologies for WPT are investigated as well as advantages, disadvantages and possible applications for each one. In addition, health safety and economical aspects of each applicable approach are discussed. A qualitative comparison between main methods has been achieved based on separation distance, transmitting power, cost, efficiency, and safety. Qi wireless power transfer standard is spreading in low power mobile devices up to 5 Watts and showed great potential for charging high power devices in the future.

2-coil non-radiative wireless power transfer (WPT) is studied to find the coil diameter ratio to effective distance of power transfer efficiency (PTE). Single circular coil and spiral coil are designed and simulated using CST software to compare the result of coil diameter versus effective distance of PTE by using  $S_{21}$  value. Accordingly, the quality factor (Q) of both coils are presented as Q factor is one of the parameter that affect the performance of WPT system. The result is promising as the effective distance is more than the coil diameter with (PTE) more than 50% using spiral coil as compare to single coil design.

**Basics:**

The Faraday Law of Induction describes the basic principle of Current flowing through the primary coil (transmitter coil) generates a magnetic flux  $\Phi_1$ . This magnetic flux  $\Phi_1$  in the winding generates an induction voltage in the secondary coil (receiver coil) based on the faraday’s law of induction (see fig. 1). As transmitter coil and receiver coil are physically separate, only a portion of the magnetic flux  $\Phi_2$  penetrates the receiver coil (and vice versa) which induces voltage on the coupled coil and eventually supplies an appliance. This magnetic coupling between two coils is described by the relation of the magnetic fluxes  $\Phi_2/\Phi_1$

M is the mutual inductance between both coils. L1 and L2 are the self-inductances of both coils. The coupling factor is very dependent on the displacement of the coils in x and z direction. The coupling can be improved by attaching ferromagnetic material to the coil because this bundles the magnetic flux. The

ferrite also protects parts of the circuit near to the transmitter and receiver coils by lowering the induced interfering voltage. The coupling factor with an ideal transformer is 1, but maximum coupling in the range of 0.2–0.7 can be achieved with an inductively coupled system

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## **2 Literature Survey:**

### **2.1 Design and optimization of solar tracker with U-PRU-PUS parallel mechanism**

The solar tracker usually adopts the serial mechanism in application, which is greatly affected by the environment, and its load capacity and stability are limited. In order to address these issues, a new type of solar tracking device with U-PRU-PUS parallel mechanism was proposed. The U-PRU-PUS parallel mechanism was analyzed based on the screw theory, which shows that this mechanism has 2R degree of freedom and is decoupled. The direct and inverse kinematics of the parallel mechanism were derived and its singularity was analyzed based on the Jacobian algebras. Then the workspace of the parallel mechanism was obtained according to the boundary search algorithm. The adaptive genetic algorithm was used to search the optimal structure parameters of the parallel mechanism. The tracking range was improved by 4.6% and the stroke of the driving rod was shortened by 11.2% after optimization. A solar tracker prototype with the optimized parallel mechanism and its control system was built. The limit tracking position at sunrise and sunset was tested, which validated the feasibility of the designed mechanism and its tracking range. Through the solar tracking error tests, the performance of the proposed tracking mechanism can track the sun effectively.

### **2.2 Determining the optimum tilt angle and orientation for photovoltaic (PV) systems**

Tilt angle of a PV module is one of the most significant parameters for receiving maximum solar irradiation falling on the PV systems. This research article investigates the numerical aspects of selecting the optimal tilt angle for the PV modules used in Bangladesh and makes recommendations on how the collected power output of the module can be increased by altering the tilt angle. The results show that the optimum tilt angle of Cox's Bazaar Chittagong, Dhaka, Jessore, Ishurdi, Bogra, Sylhet and Rangpur is 26°, 25°, 30°, 25°, 27°, 27°, 28° and 29°, respectively. The annual energy production of Cox's Bazar and Sylhet has shown the highest and the lowest energy production, the month was March and July, respectively. The characteristics curves obtained by the simulation with the data provided by using simulated software SAM (System Advisor Model). Finally, the article measures the optimum tilt for PV applications in Bangladesh on Monthly and yearly bases.

### 2.3 RENEWABLE ENERGY POLICY NETWORK:

It is the global renewable energy policy multi-stakeholder network that connects a wide range of key actors. REN21's goal is to facilitate knowledge exchange, policy development and joint action towards a rapid global transition to renewable energy. REN21 brings together governments, nongovernmental organizations, research and academic institutions, international organizations and industry to learn from one another and build on successes that advance renewable energy. To assist policy decision making, REN21 provides high-quality information, catalyses discussion and debate, and supports the development of thematic networks. REN21 facilitates the collection of comprehensive and timely information on renewable energy. This information reflects diverse viewpoints from both private and public sector actors, serving to dispel myths about renewable energy and to catalyse policy change.

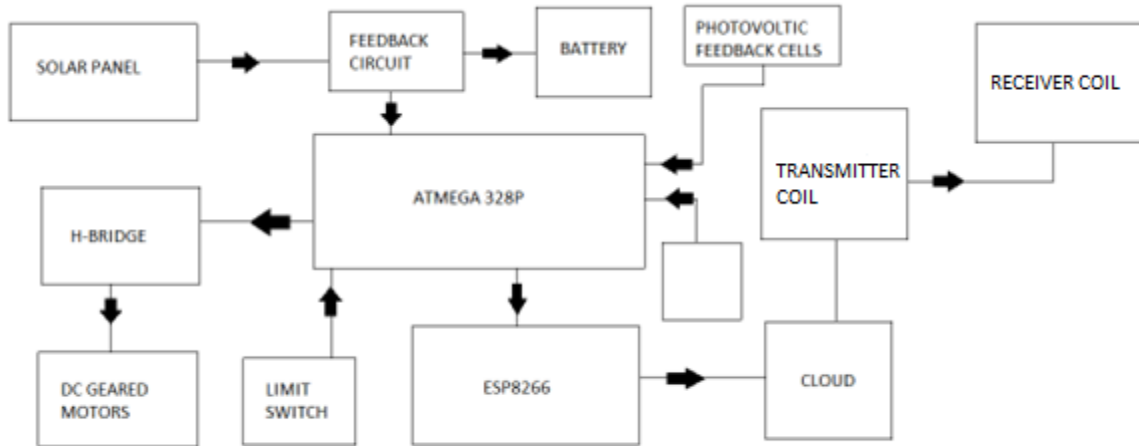
### 2.4 Remote Triggered Single-Axis Solar PV Tracking System with Varying Angle of Incidence

With the increasing number of remotely accessible laboratories, technical education is reaching student communities in more versatile and flexible ways. This work describes the design and implementation of a remotely operable, single-axis photovoltaic tracking system with two degree resolution through an online, real-time, Virtual Laboratories environment. The tracking system is shown to accurately calculate the sun's position and orient the attached photovoltaic (PV) module to face the sun either directly or at an angle of incidence selected by the user. The laboratory experiment covers topics such as the efficiency of the PV panel, the angle of incidence and how these specific variables contribute to the power extracted from the panel. In particular, the remote experiment teaches how to calculate cosine losses, which are of fundamental importance to the efficient and cost effective implementation of solar installations, and the calculation of the variation in power production as a function of the angle of incidence. The graphical user interface (GUI) allows users to experimentally determine the angle at which the maximum power is generated. The novelty of this work includes teaching power extraction from renewable, solar photovoltaic energy sources without confining the students or instrumentation to classroom walls or physical laboratories.

### 2.5 Toward a long-term evaluation of MPPT techniques in PV systems

Maximum power point tracking (MPPT) is required to extract the maximum available power in PV systems. Wide variety of methods exist in literature, with range of complexity and effectiveness. The features of these diverse methods are usually evaluated at specific environmental conditions for a tiny period, and then the evaluations are generalized for PV systems working under long-term environmental conditions. This makes it unclear which method is better in a location where a certain mixture of environmental conditions could occur. This paper shows that the MPPT evaluations may change under actual environmental conditions for a long period. The paper first provides a classification for the environmental conditions of PV systems. It then tests the most commonly used MPPT methods at long term environmental conditions for evaluating their performance.

3 **METHODOLOGY:**



The proposed system consist of 3 dimension solar tracking system the brighter region is tracked using photovoltaic feedback cells and according to the brighter area the microcontroller adjust the angle of the solar panel using H-bridge and dc geared motors and the power generation feedback line is fetched and all the data is sent to cloud using ESP8266 Wi-Fi module and power generation results are viewed. When a receiver coil is placed within vicinity of the magnetic field, the field can energize an alternating current in the receiver coil. Electronic circuit in the receiver converts back the AC current into DC current which turn to usable power. WPT main purpose is transferring the energy itself not the information encoded in the energy.

**Wireless power transfer coil**

WPT (Wireless power transmission) mainly uses three main systems such as microwaves, solar cells and resonance. Microwaves are used in an electrical device to transmit electromagnetic radiation from a source to a receiver. In the Fig 3.7 shows WPT coil in which the electrical power can be transferred from a source to a device without using wires. Basically, it includes two coils they are a transmitter coil & a receiver coil. Where the transmitter coil is powered by AC current to create a magnetic field, which in turn induces a voltage in the receiver coil.

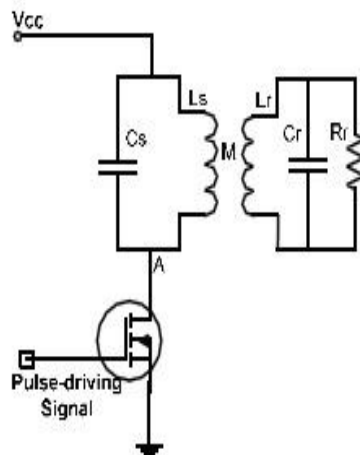


Fig 3.7 Wireless power transfer coil

The basics of wireless power transmission include the inductive energy that can be transmitted from a transmitter coil to a receiver coil through an oscillating magnetic field. The DC current supplied by a power source is changed into high frequency AC current by particularly designed electronics built into the transmitter.

In the TX (transmitter) section, the AC current increases a copper wire, that creates a magnetic field. Once an RX (Receiver) coil is located near to the magnetic field, then the magnetic field can induce an AC current in the receiving coil. Electrons in the receiving device, converts the AC current back into DC current, that becomes working power.

For maximum PTE, the transmitter and the receiver coil must resonate at the same frequency. Nowadays, WPT technologies are going through active research which focused on maximizing power transfer efficiency (PTE). Many factors affect the PTE as stated earlier but the main focused here are the design of the transmitter and receiver coil and the Q-factor. The bigger the coil, the higher the effective distance and PTE due to more magnetic fields induce in between the transmitter and receiver coil. Bigger coil will be bulky, heavy in term of weight and certainly not suitable for small application. By tuning the Q-factor of the coil, the distance and PTE is believe to improve as higher Q-factor made the coils achieved to its maximum amplitude and stayed longer at resonant frequency thus allowing maximum power transfer. Therefore, same resonant frequency exhibit at transmitter-receiver coil produce low rate of energy loss apart from other dimensional factors such as number of turn of coils and coils diameter.

In mutual induction, the electrical power is transformed from DC into AC at the transmitter and magnetic field is created around the transmitter coil. The receiver coil cuts some of the magnetic field generated by the transmitter coil, and AC current is induced in it. The received AC power is rectified and filtered to produce DC output. As the distance between the transmitter and the receiver coils increases, the receiver coil misses more lines of the magnetic field of the transmitter even in very short distance, so systems built on inductive coupling have low efficiency, so most of the transmitted power is wasted. This method can allow wireless power transfer in the range of millimeters and can reach at most few centimeters . One typical application for electromagnetic induction is electric toothbrush ]. Most electric toothbrushes use inductive coupling for recharging because daily exposure to water makes charging through an electric plug is unsafe. Wireless recharging allows completely sealed toothbrushes. This application represents one of advantages of wireless power transfer.

## WIRELESS POWER TRANSFER

Wireless Technology has been used from Telephone to satellite communication. By utilising such technology in power transfer can bring huge benefits to the society. With wireless power transmission system, we can transfer power without using wires to connect each other. Wireless transmission is useful in cases where interconnecting wires are inconvenient, hazardous, or impossible. Inductive coupling is the most widely used wireless technology

The Wireless Power Transfer (WPT) of 50W power over the distance of 200 mm, which verifies the proposed EV dynamic charging system with the salient advantages of the constant energization, flexible power control, and cost saving. Through wireless transmission electricity coursing through wires creates an oscillating magnetic field, and this field causes the nearby coil's electrons to oscillate and to generate electricity which can be done in dynamic charging of E-vehicles.



Inductive WPT Charging is that there are two parts of the inductor. One part of the inductor acts as a primary winding and the other half acts as a secondary winding of the transformer. The role of the charger is to convert the low frequency AC power to high frequency AC power. The high frequency AC is transmitted from the charger to the secondary side and then is converted to DC power and is supplied to the battery pack.

### 3.1 Project Objectives:

1. Design and construct a 3-dimensional solar panel to maximize absorption of sunlight and maximize efficiency.
2. Use a geometric shape that remains perpendicular to the rays of sunlight at all times.
3. Adapt the solar panel to residential needs by making it portable and convenient.
4. To alternate the power supply from dc to high frequency ac to wirelessly transmit the power
5. To wind the transmitter and receiver coil with respective numbers of turns to respective voltage
6. To convert ac to dc to store the power supply from receiver coil to battery

### 3.2 Conceptual Design:

Solar panel design takes into account a number of factors that will play a significant role in the efficiency of such a panel. Typically, a solar panel is made of a set of photovoltaic modules that are electrically connected and arranged on a given structure. The typical solar panels that can be found in markets today are of a rectangular shape. These solar panels have an efficiency of up to 17% ; however, there are other commercially available solar panels that have an efficiency of 27% . The goal for this project is not to increase the overall efficiency of solar panels, but rather increase the energy generated. Several design alternatives have been taken into consideration to make this goal a reality, one of which is to use different geometries for the solar panel design. The idea behind a 3-dimensional geometry is to increase the base area of the solar panel compared to the stationary rectangular shape. This will allow a possibility for increased energy generation. Another consideration for this design is to implement reflectors. The reflectors can be placed between the solar cells or around the solar panel itself. Stray sunlight that bounces off the panel can be reflected back to the solar cells where it will be absorbed and utilized as stored energy.

### 3.3 Proposed Design:

The solar panel relevant to the project objective and design is a 3-dimensional photovoltaic structure. The focus here is set on the increased base area compared to a rectangular solar panel . A auto adjusting geometry will be the main area of focus for this project. The sun is the earth's most predominate energy source and as such, it is of great importance to harvest as much of that energy as possible. Since the earth revolves around the sun, the angle of approach that the irradiation waves make with a solar panel is always changing. With a dome shaped solar panel the angle of approach will almost always be at ninety degrees, which is optimal for energy generation. Since the angle of approach will be close to ninety at any solar time of the day, there will be no need for a sun tracker. Typical rectangular shaped solar panels need a sun tracker to be effective. The absence of a sun tracker will also reduce the cost of installation for a three-dimensional solar panel, which is always a goal when engineering a new product. The WPT is included in order to transfer the energy generated from panel. The EMF is induced using the coil and the energy produced is transferred wirelessly to the various purposes

**WIRELESS METHODOLOGY:**

The supply of 1.5Amps (PV 1) supply is given to the whole circuit. The next to the supply the Diode is fixed, to avoid the reversing of the current. The Darlington Transistor (TIP127G) is used to drive the current to charge the battery, here this transistor act as a diode, whenever the battery is charged it will cut off automatically. The battery is again followed by a pair of Darlington Transistor, the base of these transistor is connected to a multi vibrator circuit and thus the frequency is calculated as per the following below equation.

$$\text{Charging } C_3 (T_2 = R_7C_3)$$

$$\text{Discharging } C_2 (T_1=R_5C_2)$$

Current delay exponentially with time constant of  $R_5C_2$  is,  $iC_1 = (V_{cc} + V_{cc})/ R_5$

$$VB2 = V_{cc}-2V_{cc} e^{-t/R_5C_2}$$

$$0 = V_{cc}-2V_{cc} e^{-t/R_5C_2}$$

$$2 e^{-t/R_5C_2} = 1$$

Hence,

$$T=T_2=R_5C_2\ln(2) \text{ and } T=T_2=R_7C_3\ln(2)$$

Total time period is calculated by,

$$T = T_1+T_2 = [R_7C_3+ R_5C_2] \ln(2)$$

$$= 0.694(R_7C_3+ R_5C_2)$$

Renaming the components,

$$R_7, R_5 =R, C_2,C_3 =C \text{ then } T= 1.4RC$$

$$\text{Frequency } f = 1/T \text{ and } f = 0.7/RC$$

The multi vibrator is used to turn on and off the transistor based on the EMF generated in given induction coil and attracted to the nearby coil based on this process a voltage

**3.4 Analytical Analysis:**

The analytical analysis for the design of a 3-dimensional solar panel requires an understanding of mathematical formulas and heat transfer concepts such as radiation.

The analysis of power production is of utmost importance for the design and development of a 3-dimensional solar panel. The main objective for this project is to increase the power production of a solar panel. A series of steps must be taken in the analysis of a solar panel. First, the power required to operate appliances. For testing purposes appliances will be used that have known power consumption. This will aid in the calculation of power consumption. Second, the amount of energy that the battery can store must be determined. Third, the energy generation for a solar panel must be determined.

Once these factors are known, the main focus can be set on collecting the solar energy. In order to complete this task, a few equations will be used to calculate the angle between a solar panel and a central ray from the sun. This angle is known as the angle of incidence. It is instrumental in solar panel design, because the maximum amount of sun radiation that can reach the surface of the panel is reduced by the cosine of this angle.

**3.5 Power consumption:**

Appliance power consumption [Wh] = P [W] x hours of use [h] [19]

**3.6 Battery storage:**

Battery capacity [Ah] =  $\frac{\text{Total appliance power consumption [Wh]}}{(\text{Battery loss} \times \text{Depth of discharge} \times \text{nominal battery voltage})} \times \text{days of use}$

Battery loss = 0.85

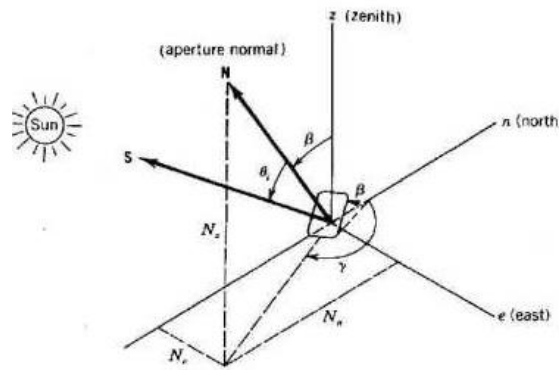
Depth of discharge = 0.6

**3.7 Solar panel energy generation:**

Solar panel energy needed [Wh] = Appliance power consumption [Wh] x energy loss factor

Energy loss factor = 1.3

**3.8 Angle of incidence:**



**Figure - Solar Panel Orientation towards the Sun [18]**

**N** = unit vector normal to the panel

**S** = unit vector pointing from the panel towards the sun

$q_i$  = angle of incidence

$b$  = tilt angle

$g$  = azimuth angle

$N_e = \cos b$  [18]

$N_z = \sin b \sin g$  [18]

$N_n = \sin b \cos g$  [18]

Angle of incidence:  $\theta_i = \cos^{-1}(\mathbf{S} \cdot \mathbf{N})$  [18]

**3.9 Solar panel:**

The solar panel is made up of photovoltaic cells, which absorbs the sun’s radiation and converts it into electricity. These cells are made up of two silicon film layers: the positively charged layer (p-type) and the negatively charged layer (n-type) [5] [9]. When the sunlight strikes the surface of the PV cells, photons are absorbed and electrons are released. Silicon is a semiconducting material, so it transports electric current efficiently. The electric circuit that connects the two layers then captures the flow of electrons. Below is a diagram showing the make-up of the photovoltaic array that covers the surface area of the solar panel.

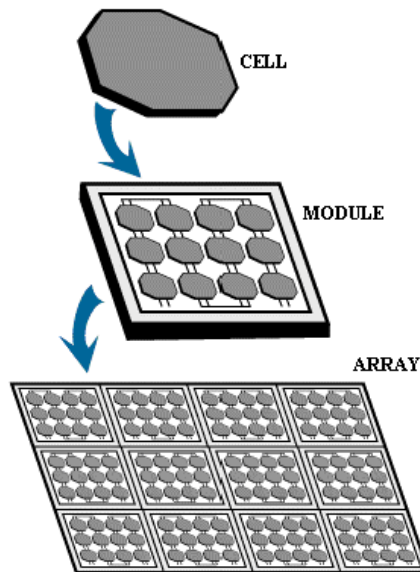


Figure 2 - Make-up of Photovoltaic Array [13]

### 3.10 Charge Controller:

The charge controller is used to regulate the output voltage between the solar panel and the battery. This voltage needs to be regulated so that no damage is done to the battery due to voltage overload. Charge controllers use a 3-stage cycle :

- Bulk: batteries draw maximum current while voltage rises to bulk level.
- Absorption: current decreases while voltage remains at bulk level.
- Float: batteries draw small amount of current while voltage is lowered to float level.

The diagram below shows the current and voltage during the three stages.

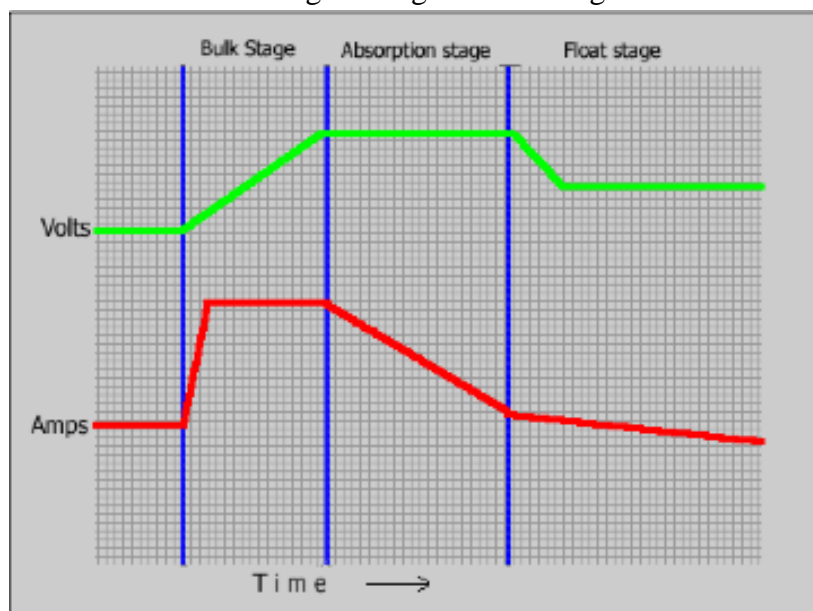


Figure 3 - 3-Stage Cycle of Charge Controller [14]

### 3.11 Battery:

The battery is used for storing the energy absorbed. The system is inoperable without the battery, since the power is stored and drawn from the battery to be used or converted. The energy stored in the battery is determined by the voltage and charge capacity in the relation:

$$\text{Energy Stored} = \text{voltage} \times \text{charge capacity}$$

Another important factor in the battery is the cycle capability or efficiency. This is determined by:

$$\text{Efficiency} = \frac{\text{energy output of discharge}}{\text{energy input to restore}}$$

## 4 Software Description:

### Arduino Development Environment

The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

### Writing Sketches

Software written using Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension .ino. It has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom righthand corner of the window displays the current board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

NB: Versions of the IDE prior to 1.0 saved sketches with the extension pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

The Arduino environment uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

Beginning with version 1.0, files are saved with a .ino file extension. Previous versions use the .pde extension. You may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

### Tabs, Multiple Files, and Compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no extension), C files (.c extension), C++ files (.cpp), or header files (.h).

### Uploading

Before uploading your sketch, you need to select the correct items from the Tools Board and Tools Serial Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyUSB0, /dev/ttyUSB1 or similar.

Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the File menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino environment will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

### Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch Import Library menu. This will insert one or more statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete it from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

## PROGRAMMING

The Arduino Uno can be programmed with the Arduino software (download). 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 preburned with a bootloader 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; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available . The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

- 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.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

### Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno 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

nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader 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 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". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

## HARDWARE DESCRIPTION

### HARDWARE DESCRIPTION

#### 4.1 ARDUINO (ATMEGA 328P)



Figure 3.2 Aurdino

The Atmel AVR® core 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.

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 Q Touch 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 non-volatile memory programmer, or by an On-chip Boot program running on the AVR core.

**Pin diagram of ATMEGA328**

The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, and Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits. Below figure 3.2.1 pin diagram of ATMEGA328.

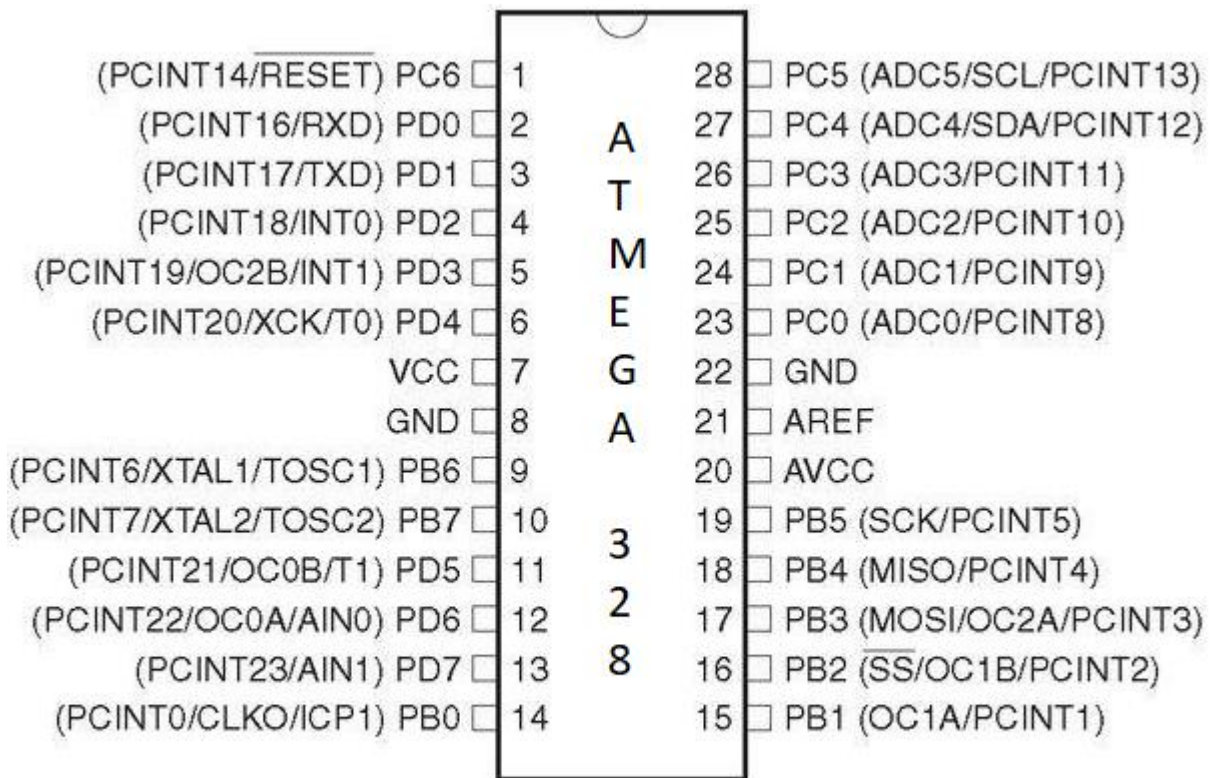


Figure 3.2.1 Pin diagram of ATMEGA328

**FEATURES OF ATMEGA328**

- 28-pin AVR Microcontroller
- Flash Program Memory: 32 kilo bytes
- EEPROM Data Memory: 1 kilo bytes
- SRAM Data Memory: 2 kilo bytes
- I/O Pins: 23
- Timers: Two 8-bit / One 16-bit



A/D Converter: 10-bit Six Channel  
PWM: Six Channels  
RTC: Yes with Separate Oscillator  
MSSP: SPI and I<sup>2</sup>C Master and Slave Support  
USART: Yes  
External Oscillator: up to 20MHz

### **ADVANTAGES/ IMPROVEMENTS IN ATMEGA328**

Still runs on 5 V, so legacy 5 V stuff interfaces cleaner  
Even though it's 5 V capable, newer parts can run to 1.8 V. This wide range is very rare.  
Nice instruction set, very good instruction throughput compared to other processors (HCS08, PIC12/16/18).  
High quality GCC port (no proprietary crappy compilers!)  
"PA" variants have good sleep mode capabilities, in micro-amperes.  
Well rounded peripheral set  
Q Touch capability  
Pin Descriptions table  
VCC  
Digital supply voltage.  
GND  
Ground.

### **Port B (PB [7:0]) XTAL1/XTAL2/TOSC1/TOSC2**

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB [7:6] is used as TOSC [2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

### **Port C (PC [5:0])**

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC [5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

### **PC6/RESET**

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port ‘C’ are elaborated in the Alternate Functions of Port C section.

**Port D (PD [7:0])**

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

**AVCC**

AVCC is the supply voltage pin for the A/D Converter, PC [3:0], and PE [3:2]. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC [6:4] use digital supply voltage, VCC.

**Arduino Uno Board Description**

We will learn about the different components on the Arduino board. We will study the Arduino UNO board because it is the most popular board in the Arduino board family. In addition, it is the best board to get started with electronics and coding. Some boards look a bit different from the one given below figure 3.2.2, but most Arduinos have majority of these components in common.

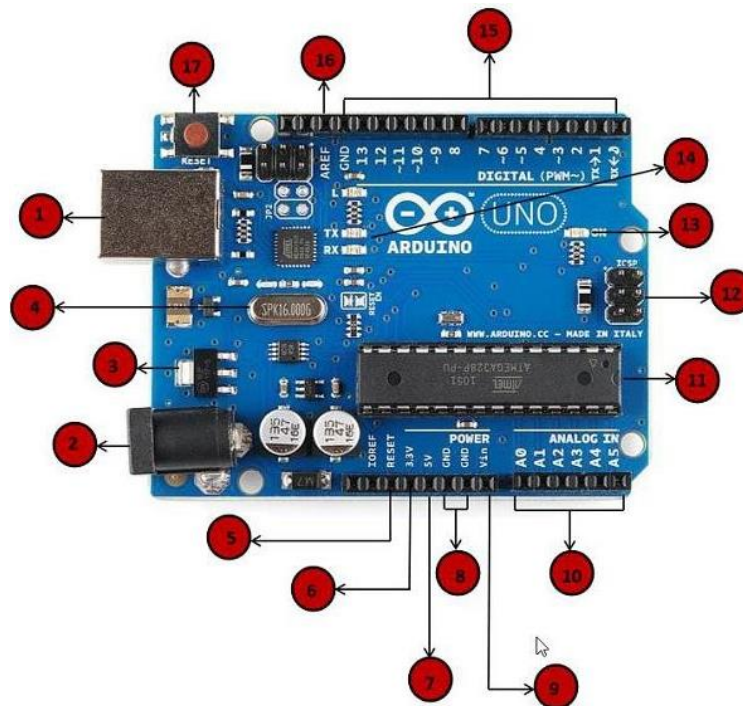


Figure 3.2.2 Arduino Uno Board

Arduino board can be powered by using the USB cable from computer. All we need to do is connect the USB cable to the USB connection (1).

**Power (Barrel Jack)**

Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack.

**Voltage Regulator**

The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

### **Crystal Oscillator**

The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

### **Arduino Reset**

We can reset our Arduino board, i.e., start our program from the beginning. We can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, we can connect an external reset button to the Arduino pin labelled RESET (5).

Pins (3.3, 5, GND, Vin)

3.3V (6) – Supply 3.3 output volt

5V (7) – Supply 5 output volt

Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.

GND (8) (Ground) – There are several GND pins on the Arduino, any of which can be used to ground our circuit.

Vin (9) – This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

### **Analog pins**

The Arduino UNO board has five analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

## **4.1 NODEMCU (ESP8266)**



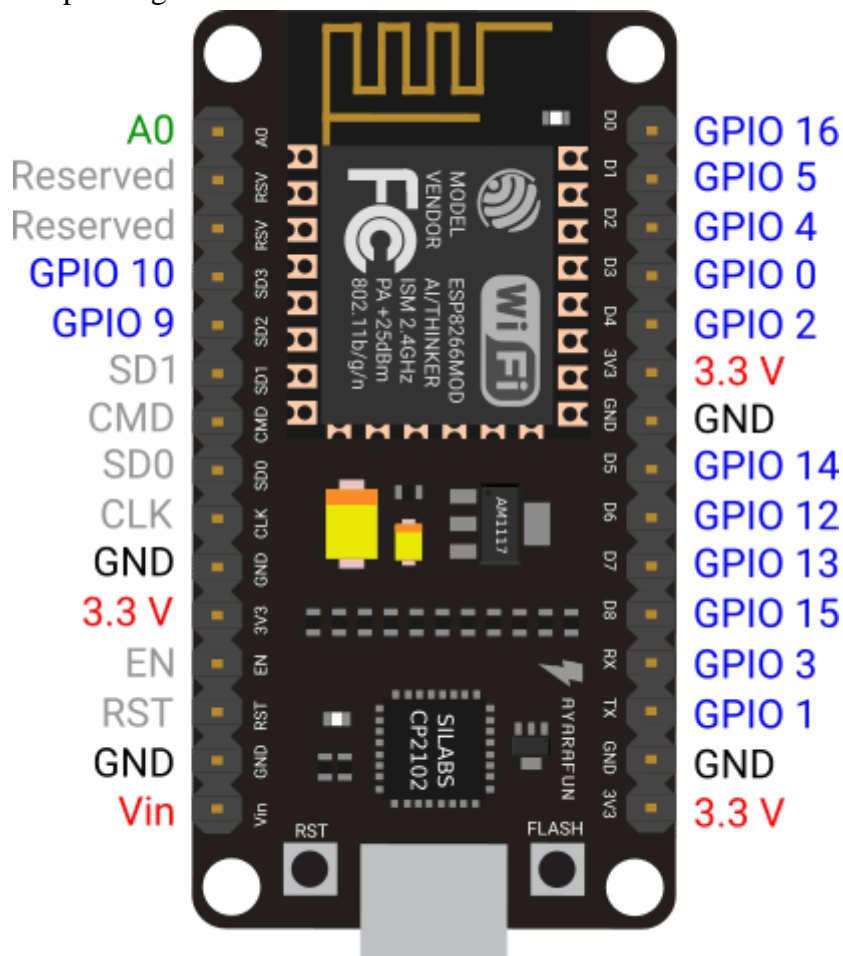
The Atmel AVR® core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle. The resulting architecture 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.

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 Q Touch 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 non-volatile memory programmer, or by an On-chip Boot program running on the AVR core.

**Pin diagram of ATMEGA328**

The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, and Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits. Below figure 3.2.1 pin diagram of ATMEGA328.



**FEATURES OF ATMEGA328**

- 28-pin AVR Microcontroller
- Flash Program Memory: 32 kilo bytes

EEPROM Data Memory: 1 kilo bytes  
SRAM Data Memory: 2 kilo bytes  
I/O Pins: 23  
Timers: Two 8-bit / One 16-bit  
A/D Converter: 10-bit Six Channel  
PWM: Six Channels  
RTC: Yes with Separate Oscillator  
MSSP: SPI and I<sup>2</sup>C Master and Slave Support  
USART: Yes  
External Oscillator: up to 20MHz

### **ADVANTAGES/ IMPROVEMENTS IN ATMEGA328**

Still runs on 5 V, so legacy 5 V stuff interfaces cleaner  
Even though it's 5 V capable, newer parts can run to 1.8 V. This wide range is very rare.  
Nice instruction set, very good instruction throughput compared to other processors (HCS08, PIC12/16/18).  
High quality GCC port (no proprietary crappy compilers!)  
"PA" variants have good sleep mode capabilities, in micro-amperes.  
Well rounded peripheral set  
Q Touch capability  
Pin Descriptions table  
VCC  
Digital supply voltage.  
GND  
Ground.

### **Port B (PB [7:0]) XTAL1/XTAL2/TOSC1/TOSC2**

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB [7:6] is used as TOSC [2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

### **Port C (PC [5:0])**

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC [5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs,

Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

**PC6/RESET**

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port ‘C’ are elaborated in the Alternate Functions of Port C section.

**Port D (PD [7:0])**

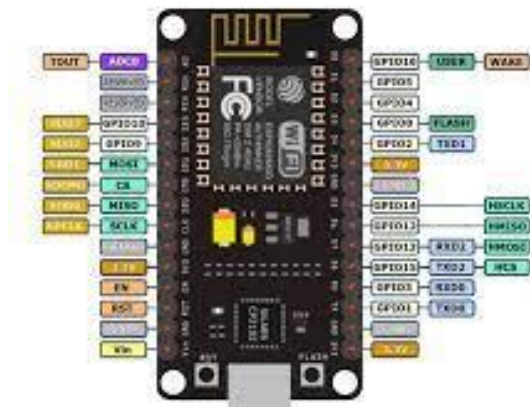
Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

**AVCC**

AVCC is the supply voltage pin for the A/D Converter, PC [3:0], and PE [3:2]. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC [6:4] use digital supply voltage, VCC.

**NODEMCU Uno Board Description**

We will learn about the different components on the NODEMCU board. We will study the NODEMCU UNO board because it is the most popular board in the NODEMCU board family. In addition, it is the best board to get started with electronics and coding. Some boards look a bit different from the one given below figure 3.2.2, but most NODEMCUs have majority of these components in common.



### **Power (Barrel Jack)**

NODEMCU boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack.

### **Voltage Regulator**

The function of the voltage regulator is to control the voltage given to the NODEMCU board and stabilize the DC voltages used by the processor and other elements.

### **Crystal Oscillator**

The crystal oscillator helps NODEMCU in dealing with time issues. How does NODEMCU calculate time? The answer is, by using the crystal oscillator. The number printed on top of the NODEMCU crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

### **NODEMCU Reset**

We can reset our NODEMCU board, i.e., start our program from the beginning. We can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, we can connect an external reset button to the NODEMCU pin labelled RESET (5).

Pins (3.3, 5, GND, Vin)

3.3V (6) – Supply 3.3 output volt

5V (7) – Supply 5 output volt

Most of the components used with NODEMCU board works fine with 3.3 volt and 5 volt.

GND (8) (Ground) – There are several GND pins on the NODEMCU, any of which can be used to ground our circuit.

Vin (9) – This pin also can be used to power the NODEMCU board from an external power source, like AC mains power supply.

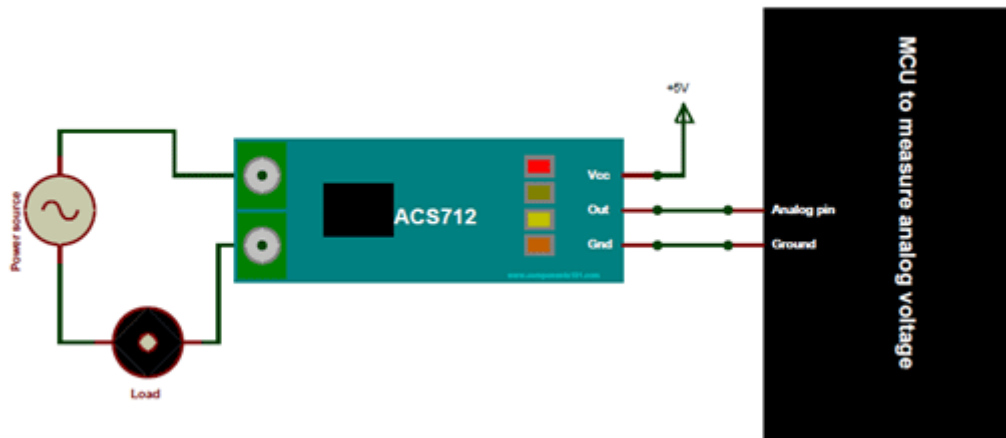
### **Analog pins**

The NODEMCU UNO board has five analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

The **ACS712 Module** uses the famous **ACS712 IC** to **measure current** using the Hall Effect principle. The module gets its name from the IC (ACS712) used in the module, so for your final products use the IC directly instead of the module.

These ACS712 module can measure current AC or DC current ranging from +5A to -5A, +20A to -20A and +30A to -30A. You have to select the right range for your project since you have to trade off accuracy for higher range modules. This module outputs Analog voltage (0-5V) based on the current flowing through the wire; hence it is very easy to interface this module with any microcontroller. So if you are looking for a module to measure current using a microcontroller for your project, then this module might be the right choice for you.

As told earlier it is very simple to **interface the ACS712 Module with Microcontrollers**. The below diagram would be more illustrative



The ACS712 module has two phoenix terminal connectors (green colour ones) with mounting screws as shown above. These are the terminals through which the wire has to be passed. In our case I am measuring the current drawn by the motor so the wires that is going to the load (motor) is passed through the ACS 712 Module. Make sure the module is connected in series with the load and be extra cautious to avoid shorts.

On the other side we have three pins. The Vcc is connected to +5V to power the module and the ground is connected to the ground of the MCU (system). Then the analog voltage given out by the ACS712 module is read using any analog pin on the Microcontroller.

### Programming for ACS712 Module

There are few things to know before we could program our Microcontrollers to read current from ACS712 Module. By default when no current is flowing through the module terminals the output voltage will be +2.5V ( $V_{cc}/2$ ), when the current flows in one direction the value will increase from 2.5V and when it flows in other direction the values will decrease from 2.5V. This way the module enables us to measure both AC current and DC current.

Let us assume that the microcontroller you are using has a 10-bit ADC and operates at 5V with a reference voltage of 5V for ADC conversion in that case the microcontroller will read the values of ADC from 0 to 1024. Then you can use the formulae below to calculate the Output Voltage from ADC values.

$$V_{out} \text{ (mV)} = (\text{ADC Value} / 1023) * 5000$$

After calculating the output voltage we can, calculate the value of current from the voltage using the below formulae

$$\text{Current Through the Wire (A)} = (V_{out}(\text{mv}) - 2500) / \text{Scale factor}$$

Note that the value of scale factor changes for every module based on its range. The values of scale factor for all three modules are given in the specifications above.



**POWER SUPPLY:****TRANSFORMER:**

This document presents the solution for a 12V 1A flyback converter based on the Infineon OPTIREG™ TLE8386-2EL controller and IPD50N08S4-13 OptiMOS™-T2. The user is guided through the component selections, the circuit design and, finally, an overview of the experimental results are presented. The TLE8386-2EL is part of the Automotive OPTIREG™ family and it implements a low-side-sense current mode controller with built in protection features. The device is AECQ-100 qualified. The IPD50N08S4-13 is an AEC-Q101 qualified 80V N-channel enhanced mode MOSFET, it is part of the OptiMOS™-T2 family. Intended audience This document is intended for power supply design engineers, application engineers, students, etc., who need to design a Flyback converter for automotive power applications where a galvanic isolation between two voltage domains is required. In particular the focus is on a battery connected flyback that delivers up to 12W at 12V output voltage; the intention is to provide the user with all of the needed information to fully design and characterize the SMPS bringing it from an engineering concept to its production. Specific features and applications are: - 48V to 12V Automotive applications - Isolated current mode SMPS - Flyback regulators with auxiliary sensing

**4.1.1 Centre Tapped Transformer Specifications**

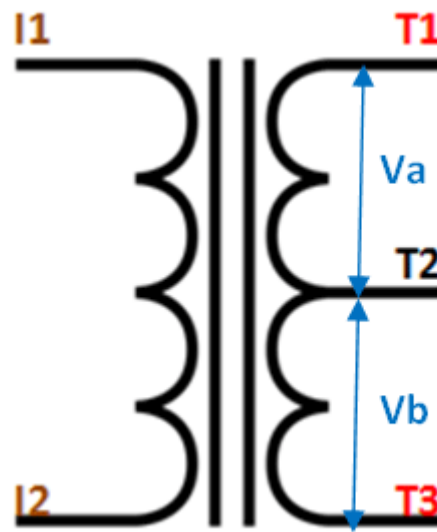
- Step-down Centre tapped Transformer
- Input Voltage: 220V AC at 50Hz
- Output Voltage: 24V, 12V or 0V
- Output Current: 1A
- Vertical mount type
- Low cost and small package

A **centre-tapped transformer** also known as **two phase three wire transformer** is normally used for rectifier circuits. When a digital project has to work with AC mains a Transformer is used to step-down the voltage (in our case, to 24V or 12V) and then convert it to DC by using a rectifier circuit. In a center-tapped transformer the peak inverse voltage is twice as in bridge rectifier hence this transformer is commonly used in full wave rectifier circuits.

The operation and theory behind a Center tapped transformer is very similar to a normal secondary transformer. A primary voltage will be induced in the primary coil (I1 and I3) and due to magnetic induction the voltage will be transferred to the secondary coil. Here in the secondary coil of a centre tapped transformer, there will be an additional wire (T2) which will be placed exactly at the center of the secondary coil, hence the voltage here will always be zero.

If we combine this zero potential wire (T2) with either T1 or T2, we will get a voltage of 12V AC. If this wire is ignored and voltage across T1 and T2 is considered then we will get a voltage of 24V AC. This feature is very useful for the function of a full wave rectifier.

Let us consider the voltage given by the first half of the secondary coil as  $V_a$  and the voltage across the second half of the secondary coil as  $V_b$  as shown



### RECTIFIER CIRCUIT:

We have learnt in rectifier circuits about converting a sinusoidal ac voltage into its corresponding pulsating dc. Apart from the dc component, this pulsating dc voltage will have unwanted ac components like the components of its supply frequency along with its harmonics (together called ripples). These ripples will be the highest for a single-phase half wave rectifier and will reduce further for a single-phase full wave rectifier. The ripples will be minimum for 3-phase rectifier circuits. Such supply is not useful for driving complex electronic circuits. For most supply purposes constant dc voltage is required than the pulsating output of the rectifier. For most applications the supply from a rectifier will make the operation of the circuit poor. If the rectifier output is smoothed and steady and then passed on as the supply voltage, then the overall operation of the circuit becomes better. Thus, the output of the rectifier has to be passed through a filter circuit to filter the ac components. The filter is a device that allows passing the dc component of the load and blocks the ac component of the rectifier output. Thus the output of the filter circuit will be a steady dc voltage. The filter circuit can be constructed by the combination of components like capacitors, resistors, and inductors. Inductor is used for its property that it allows only dc components to pass and blocks ac signals. Capacitor is used so as to block the dc and allows ac to pass. All the combinations and their working are explained in detail below. Series Inductor Filter The circuit diagram of a full wave rectifier with a series inductor filter is given below. As the name of the filter circuit suggests, the Inductor L is connected in series between the rectifier circuit and the load. The inductor carries the property of opposing the change in current that flows through it. In other words, the inductor offers high impedance to the ripples and no impedance to the desired dc components. Thus the ripple components will be eliminated. When the rectifier output current increases above a certain value, energy is stored in it in the form of a magnetic field and this energy is given up when the output current falls below the average value. Thus all the sudden changes in current that occurs in the circuit will be smoothed by placing the inductor in series between the rectifier and the load. The waveform below shows the use of inductor in the circuit. From the circuit, for zero frequency dc voltage, the choke resistance  $R_i$  in series with the load resistance  $R_L$  forms a voltage divider circuit, and thus the dc voltage across the load is  $V_{dc} = \frac{R_L}{(R_i + R_L)} V_{dc}$   $V_{dc}$  is the output from a full wave rectifier. In this case, the value of  $R_i$  is negligibly small when compared to  $R_L$ . The effect of higher harmonic voltages can be easily neglected as better filtering for the higher harmonic components take place. This is because of the fact that with the increase in frequency, the

reactance of the inductor also increases. It should be noted that a decrease in the value of load resistance or an increase in the value of load current will decrease the amount of ripples in the circuit. So, the series inductor filter is mostly used in cases of high load current or small load resistance. A simple series inductor filter may not be properly used. It is always better to use a shunt capacitor (C) with series inductor (L) to form an LC Filter. Shunt Capacitor Filter As the name suggests, a capacitor is used as the filter and this high value capacitor is shunted or placed across the load impedance. This capacitor, when placed across a rectifier gets charged and stores the charged energy during the conduction period. When the rectifier is not conducting, this energy charged by the capacitor is delivered back to the load. Through this energy storage and delivery process, the time duration during which the current flows through the load resistor gets increased and the ripples are decreased by a great amount. Thus for the ripple component with a frequency of ‘f’ megahertz, the capacitor ‘C’ will offer a very low impedance. The value of this impedance can be written as: Shunt Capacitor Impedance =  $1/2 fC$  Thus the dc components of the input signal along with the few residual ripple components, is only allowed to go through the load resistance  $R_{Load}$ . The high amount of ripple components of current gets bypassed through the capacitor C. Now let us look at the working of Half-wave rectifier and Full-wave rectifier with Capacitor filters, their output filtered waveform, ripple factor, merits and demerits in detail.

**LEAD ACID BATTERY:**

Lead acid batteries are the most common large-capacity rechargeable batteries. They are very popular because they are dependable and inexpensive on a cost-per-watt base. There are few other batteries that deliver bulk power as cheaply as lead acid, and this makes the battery cost-effective for automobiles, electrical vehicles, forklifts, marine and uninterruptible power supplies (UPS).

Lead acid batteries are built with a number of individual cells containing layers of lead alloy plates immersed in an electrolyte solution, typically made of 35% sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) and 65% water (Figure 1). Pure lead (Pb) is too soft and would not support itself, so small quantities of other metals are added to get the mechanical strength and improve electrical properties. The most common additives are antimony (Sb), calcium (Ca), tin (Sn) and selenium (Se). When the sulphuric acid comes into contact with the lead plate, a chemical reaction is occurring and energy is produced.

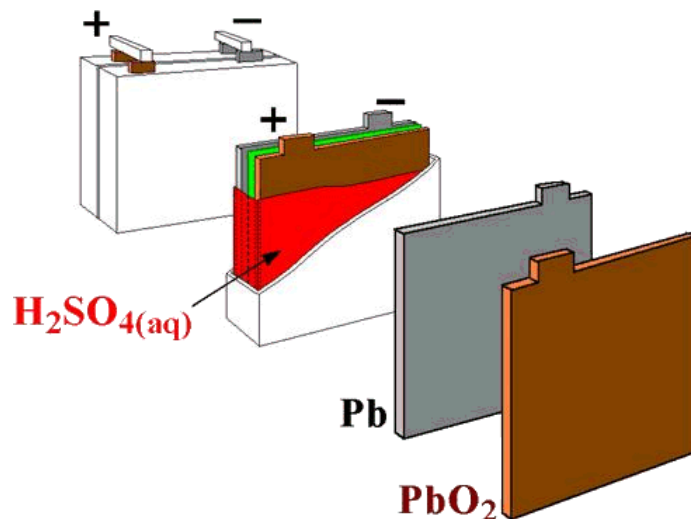


Figure 1: Typical lead acid battery schematic

Lead acid batteries are heavy and less durable than nickel (Ni) and lithium (Li) based systems when deep cycled or discharged (using most of their capacity). Lead acid batteries have a moderate life span and the charge retention is best among rechargeable batteries. The lead acid battery works well at cold temperatures and is superior to lithium-ion when operating in sub-zero conditions. Lead acid batteries can be divided into two main classes: vented lead acid batteries (spillable) and valve regulated lead acid (VRLA) batteries (sealed or non-spillable).

### Vented Lead Acid Batteries

Vented lead acid batteries are commonly called “flooded”, “spillable” or “wet cell” batteries because of their conspicuous use of liquid electrolyte (Figure 2). These batteries have a negative and a positive terminal on their top or sides along with vent caps on their top. The purpose of the vent caps is to allow for the escape of gases formed, hydrogen and oxygen, when the battery is charging. During normal operation, water is lost due to evaporation. In addition, the vent caps allow water and acid levels of the battery to be checked during maintenance.

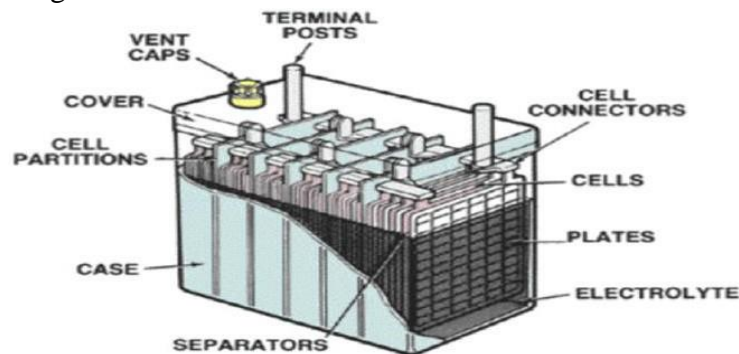


Figure 2: Typical vented lead acid battery schematic

The main hazards associated with lead acid batteries are:

Chemical (corrosive) hazards

Risk of fire or explosion

Electrical shocks

Ergonomic hazards related to their heavy weight

Transportation hazards

Acid burns to the face and eyes comprise about 50% of injuries related to the use of lead acid batteries. The remaining injuries were mostly due to lifting or dropping batteries as they are quite heavy.

Wear the proper personal protective equipment (PPE), specifically splash-proof goggles, acid-resistant lab coat or apron, safety shoes and rubber gloves. A face shield must also be worn when refilling batteries with electrolytes.

Know where the emergency showers and emergency eyewash stations are located; they must be located near lead acid battery storage and charging areas.

Slowly pour concentrated acid into water; do not add water to acid. (warning: electrolyte will become hot; do not close battery vents until electrolyte has cooled down)

Use non-metallic containers and funnels.

Ensure neutralizers (e.g. baking soda) are available for immediate use.

Use extreme care to avoid spilling or splashing the sulphuric acid solution

The NFPA 1 and IFC state that, for vented lead acid and VRLA batteries, the ventilation system shall be designed to limit the maximum concentration of hydrogen to 1% of the total volume of the room or that a continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot [1ft<sup>3</sup>/min/ft<sup>2</sup> or 0.0051 m<sup>3</sup>/(s . m<sup>2</sup>)] of floor area of the room. Other standards that are often used to determine proper ventilation include, but are not limited to:

National Fire Protection Association (NFPA) 76: suggests that any battery room exhaust fan capacity in Cubic Feet Minute (CFM) should be in the room area (in sq. ft.).

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62: recommends 1 CFM per charging ampere to be provided, but not less than 6 air changes per hour.

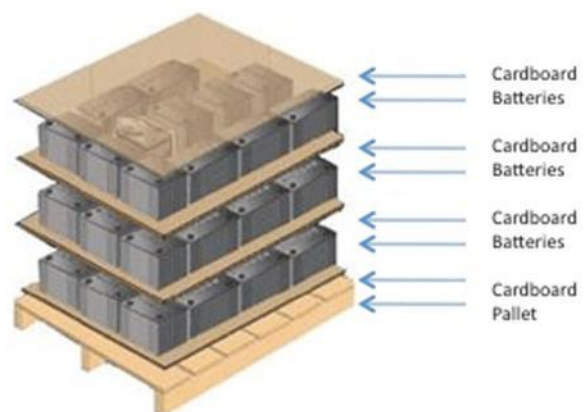
While all batteries will operate within a fairly wide temperature range, the life expectancy of a battery can be severely shortened at high temperatures. The optimum temperature for air around a stationary battery is 22° +/- 5°C. The reduction of a vented lead acid battery life from heat above the recommended temperature is about 2.5% per each 1°C.

As these batteries contain an electrolyte in the liquid form, special spill containment systems (e.g. spill tray) (Figure 6) and the presence of an acid-neutralizing spill kit are required (NFPA 1 and IFC). An ABC-type fire extinguisher must also be present in these rooms.

Strictly follow all manufacturer's instructions when installing or maintaining battery systems. Mainly:

Do not allow conductive material to touch battery terminals. A dangerous short circuit may occur and cause battery failure and fire. If installed batteries are at risk of metal tools or other conductive materials touching terminals, then the terminals should be insulated.

When batteries are stacked or palletized, cardboards must be placed between layers of stacked batteries to avoid damage and short circuits (Figure 7).



Tools or cables should not be placed on batteries or in an area where they can fall onto the terminals. Only insulated tools should be used.

When working on batteries, workers must not wear items of jewellery (e.g. watches, rings) as they may short out the terminals.

Use an appropriate strap or cradle to carry batteries. Never carry them by their terminal posts.

## Charging Batteries

The following precautions shall be taken when charging or recharging vented lead acid batteries:

Make sure that you have been trained how to charge the battery; check battery manufacturer's specifications on recommended charging voltage thresholds. Avoid excessive charging which electrolyses some of the water, emitting hydrogen and oxygen (outgassing).

Check that the battery ventilation holes are clean to allow the hydrogen gas to escape and prevent the battery from exploding. If the battery is not maintenance-free, remove the filler caps to vent hydrogen gas. Stand at arm's length when removing battery caps.

Before recharging a battery, check the electrolyte level; if the electrolyte is covering the top of the plates, do not add more water. If the plates are not fully covered, fill to the designated level before charging and top up after charging if necessary. Never add electrolyte during charging.

Fill batteries with distilled or deionized water, not tap water.

Wear safety gloves, chemical apron, goggles and face shield while removing caps and filling up batteries with water.

Make sure the power is shut off at the charger before connecting or removing the cable clamps. Connect the charger's positive (+) lead to the battery's positive terminal and the negative (-) lead to the negative terminal.

Charge batteries in a properly ventilated area.

Do not smoke, carry out hot work (e.g. welding, brazing, grinding), or use a mobile phone in the charging area.

Ensure there is an ABC-type fire extinguisher nearby

Do not allow batteries to freeze. A discharged battery freezes sooner than one that is fully charged. Never charge a frozen battery. If the battery has been outside in cold weather, let it warm up to room temperature before charging.

Do not charge at temperatures above 49°C (120°F).

Formation of gas bubbles in a flooded lead acid cell indicates that the battery is reaching full state-of-charge (hydrogen on negative plate and oxygen on positive plate).

Allow a vented battery to stand for at least 20 minutes after disconnecting it from the charger. Carefully top up the electrolyte with distilled or deionized water to the manufacturer's recommended level.

Valve regulated lead acid (VRLA) batteries, also known as "sealed lead acid (SLA)", "gel cell", or "maintenance free" batteries, are low maintenance rechargeable sealed lead acid batteries. They limit inflow and outflow of gas to the cell, thus the term "valve regulated".

VRLA batteries are the most widely used battery type because of their high power density and ease of use. These batteries come in all shapes, voltages, amperages and sizes. VRLA batteries are considered to be "sealed" because they normally do not allow for the addition or loss of liquid. The term VRLA derives from the use of safety valves that allow pressure to be released when a fault condition causes internal gas to build up faster than it can be recombined.

Sealed valve regulated wet cell (non-spillable): this battery type contains acid in the liquid form similarly to a vented lead acid battery but the wet cell VRLA battery case is better sealed.

Absorbed Glass Mat (AGM): AGM batteries differ from flooded lead acid batteries in that the electrolyte is held in the glass mats, as opposed to freely flooding the plates. The fibers that compose the fine glass mat do not absorb nor are they affected by the acidic electrolyte.

Gel: gel cells add silica dust to the electrolyte, forming a thick putty-like gel. These are sometimes referred to as "silicone batteries". Unlike a flooded lead-acid battery, these batteries do not need to be kept upright. Gel batteries reduce the electrolyte evaporation, spillage (and subsequent corrosion problems) common to the wet-cell battery and boast greater resistance to shock and vibration.

## 5 DC MOTOR

A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore the current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque.

DC motors have a rotating armature winding (winding in which a voltage is induced) but non-rotating armature magnetic field and a static field winding (winding that produce the main magnetic flux) or permanent magnet. Different connections of the field and armature winding provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.

The introduction of DC motors to run machinery eliminated the need for local steam or internal combustion engines, and line shaft drive systems. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines.

### **Brush**

A brushed DC electric motor generating torque from DC power supply by using an internal mechanical commutation. Stationary permanent magnets form the stator field. Torque is produced by the principle that any current-carrying conductor placed within an external magnetic field experiences a force, known as Lorentz force. In a motor, the magnitude of this Lorentz force (a vector represented by the green arrow), and thus the output torque, is a function for rotor angle, leading to a phenomenon known as torque ripple) Since this is a single phase two-pole motor, the commutator consists of a split ring, so that the current reverses each half turn ( 180 degrees).

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the carbon brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Brushes consist of conductors.

## Brushless

Typical brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical current/coil magnets on the motor housing for the stator, but the symmetrical opposite is also possible. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

## Uncommutated

Other types of DC motors require no commutation.

- Homopolar motor – A homopolar motor has a magnetic field along the axis of rotation and an electric current that at some point is not parallel to the magnetic field. The name homopolar refers to the absence of polarity change.

Homopolar motors necessarily have a single-turn coil, which limits them to very low voltages. This has restricted the practical application of this type of motor.

- Ball bearing motor – A ball bearing motor is an unusual electric motor that consists of two ball bearing-type bearings, with the inner races mounted on a common conductive shaft, and the outer races connected to a high current, low voltage power supply. An alternative construction fits the outer races inside a metal tube, while the inner races are mounted on a shaft with a non-conductive section (e.g. two sleeves on an insulating rod). This method has the advantage that the tube will act as a flywheel. The direction of rotation is determined by the initial spin which is usually required to get it going.

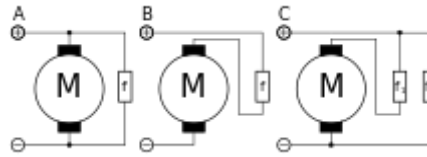
## Permanent magnet stators

A PM motor does not have a field winding on the stator frame, instead relying on PMs to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. PM fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most larger DC motors are of the "dynamo" type, which have stator windings. Historically, PMs could not be made to retain high flux if they were disassembled; field windings were more practical to obtain the needed amount of flux. However, large PMs are costly, as well as dangerous and difficult to assemble; this favors wound fields for large machines.

To minimize overall weight and size, miniature PM motors may use high energy magnets made with neodymium or other strategic elements; most such are neodymium-iron-boron alloy. With their higher flux density, electric machines with high-energy PMs are at least competitive with all optimally designed singly fed synchronous and induction electric machines. Miniature motors resemble the structure in the illustration, except that they have at least three rotor poles (to ensure starting, regardless of rotor position) and their outer housing is a steel tube that magnetically links the exteriors of the curved field magnets.



## Wound stators



A field coil may be connected in shunt, in series, or in compound with the armature of a DC machine (motor or generator)

Main article: [universal motor](#)

See also: [Excitation \(magnetic\)](#)

There are three types of electrical connections between the stator and rotor possible for DC electric motors: series, shunt/parallel and compound ( various blends of series and shunt/parallel) and each has unique speed/torque characteristics appropriate for different loading torque profiles/signatures.<sup>[1]</sup>

### Series connection

A series DC motor connects the armature and field windings in series with a common D.C. power source. The motor speed varies as a non-linear function of load torque and armature current; current is common to both the stator and rotor yielding current squared ( $I^2$ ) behavior<sup>[citation needed]</sup>. A series motor has very high starting torque and is commonly used for starting high inertia loads, such as trains, elevators or hoists.<sup>[2]</sup> This speed/torque characteristic is useful in applications such as dragline excavators, where the digging tool moves rapidly when unloaded but slowly when carrying a heavy load.

With no mechanical load on the series motor, the current is low, the counter-EMF produced by the field winding is weak, and so the armature must turn faster to produce sufficient counter-EMF to balance the supply voltage. The motor can be damaged by over speed. This is called a runaway condition.

Series motors called "universal motors" can be used on alternating current. Since the armature voltage and the field direction reverse at (substantially) the same time, torque continues to be produced in the same direction. Since the speed is not related to the line frequency, universal motors can develop higher-than-synchronous speeds, making them lighter than induction motors of the same rated mechanical output. This is a valuable characteristic for hand-held power tools. Universal motors for commercial power frequency are usually small, not more than about 1 kW output. However, much larger universal motors were used for electric locomotives, fed by special low-frequency traction power networks to avoid problems with commutation under heavy and varying loads.

### Shunt connection

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed regulation even as the load varies, but does not have the starting torque of a series DC motor.<sup>[3]</sup> It is typically used for industrial, adjustable speed applications, such as machine tools, winding/unwinding machines and tensioners.

### Compound connection

A compound DC motor connects the armature and fields windings in a shunt and a series combination to give it characteristics of both a shunt and a series DC motor.<sup>[4]</sup> This motor is used when both a high starting torque and good speed regulation is needed. The motor can be connected in two

arrangements: cumulatively or differentially. Cumulative compound motors connect the series field to aid the shunt field, which provides higher starting torque but less speed regulation. Differential compound DC motors have good speed regulation and are typically operated at constant speed.

## 6 Conclusion:

In the design of the 3-dimensional solar panel, we are trying to increase sunlight absorption and efficiency of the panel. The sunlight is absorbed by the photovoltaic cells, and converted into usable energy. During our initial design, we considered several different geometries for analysis and simulation. There are many geometries that we believe are more efficient than the flat panel, but we focused on the design of a parabolic curve to perform our experiment and confirm our theory of greater absorption and efficiency.

We believe that our project will have a positive impact on the environment and on society. By implementing solar power into residential and commercial areas, eventually it can become the primary power source, and reduce the dependence on fossil fuels and the negative environmental impacts that come with it. Not only is solar energy clean, but also it is in abundance and comes from an unlimited resource; the sun.

More over the proposed system includes wireless charging power generation which transfers the energy to e-vehicles. dynamic wireless power transfer is a practical method to solve electric vehicle range anxiety and reduce the cost of onboard batteries. Wireless recharging has long been common with pure electric vehicles and is designed to allow charging even when the vehicle is in motion

## 7 References:

1. X. Du *et al.*, "Design and optimization of solar tracker with u-pru-pus parallel mechanism," vol. 155, p. 104107, 2021. <https://doi.org/10.1016/j.mechmachtheory.2020.104107>
2. M. Mamun, M. R. Sarkar, M. Parvez, M. J. Nahar, and M. S. Rana, "Determining the optimum tilt angle and orientation for photovoltaic (PV) systems in Bangladesh," in *2017 2nd International Conference on Electrical & Electronic Engineering (ICEEE)*, 2017, pp. 1-4, IEEE. <https://doi.org/10.1109/CEEE.2017.8412910>
3. Renewables 2016 - Global status report, REN21 - Renewable Energy Policy for the 21st Century, 2016.
4. A. Belkaid, U. Colak and K. Kayisli, "A comprehensive study of different photovoltaic peak power tracking methods", IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA), San Diego, USA, pp. 1073-1079, 5-8 November 2017.
5. Y. Mahmoud, "Toward a long-term evaluation of MPPT techniques in PV systems," IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA), San Diego, USA, pp. 1106-1113, 5-8 November 2017. I. Nayshevsky, Q. Xu, G. Barahman and A. Lyons Anti-reflective and anti-soiling properties of a
6. KleanBoost, a superhydrophobic nano-textured coating for solar glass 2017 IEEE 44th Photovoltaic Specialist Conference (PVSC), Washington, DC, 2017, pp. 2285-2290, doi: 10.1109/PVSC.2017.8366777
7. Mo Yibo, Yang Liang, Huang Liuyan, Xu Qiongying, Chen Haifeng Review of various solar power generation technologies Dongfang Electric Review, 2018, 32(125):78- 82.

8. Mayank Kumar Lokhande (2014) Automatic Solar Tracking System Journal of Core Engineering & Management, Volume 1
9. N. Bose, Arindam & Sarkar, Sounak& Das, Sayan. (2012). Helianthus – A Low Cost High Efficient Solar Tracking System Using AVR Microcontroller International Journal of Scientific and Engineering
10. Maghami, Mohammad Reza & Hizam, Hashim & Gomes, Chandima&MohdRadzi, MohdAmran&Rezadad, Sina&Hajjighorbani, Shahrooz. (2016) Power Loss Due to Soiling on Solar Panel: A review. Renewable & Sustainable Energy Reviews 59. 1307-1316.  
10.1016/j.rser.2016.01.044.

#### APPENDIX:

```
#include <Servo.h>
```

```
Servo myservo,myservo1;  
void setup() {  
  Serial.begin(9600);  
  // put your setup code here, to run once:  
  pinMode(7,OUTPUT);  
  pinMode(A0,INPUT_PULLUP);  
  pinMode(A1,INPUT_PULLUP);  
  pinMode(A2,INPUT_PULLUP);  
  pinMode(A3,INPUT_PULLUP);  
  myservo.attach(2);  
  myservo1.attach(3);  
  myservo.write(90);  
  myservo1.write(90);  
}
```

```
void loop() {  
  int a=analogRead(A0);  
  int b=analogRead(A1);  
  int c=analogRead(A2);  
  int d=analogRead(A3);  
  Serial.println(a);  
  Serial.println(b);  
  Serial.println(c);  
  Serial.println(d);  
  if((a<b)&&(a<c)&&(a<d))  
  {  
    myservo.write(0);
```

```
myservo1.write(90);
delay(3000);
}
else if((b<a)&&(b<c)&&(b<d))
{
myservo.write(180);
myservo1.write(90);
delay(3000);
}
else if((c<a)&&(c<b)&&(c<d))
{
myservo.write(90);
myservo1.write(0);
delay(3000);
}
else if((d<a)&&(d<b)&&(d<c))
{
myservo.write(90);
myservo1.write(180);
delay(3000);
}

}

// put your main code here, to run repeatedly:
digitalWrite(7,HIGH);
delay(10);
digitalWrite(7,LOW);
delay(10);
}

#include "ThingSpeak.h"
#include <ESP8266WiFi.h>
const char ssid[] = "Project"; // your network SSID (name)
const char pass[] = "12345678"; // your network password
WiFiClient client;

unsigned long counterChannelNumber = 992560; // Channel ID
const char * myCounterWriteAPIKey = "CGKKAUA33E2VK9J6";
const int sensorIn = A0;
```

```
int mVperAmp = 100; // use 185 for 5A, 100 for 20A Module and 66 for 30A Module

double Voltage = 0;
double VRMS = 0;
double AmpsRMS = 0;

void setup(){
  pinMode(A0, INPUT);
  Serial.begin(115200);
  delay(10);
  Serial.println(F("Init...."));
  if (WiFi.status() != WL_CONNECTED)
  {
    Serial.print("Connecting to ");
    Serial.print(ssid);
    Serial.println(" ....");
    while (WiFi.status() != WL_CONNECTED)
    {
      WiFi.begin(ssid, pass);
      delay(5000);
    }
    Serial.println("Connected to Wi-Fi Successfully.");
  }
  WiFi.mode(WIFI_STA);
  ThingSpeak.begin(client);
}

void loop(){
  int u=analogRead(A0);
  Serial.println(u);
  Voltage = getVPP();
  VRMS = (Voltage/2.0) *0.707; // sq root
  AmpsRMS = (VRMS * 1000)/mVperAmp;
  float Wattage = (220*AmpsRMS)-18; //Observed 18-20 Watt when no load was connected, so
  subtracting offset value to get real consumption.
  Serial.print(AmpsRMS,6);
  Serial.println(" Amps RMS ");
  Serial.print(Wattage,6);
  Serial.println(" Watt ");
  ThingSpeak.writeField(counterChannelNumber,1,String(AmpsRMS),myCounterWriteAPIKey );
  ThingSpeak.writeField(counterChannelNumber,2,Wattage,myCounterWriteAPIKey );
```

```
}
```

```
float getVPP()
{
    float result;

    int readValue;          //value read from the sensor
    int maxValue = 0;       // store max value here
    int minValue = 1024;    // store min value here

    uint32_t start_time = millis();

    while((millis()-start_time) < 1000) //sample for 1 Sec
    {
        readValue = analogRead(sensorIn);
        // see if you have a new maxValue
        if (readValue > maxValue)
        {
            /*record the maximum sensor value*/
            maxValue = readValue;
        }
        if (readValue < minValue)
        {
            /*record the maximum sensor value*/
            minValue = readValue;
        }
        /*    Serial.print(readValue);
        Serial.println(" readValue ");
        Serial.print(maxValue);
        Serial.println(" maxValue ");
        Serial.print(minValue);
        Serial.println(" minValue ");
        delay(1000); */
    }

    // Subtract min from max
    result = ((maxValue - minValue) * 5)/1024.0;

    return result;
}
```