Department of Electrical and Computer Engineering
North South University

Senior Design Project

SOLAR GRID SYNCRONIZATION SYSTEM

NAME	ID
Bishawgit Sarker	**123 0115 043**
Towfique Ahamed Khan	**151 0547 643**
Koushik Saha	**142 0371 042**

Faculty Advisor:

Dr. Kazi Mohammad Abdus Salam

Professor

ECE Department

Spring, 2019

DECLARATION

This is to certify that this Project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

Students' names & Signatures

1. Bishawgit Sarker

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

2. Towfique Ashamed Khan

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

3. Koushik Saha

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

APPROVAL

We, **Bishawgit Sarker (123 0115 043)**, **Towfique Ashamed Khan (151 0547 643)** and **Koushik Saha (142 0371 042)**, members of EEE/ETE: 499 (Senior Design) from the Electrical and Computer Engineering department of **North South University**; have worked on the project titled **"Title of your project"** under the supervision of Dr. K. M. A. Salam as a partial fulfillment of the requirement for the degree of Bachelors of Science in Engineering and has been accepted as satisfactory.

Supervisor's Signature

.....

Dr. K. M. A. Salam
Professor

Department of Electrical & Computer Engineering

North South University

Dhaka, Bangladesh.

Chairman's Signature

.....

Dr. K. M. A. Salam
Professor

Department of Electrical & Computer Engineering

North South University

Dhaka, Bangladesh.

ACKNOWLEDGEMENT

By mercy of the Almighty we have completed our senior design capstone project entitled “Solar Grid System”.

Foremost, we would like to express our sincere gratitude to our advisor Dr. K. M. A. Salam for his continuous support in our capstone project progress throughout the whole 499A and 499B, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped us in all the time of research, writing and completing of this project.

Our sincere thanks also goes to North South University, Dhaka, Bangladesh for providing an opportunity in our curriculum which enabled us to have an industrial level experience as part of our academics.

We are also very grateful to one of our dearest friends, [you can put any name], for his help in this project.

Last but not the least, we would like to thank our family as their inspiration and guidance kept us focused and motivated.

Abstract

Our aim is to make a Smart Solar-Grid System that will reduce the cost of electricity bill and save power that are mostly wasted in solar energy. In that process we need more efficient and accurate solar tracker which will produce much more energy than other solar trackers. So we made an Arduino base Dual Axis Solar Tracker, which is a low cost, more efficient and accurate then Single Axis Solar Tracker. A Dual Axis Solar Tracker produces more energy than a single axis solar tracker that has only one axis of movement, usually aligned with North and South. But Dual-axis tracker have two axis of movement. This paper presents the design of a solar tracking system which is based on Arduino MEGA providing the movement of solar panel in the direction of maximum sun light INCIDENT. We also designed and simulated inverter in Matlab Simulink which converted solar power to the grid power 12v DC to 220v ac current. So, it will surely help us and the people of our country by saving the wastage of power any further by reducing load shedding.

List of Figures

Table of Contents

Chapter 1

Overview

1.1 Introduction

Our aim is to make a Smart Solar-Grid System that will reduce the cost of electricity bill and save power that are mostly wasted in solar energy. In that process we need more efficient and accurate solar tracker which will produce much more energy than other solar trackers. So we made an Arduino base Dual Axis Solar Tracker, which is a low cost, more efficient and accurate then Single Axis Solar Tracker. In addition, our solar tracker system can track sunlight or any kind of light by x and y axis, in x axis it track 0-180 degree and in y axis it track 180-360 degree. There's an enormous gap between generation and demand of electrical energy. Nearly 50% population of the country is extremely isolated from this blessing. Renewable energy is the only answer to solve this issue. Solar energy is one of the most effective resources of the renewable energy which could play a significant role to solve this crisis.

1.2 Project Definition

Power travelling from the grid to your home incurs significant transmission and distribution losses, thus wasting electricity generated by burning fossil fuels. These losses are almost nil in net metering systems as energy is generated and consumed at the same location. This not only reduces energy congestion and stress on overall grid infrastructure more efficient, it also provide financial relief to the distribution companies (DISCOMs) and improved grid voltage to consumers.

In a rooftop net metering system, the DC power generated from the solar panels is Converted to AC power using a power conditioning unit and is fed to the grid (the phase lines are selected

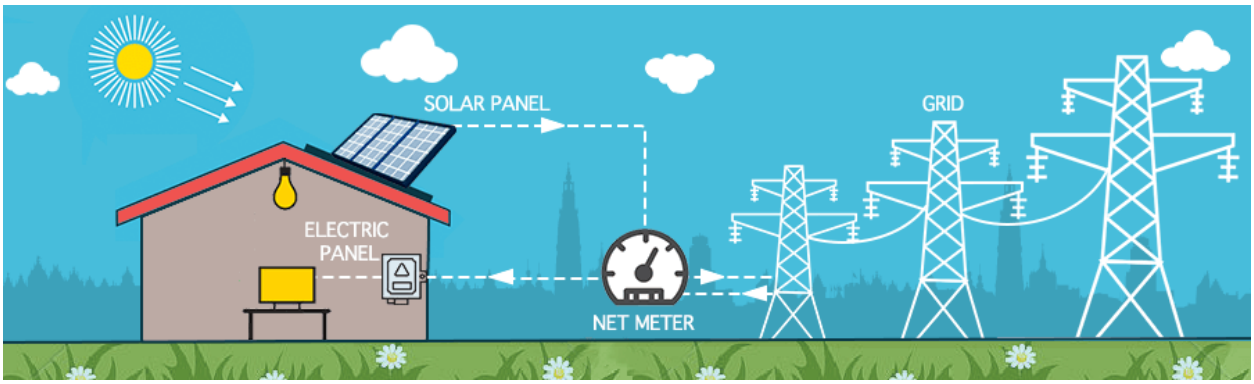


Fig1.1: Design of Our Solar Grid Hybrid System

Depending on the capacity of the installed system and the regulatory framework specified by respective States).

These systems generate power during the day time, which is utilized fully to power captive loads and feed excess power to the grid. In case solar power is insufficient due to cloud cover or rain, the captive loads are served by drawing power from the grid.

To enable this system of net-metering, state electricity boards replaces the existing service connection meter with a bidirectional meter that displays the import and export energy separately. For more details, please see the relevant state-specific policies here.

.It is a process of detecting change of the maximum position of the sunlight. Solar panel efficiency (expressed as a percentage) quantifies a solar panel's ability to convert sunlight into electricity. Given the same amount of sunlight shining for the same duration of time on two solar panels with different efficiency ratings, the more efficient panel will produce more electricity than the less efficient panel.

In practical terms, for two solar panels of the same physical size, if one has a 21% efficiency rating and the other has a 14% efficiency rating, the 21% efficient panel will produce 50% more kilowatt

hours (kWh) of electricity under the same conditions as the 14% efficient panel. Thus, maximizing energy use and bill savings is heavily reliant on having top-tier solar panel efficiency.

A recent report by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) recommended that consumers compare as many solar options as possible to avoid paying inflated prices offered by the large installers in the solar industry.

1.3 Purpose of this Project

Nowadays solar energy is widely used as an alternative form of power. Solar panels transform the energy from the sun into electricity. World's energy demand is growing fast because of population explosion and technological advancements. It is therefore important to go for reliable, cost effective and everlasting renewable energy source for energy demand arising in future. Solar energy, among other renewable sources of energy, is a promising and freely available energy source for managing long term issues in energy crisis. Solar industry is developing steadily all over the world because of the high demand for energy while major energy source, fossil fuel, is limited and other sources are expensive. The solar industry would definitely be a best option for future energy demand since it is superior in terms of availability, cost effectiveness, accessibility, capacity and efficiency compared to other renewable energy sources.

Not so long ago, solar power was something of a dream for those who were ahead of the curve in the environmental movement. It appeared to be an option for the wealthy and for those who had committed themselves to environmentalism.

The idea that we could heat our homes and generate electricity from little more than sunshine seemed like a utopian ideal.

Solar power has been steadily on the rise around the world, and as fossil fuels become increasingly scarce, we can expect to see solar power increasingly adopted.

Solar is now the fastest rising source of renewable energy in the world, reaching about 1% of the total energy produced globally.

In fact, solar energy production now rivals nuclear power globally. Solar energy reached a capacity of about 350 GW (gigawatts) globally in 2015, compared to nuclear energy which topped out at 391 GW in the same year. In addition, it is predicted that at the current rate of conversion to solar energy, it will overtake the use of fossil fuels by 2050, with most of the globe running on energy produced by the sun.

Global use of solar power grew especially fast in the last year, rising by 50%, with China and the United States at the forefront in terms of growth.

Why is solar power development so slow in Bangladesh?

The pace at which renewable energy including solar and wind is being developed worldwide suggests that these will overtake the fossil fuels (oil, gas, coal) as dominant sources in power generation in a shorter time frame than previously forecasted. In mid-1990s renowned energy experts predicted that oil, gas and coal will remain the predominant fuel for power generation until 2030. This will give way to natural gas becoming the universal fuel in 2050; the battle

between fossil fuels and renewable (solar and wind) for dominance over world energy market will begin in earnest by 2060 and the battle will clearly swing in favor of renewables by 2070.

The scientists are beginning to believe that this will happen in a timeframe earlier than suggested above. There are two reasons for such notion: firstly, the advances in solar and wind technology have been and will continue to be fast moving, thus lowering the cost and becoming logistically more acceptable and secondly, the green lobby has successfully influenced the governments worldwide to be more proactive towards the campaign for renewable replacing fossil fuels.

Developing on grid solar in Bangladesh is lack of governmental incentive. The companies which are engaged in negotiations and implementation of solar park opine that solar industry in Bangladesh is still in an immature and infant stage and requires incentives from the local authorities. A major point in this is fixing the tariff of the produced power. Over the last few years the cost of solar power generation and therefore the tariff offered has moved progressively downward as seen in India and China for example. In India, solar power was offered a tariff of 19 cents (Tk 15.80) per unit in 2010 and this has come down to 5 cents (Tk 4) in 2017. Nevertheless, how logical will it be to take the Indian experience directly to fix the tariff in Bangladesh at this moment may be questionable for a number of reasons?

According to the government plan, renewable sources should provide about 10 percent of the total power generation capacity by 2021, meaning 2400MW power generation from renewable sources. The prospect of wind power (presently total installed capacity is 2MW), bio-energy (present installed capacity 1MW) or new hydro-power have been limited in Bangladesh and therefore, growth of renewable energy in Bangladesh will rely mainly on the development of on-grid solar power. At present the on-grid solar power generation capacity amounts to 15MW

(Sreda 2018) including one well-publicized solar park with 3MW capacity built on 8 acres of land in Sarishabari in Jamalpur district.

The use of traditional fuels oil gas and coal will gradually decrease to be replaced by renewable solar winds etc. till a time when the formers will find their place in history book. Bangladesh does not have an option to remain isolated when rest of the world embraces a future with smarter and cleaner renewable energy for their power. The challenges in developing renewables may be high, but it is the government which should extend its hand to help it grow in the initial stage.

CURRENT INSTALLED CAPACITY AND GENERATED ELECTRICITY			
Country	Total Installed Capacity (MW)	Renewable Installed Capacity (Non-hydro) (MW)	Renewable Generated Electricity (Non-hydro)
BANGLADESH	16,288	242	0.07%
INDIA	310,005	45,916	6.01%
WORLD	6,180,000	657,000	6.43%
Ref: SREDA, IEA Sankey Diagram, Government of India Annual Report 2016-17, World Energy Council Report 2016			

Fig 1.2: List of Current Installed Capacity

CURRENT INSTALLED CAPACITY AND GENERATED ELECTRICITY.

So we come up with a new idea that reduce the cost of electricity bill and help government to produce more electricity for our county.

1.4 Project Goal

In this era of modern technology and development methods and features of solar energy and reuse of power works has grown largely. There are some works done before and has some similarity with our work. Some of the solar panel used in rural area has first experiment of solar energy.

Our main aim is to make the engineering concepts we earn and spread it for a better implement. Needs Less Resources, Reduce Electricity Bill, Reuse of Power, Low Maintenance. Our primary goal is to reduce waste of power and also reuse those power to other side.

The produced dc current will be converted into 240 volt ac using inverter. This current will be controlled by a smart controller. Smart controller will take different operating conditions into account. This controller will also integrate this solar system with the grid. It will also deliver energy to the grid when there is surplus and feed the load from the grid when solar system failed to feed the loads. There will also be a battery backup that will be used when there will be no solar power generation and grid failure. We will develop a smart monitoring system that will notify the user in case of any failure in the integration system. To know how much power is consumed from the grid, net metering system will be used.

1.5 Summary

Bangladesh is a middle class country. In 2010 Bangladesh population is 129.6 million and it grown in 2018 about 162.95 million. Our country need more electricity and reduce the cost of electricity so that people can get electricity at low price. So we come with an idea that not only reduce load shedding but also reduce the cost of electricity bill. So our grid electricity use in our factory so that

our country develop in power development. Deciding whether or not to grid-tie your solar panels is usually pretty straightforward – the clear-cut benefits of being grid-tied appeals to the majority of homeowners. There are, however, some people that choose to live off the grid. Grid-tied, on-grid, utility-interactive, grid intertie and grid back feeding are all terms used to describe the same concept – a solar system that is connected to the utility power grid. A grid-connection will allow you to save more money with solar panels through better efficiency rates, net metering, plus lower equipment and installation costs.

Chapter 2

Existing Systems and Solution Adopted

2.1 Introduction

In this time of present-day innovation and advancement strategies and components of apply Dual axis solar tracking system. There are a few works done before and has some similarity with our work. There is many Dual axis solar tracking system but all paper use LDR and 3D printing and there price goes high but our paper is low cost for our dual axis solar tracking. Three possible solutions of controlling were considered to overcome the problems in developing the proposed dual axis solar tracker with solar grid system of discussed in this chapter. The principle reason for the task will be accomplished in the event that we get the most ideal arrangements by dispensing with issues. The chapter emphasizes on presently existing systems, similarity with those systems and also new features of our project. It also demonstrates the problems, alternative solutions and best possible solution to tackle problems.

2.2 Existing Solution

In this era of modern technology and development methods and features dual axis solar tracing system related works has grown largely but there is no or less smart solar grid hybrid system . There are some works done before and has some similarity with our work.

Tung-Sheng Zhan Systems build a capability of photovoltaic (PV) panel to generate energy approximately follows the intensity of the sunlight on the panel. A dual axis solar programmable logical controller (PLC) based automatic tracking system and its supervisory and control system was designed and implemented in this paper. The proposed automatic tracking system controls elevation and orientation angles of solar panels such that the panels always maintain perpendicular to the sunlight. The measured variables of our automatic solar tracking system were compared with those of a fixed-angle PV system. The results indicated that the automatic solar tracking

system is low-cost, reliable and efficient. As a result of the experiment, the electricity generated by the proposed tracking system has an overall increase of about 8%~25% more than the fix-angle PV system.

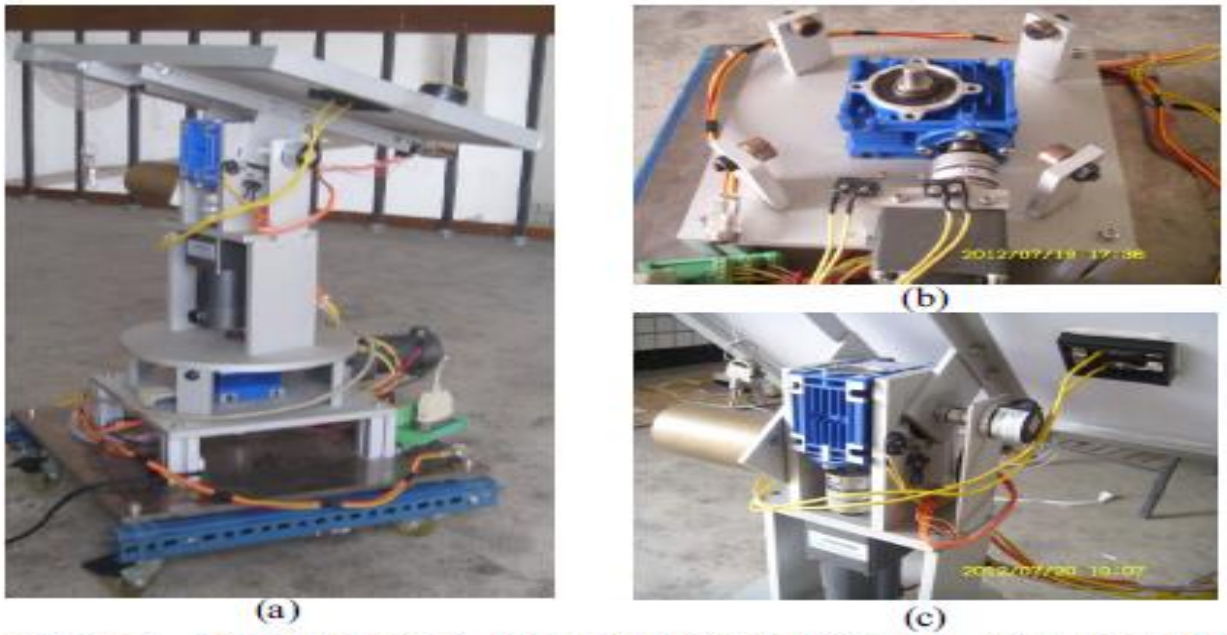


Figure 2. (a)The proposed prototype of the automatic dual-axis solar tracking mechanism. (b)Azimuth angle adjusting mechanism. (c) Altitude angle adjusting mechanism.

Fig. 2.1. (a)The proposed prototype of the automatic dual-axis solar Tracking mechanism. (b)Azimuth angle adjusting mechanism. (c) Altitude Angle adjusting mechanism.

In Mr. S. G. Mane Paper Sun is inexhaustible and nonpolluting source of energy. Due to reduction in amount of fossil fuels the renewable energy sources earn great attention. Sun is considered to be one of the biggest sources of renewable energy. Electricity can be generated from solar energy by different ways. The most efficient way to generate electricity from solar radiations is from

photovoltaic (PV) panels, where solar cells made from silicon convert solar radiations to electricity. Efficiency of Photovoltaic (PV) module is depending upon amount of solar radiations fall on it. There are two types of solar radiations, direct solar radiations and diffused solar radiations. Direct solar radiations are the solar radiations received by earth without scattering into atmosphere and diffused solar radiations are the solar radiations received by earth after changing their direction or after scattered into atmosphere. Direct solar radiations consist approximate 90% of solar energy. For collecting these solar radiations PV panel must be mounted in such a way that solar radiations fall perpendicular on it.

Solar radiations fall on the fixed solar panel are maximum at 12:00 to 14:00 hrs. Significant solar energy is also available in the early mornings and late afternoons, but due to the fixed position of solar panel this energy is not properly collected. By rotating the PV module according to movement of sun solar energy at early mornings and late afternoons is also properly collected. By considering earth as a reference (earth rotates around itself and also around the sun) sun moves east to west in a day and sun also moves north and south in one year (seasonal motion of sun). To maximize the collection of solar radiations throughout the day the PV module must be mount in such a way that it tracks the movement of sun from east to west in a day and north to south in year . Dual axis solar tracking system has two degrees of freedom i.e. there are two axes of rotation. These axes are typically normal to one another. The axis which is fixed with respect to the ground can be taken as a primary axis. The axis which is referenced to the primary axis can be taken as a secondary axis. Dual axis tracker can track the sun vertically as well as horizontally. Therefore, sun is visible to PV module as long as possible and solar radiations are always falling perpendicular on PV

module. It will maximize the collection of solar radiations and electricity output. It will also improve the efficiency of PV system.

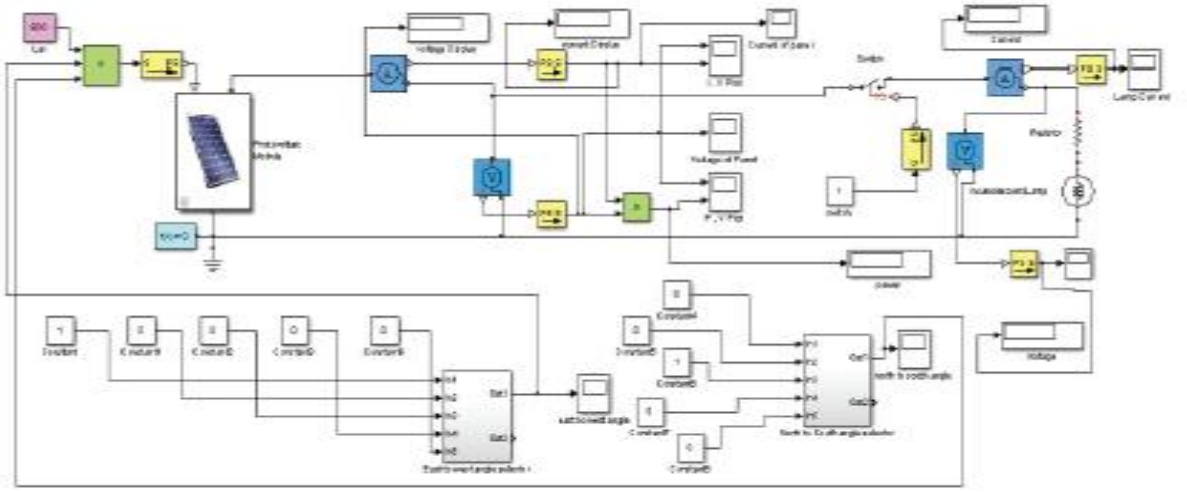


Fig. 1. MATLAB simulation of Dual Axis Solar Tracking System(DASTS)

Fig. 2.2: MATLAB simulation of Dual Axis Solar Tracking System (DASTS)

2.3 Proposed Solution

To prevent the effects related to global warming caused by green house gases emission, the renewable energy has been the best substitution strategy. About 40 minutes of total solar radiation on earth could provide enough power to meet the energy demands of all human beings for approximately one year. The generation capability of PV panel follows the intensity of the sunlight. The position of the sun with respect to any location of the earth changes in a cyclic track during the course of a calendar year. Tracking the position of the sun in order to expose a PV panel to maximum radiation at any given time and any location is the aim of an automatic solar tracking

system. A prototype of the automatic dual-axis solar tracking system with a new designed sun-position tracker mechanism and wireless supervisory and control system was designed and implemented in this paper. The sun-position tracker mechanism was composed of the PLC, DC motors, worm gears, photo-sensors, encoders and power relays. According to feedback signal of encoders and sensors, the PLC command DC motors to controls elevation and orientation angles of solar panels the such that the panels always maintain perpendicular to the sunlight. The worm-gear connected with DC motors and the strong point of the worm-gear is keeping present mechanical angle of elevation and orientation without any power consumption. Each parameter of the system was collected by the PLC and its external module will be transmitting to the supervisory and control program on PCs through the wireless network. As a result of the experiment, the electricity generated by the proposed tracking system has an overall increase.

Sr. no.	Time	Illuminance (lux)	Voltage V_f (Volt) Fixed PV module	Voltage V_p (Volt) DASTS
1.	7:36	800	15.75	18.76
2.	10:00	20000	19.32	21.59
3.	12:00	100000	21.1	21.75
4.	15:00	24000	19.52	21.71
5.	17:30	8000	18.31	21.28
6.	18:30	700	15.6	18.79

Sr. no.	Time	Illumina-nce (lux)	Current I_f (A) Fixed PV module	Current I_p (A) DASTS	Power (W) Fixed PV module	Power (W) DASTS
1.	7:36	800	1.55	1.846	24.41	34.62
2.	10:00	20000	1.90	2.12	36.74	45.87
3.	12:00	100000	2.07	2.14	43.81	46.55
4.	15:00	24000	1.92	2.13	37.51	46.35
5.	17:30	8000	1.80	2.09	32.99	44.56
6.	18:30	700	1.53	1.849	23.95	34.75

2.4 Solution adopted and reasons

For tracking position of the sun rapidly, the supervisory and control program should firstly calculate the theoretical altitude angle and azimuth angle as coarse adjustment of the automatic tracking mechanism through following equations

The theoretical value of altitude angle and azimuth angle were translated into command string for driving DC motors rotate to the corresponding position. Then, the system automatically trimming the altitude and azimuth angle of the PV panel according to feedback signal of the proposed sunlight sensor module. The sunlight sensor module is consist of eight photo-sensors, glass filters and opaque partitions.

Input taken by photovoltaic module is combination of particular illuminance at particular time of the day and outputs of east to west angle selector and north to south angle selector. Illuminance (Lux) block provides intensity of sunlight at particular time. At a particular range of illuminance the particular angle from both east to west and north to south angle selector is selected. Change in illuminance at different times of the day and angles from both angle selectors together determine position of photovoltaic module at which it receives maximum amount of solar radiations. At the

different times of the day illuminance is different, so considering it with angular movement of sun throughout the day, angles for east to west and north to south movement of PV module at different illuminance level are calculated.

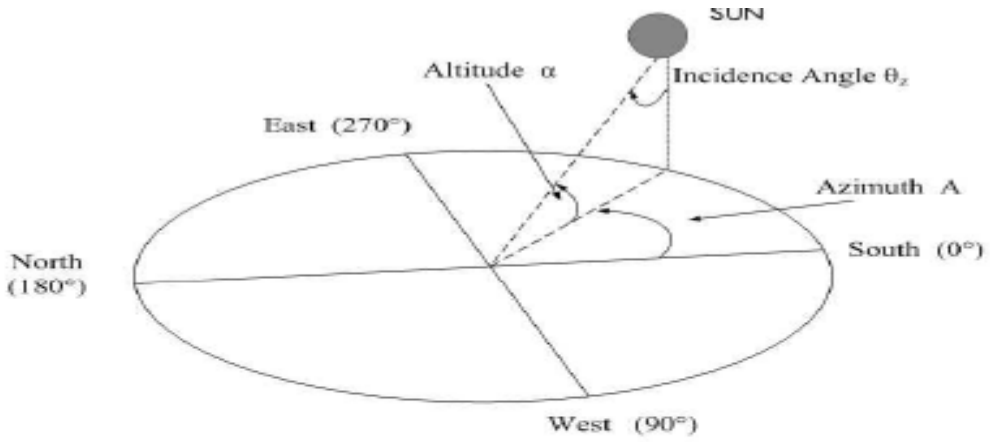


Figure 1. Illustration of Azimuth and Altitude angle of the Sun

$$\theta_z = \cos^{-1}\left[\sin\delta \cdot \sin\varphi + \cos\delta\cos\varphi\cos\omega\right] \quad (1)$$

$$\alpha = 90^\circ - \theta_z \quad (2)$$

$$A = \cos^{-1}\left[\frac{\sin\alpha \cdot \sin\varphi - \sin\delta}{\cos\alpha \cdot \cos\varphi}\right] \quad (3)$$

2.5 Summary

The objective of this chapter includes the utility of our system and solutions to the problem we are facing and we are going to face. There are a couple works done before and has some similitude with our work. A segment of the perception dual axis solar tracker with solar grid system. There are conceivable arrangements of controlling were considered to conquer the issues in adding to the

proposed wanderer are talked about in this section. The standard purpose behind the assignment will be proficient if we get the best game plans by getting rid of issues.

Chapter 3

Technical Description

3.1 Introduction

The chapter describes System blocks, characteristics, working principle of microcontroller, Arduino MEGA, Light Intensity Sensor, Motor Driver, Wiper Motor controlling surveillance system and grid system of our project. A microcontroller or Arduino MEGA is a basically a little PC (SoC) on a solitary coordinated circuit containing a processor center, memory, and programmable information/yield peripherals. Numerous installed frameworks need to peruse sensors that deliver simple signs. This is the reason for the simple to-computerized converter (ADC).Arduino is an open-source PC equipment and programming organization, task and client group that outlines and produces microcontroller-based units for building advanced gadgets and intuitive articles that can sense and control objects in the physical world. Temperature estimation portrays the procedure of measuring a present nearby temperature for environment. Datasets comprising of rehashed institutionalized estimations can be utilized to survey temperature patterns. X axis and Y axis rotation using motor driver and wiper motor to the light intensity sensor gives us idea about Arduino systems to rotate the solar panel and give maximum efficiency of a solar panel energy and give those energy to the grid so that no power or energy is not waste and reuse of those energy to other area.

3.2 Overview of the total system

Since it is a dual axis solar panel system rover there is a necessity of wiper motor and motor driver which will help the solar panel to move. To perform this task DC motor driver are needed and the wheels will be rotated along with the rotation of the motors. DC motors will be powered up by an

external power source. The speed of the motors are controllable. So it will be very easy to give the motors such a speed through which the solar panel can be moved very easily. Our purpose is not only to move the solar panel but also to do more energy create with the sunlight and light. We have used various kinds of driver such as wiper motor and DC motor driver. These two types of systems (movement control and sensor system) are connected with a central microcontroller. Central microcontroller unit synchronizes these two systems.

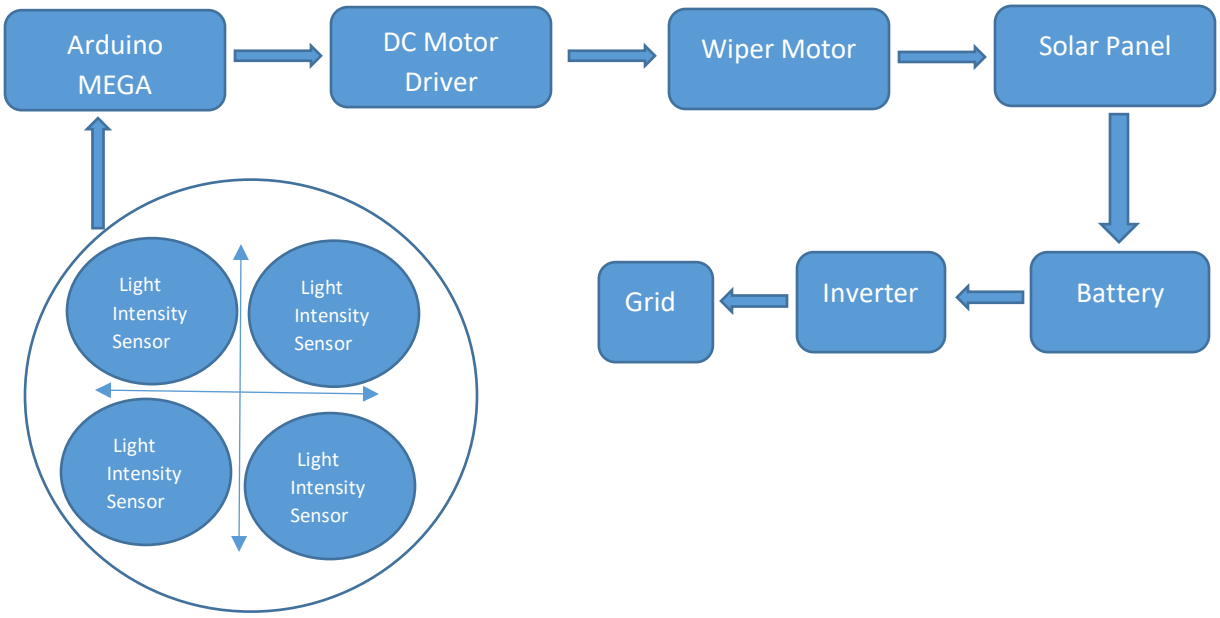


Fig. 3.1. Simplified block diagram.

3.3 System Blocks

In this section total block diagram of the system including all the subsystems will be shown.

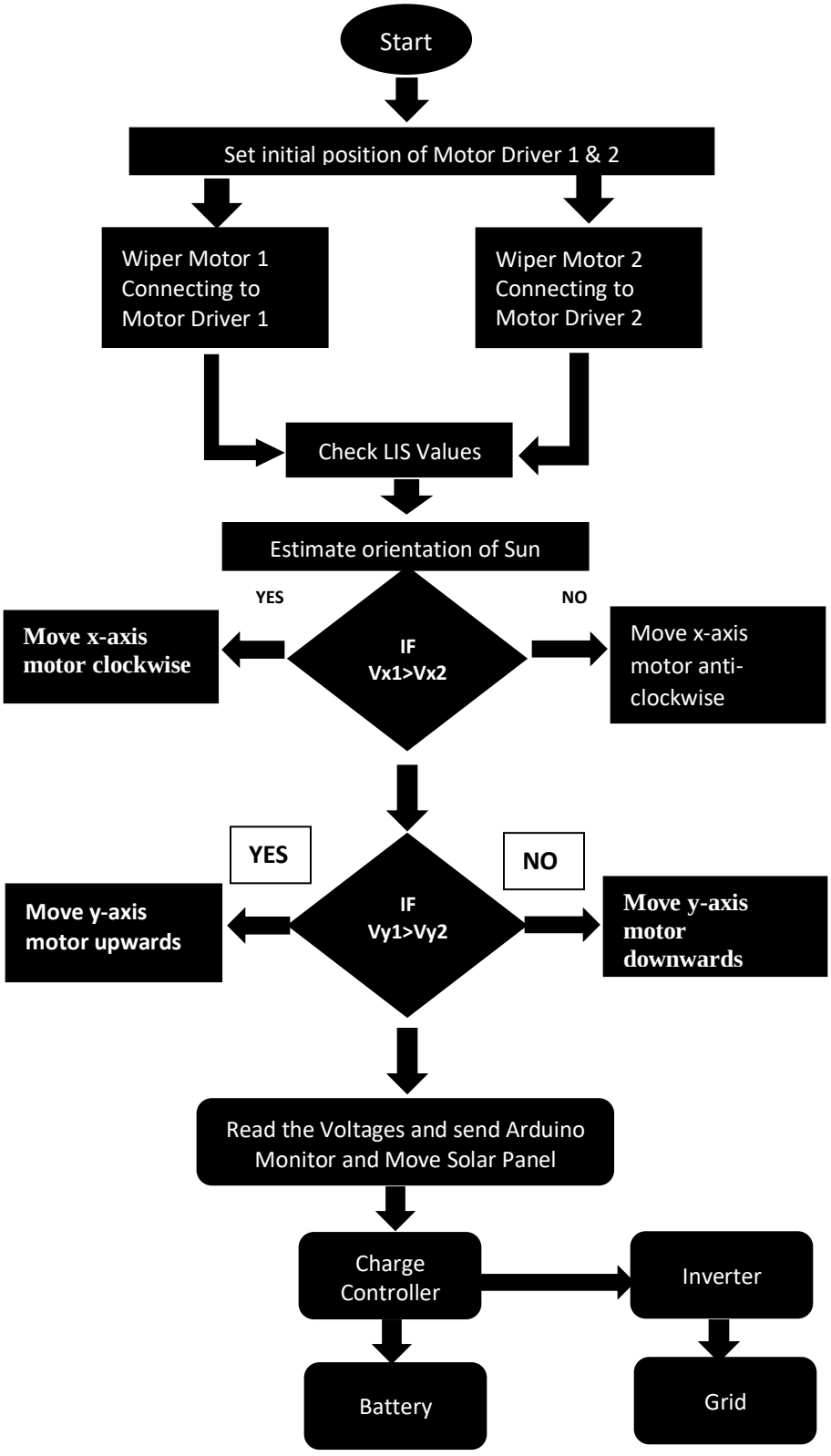


Fig. 3.2. Detailed block diagram of the whole system.

Microcontrollers is used to build the designed Dual axis solar tracker. We starts with a central microcontroller which we will use to keep communication and for synchronization with all the subsystems. Arduino is an open source microcontroller based hardware platform which is used the system. It is very easy to work with various kinds of sensors to interact with the external physical world. Wikipedia states “Arduino is a single-board microcontroller designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open-source hardware board designed around an 8-bit Atmel AVR microcontroller, though a new model has been designed around a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.”[16]

Here we are using Arduino Mega 2560. It is based on Atmel microcontroller ATMEGA 2560. It includes 54 digital input/output pins, 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, Reset button.

Arduino can be powered up by the USB connection. There is also a power jack to power up. The USB port is also used to program the microcontroller to make it able to perform specific task.[17]

3.4 Description of all Subsystems

Because of the whole system being complicated, it will be very easy to understand the working principle of the whole system if it is divided into several small parts. We can treat each part as a subsystem. The subsystems are

- Dual axis solar Tracker
- Motor System
- Inverter

Now each of the subsystems will be described in details including the various possible ways to implement those.

3.4.1 Movement Control System

Arduino:

Fig 3.3: Picture of Arduino MEGA

The MEGA 2560 is designed for more complex projects. With 54 digital I/O pins, 16 analog inputs and a larger space for your sketch it is the recommended board for 3D

printers and robotics projects. This gives your projects plenty of room and opportunities.

The **Arduino Mega 2560** is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB

Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

.

- DC power jack is coupled with the board that is used to power the board. Some version of Arduino board lacks this feature like Arduino Pro Mini doesn't come with DC power jack.

Fig 3.4: Arduino Mega 2560

- This board comes with two voltage regulators i.e. 5V and 3.3V which provides the flexibility to regulate the voltage as per requirements as compared to Arduino Pro Mini which comes with only one voltage regulator.
- There is no much difference between Arduino Uno and Arduino Mega except later comes with more memory space, bigger size and more I/O pins.

- Arduino software called Arduino IDE is used to program the board which is a common software used for all boards belonged to Arduino family.
- Flowing through the board. Most of the computers come with an ability to protect themselves from such devices, however, the addition of fuse provides an extra layer of protection.
- It can be used either way i.e. for creating stand-alone projects or in combination with other Arduino boards. Most complex projects can be created using this board.

Arduino Mega 2560 Pinout

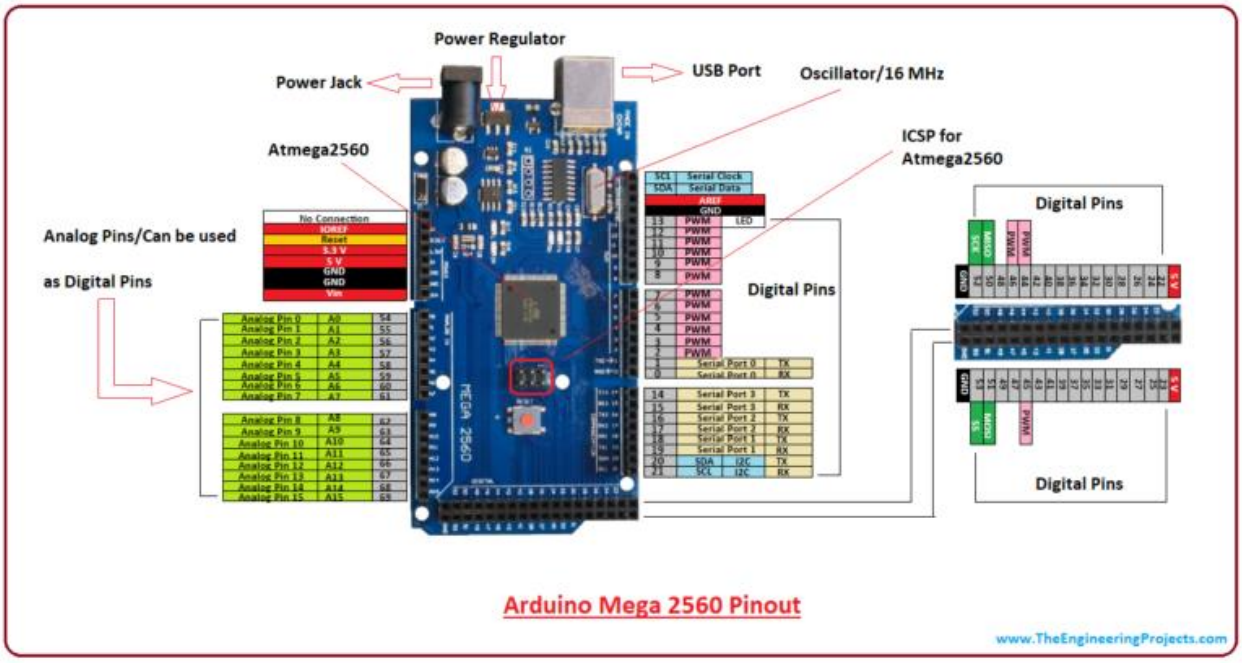


Fig 3.5: Following figure shows the Pinout of Arduino Mega 2560.

Motor Controller:

A motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

Fig 3.6: Motor Driver

The AC Motor receives power, which is ultimately converted by the AC Controller into an adjustable frequency. This adjustable output allows the motor speed to be precisely controlled. Typically, an AC Controller consists of three basic parts: the rectifier, inverter, and the DC link to connect the two. A motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor.

The simplest case is a switch to connect a motor to a power source, such as in small appliances or power tools. The switch may be manually operated or may be a relay or contactor connected to some form of sensor to automatically start and stop the motor. The switch may have several positions to select different connections of the motor. This may allow reduced-voltage starting of the motor, reversing control or selection of multiple speeds. Overload and over current protection may be omitted in very small motor controllers, which rely on the supplying circuit to have over current protection. Small motors may have built-in overload devices to automatically open the circuit on overload. Larger motors have a protective overload relay or temperature sensing relay included in the controller and fuses or circuit breakers for over current protection. An automatic motor controller may also include limit switches or other devices to protect the driven machinery.

More complex motor controllers may be used to accurately control the speed and torque of the connected motor (or motors) and may be part of closed loop control systems for precise positioning of a driven machine.

Motor Driver Application:

1: driving stepper motor

2: driving brushed DC motor

This module can drive either 2 DC motors or 1 Stepper motor at a time.

Double H driver module uses ST L298N dual full-bridge driver, an integrated monolithic circuit in a 15- lead Multi watt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as

relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

Specification

- Driver: L298N
- Driver power supply: +5V~+46V
- Driver Io: 2A
- Logic power output Vss: +5~+7V (internal supply +5V)
- Logic current: 0~36mA
- Controlling level: Low -0.3V~1.5V, high: 2.3V~Vss
- Enable signal level: Low -0.3V~1.5V, high: 2.3V~Vss
- Max power: 25W (Temperature 75 cesus)
- Working temperature: -25C~+130C
- Dimension: 60mm*54mm
- Driver weight: ~48g
- Other extensions: current probe, controlling direction indicator, pull-up resistor switch, logic part power supply.

Hardware Diagram

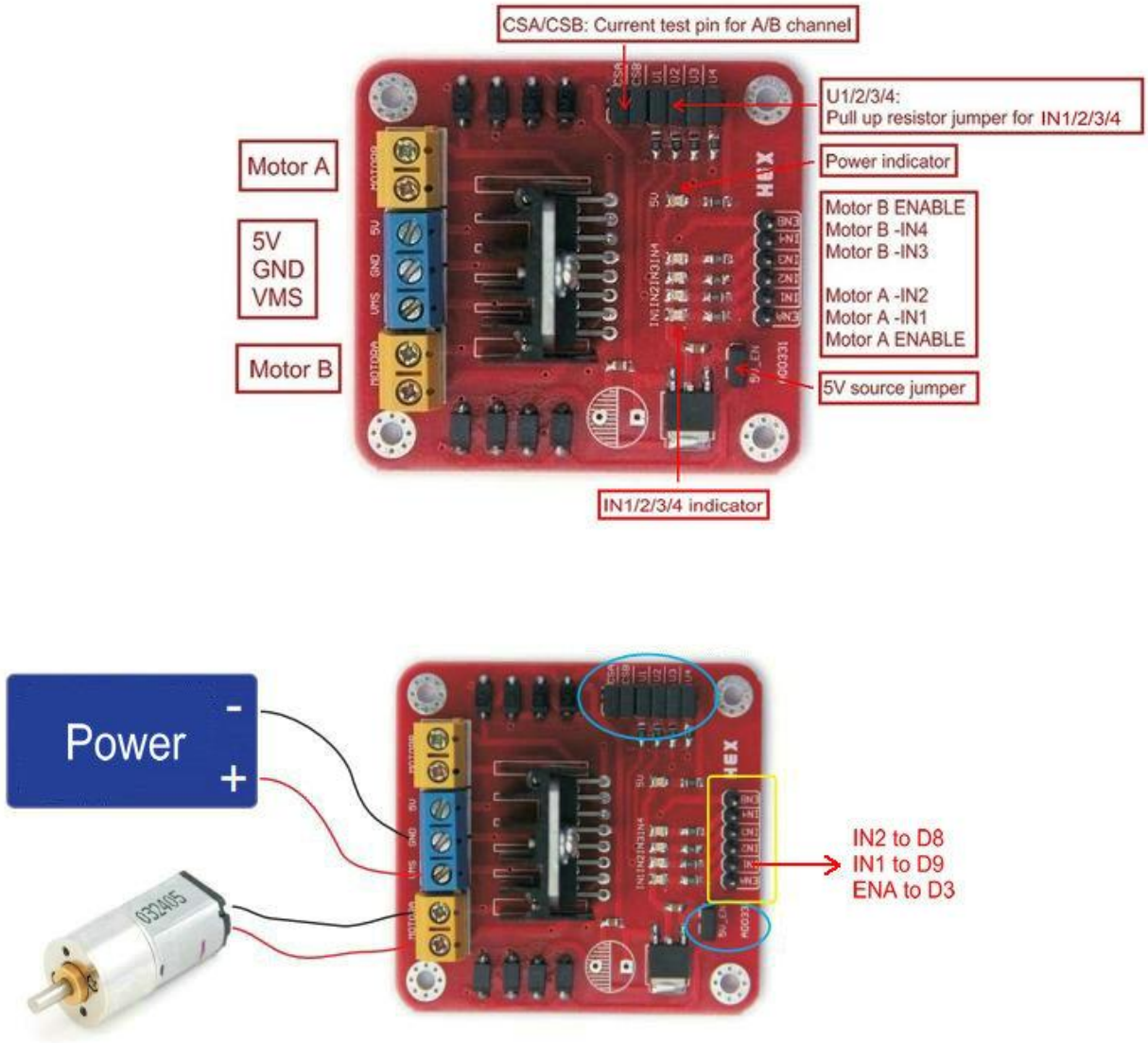
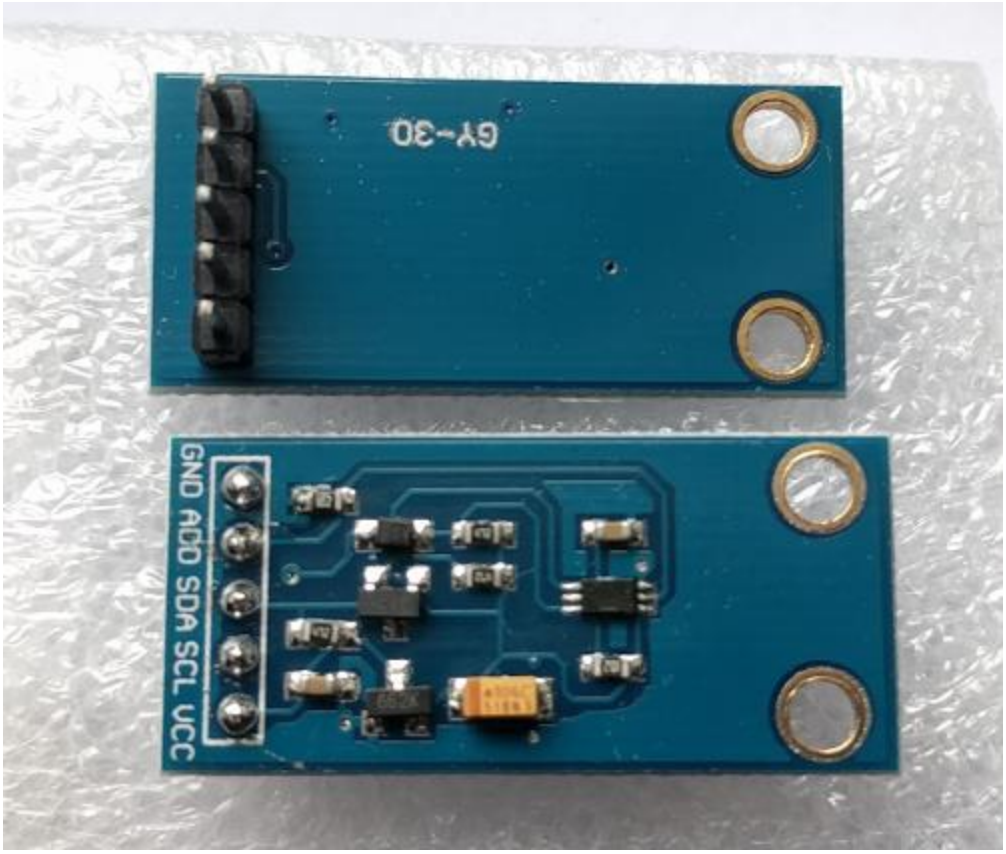


Fig 3.7: Light Intensity Sensor

Light Intensity Sensor

BH1750FVI is a digital Ambient Light Sensor having I2C interface. This IC is the suitable for obtaining the ambient light data. It is possible to detect wide range at high resolution**.**



Description:

- Chip: BH1750FVI
- Power Supply: 3.3V - 5V
- Light Range：0 - 65535 lx(Lux)
- Sensor Built-in: 16 bit AD converter
- Size(L x W): Approx. 3.2cm x 1.5cm
- Direct digital output, bypassing the complex calculation, bypassing the calibration
- Close to the spectral characteristics of visual
- Widely used to 1-lux high precision measurement
- Standard NXP IIC communication

.

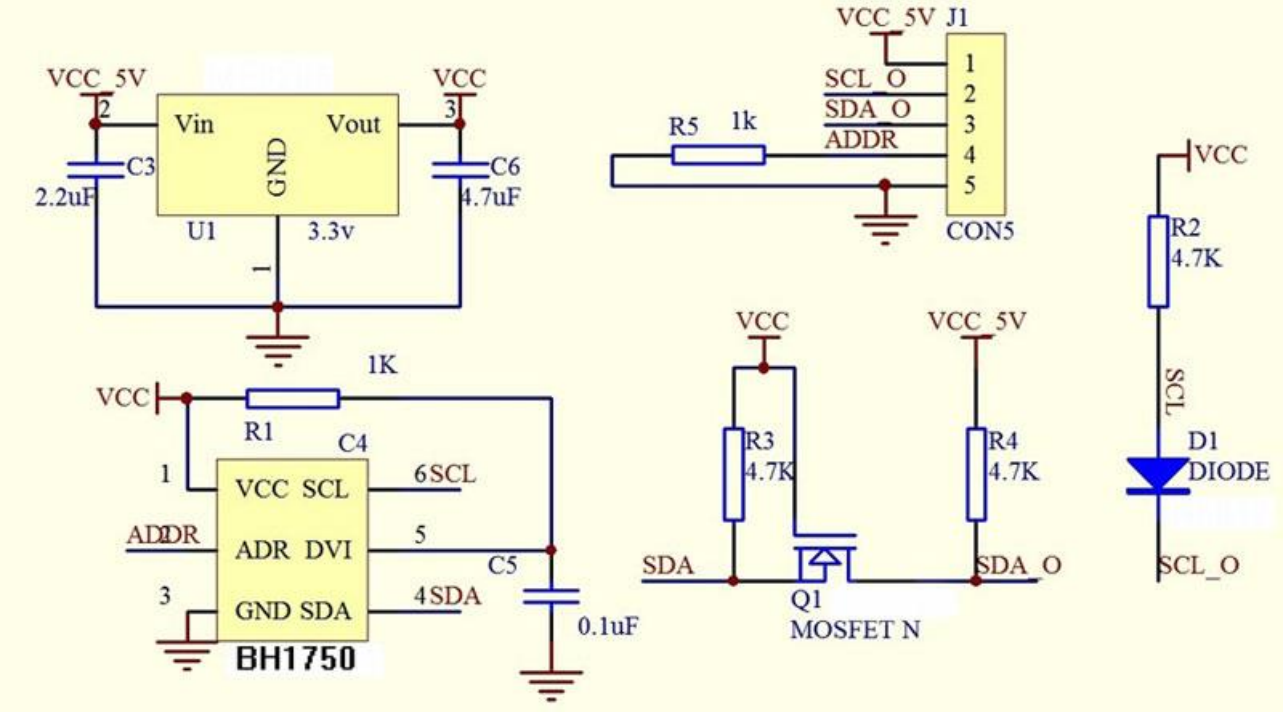
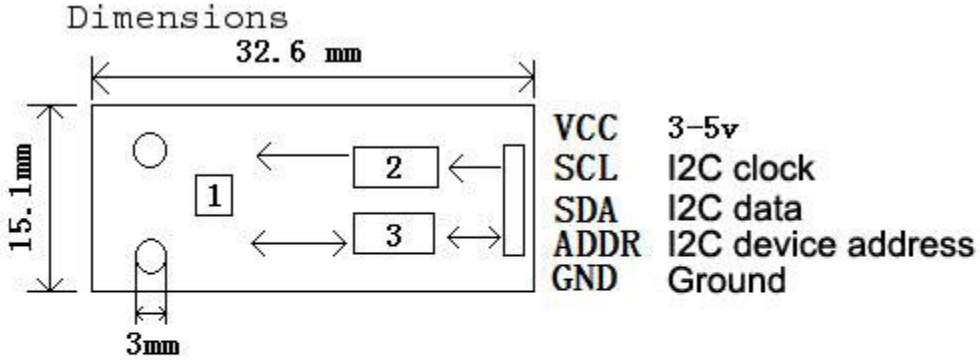


Fig 3.8 Circuit Diagram of LIS



1 BH1750FVI

2 Low-power 3.3V regulator (3-5V compatible)

3 Level conversion

The BH1750 has six different measurement modes which are divided in two groups; continuous and one-time measurements. In continuous mode the sensor continuously measures lightness value. In one-time mode, the sensor makes only one measurement and then goes into Power Down mode.

Each mode has three different precisions:

- Low Resolution Mode - (4 lx precision, 16ms measurement time)
- High Resolution Mode - (1 lx precision, 120ms measurement time)
- High Resolution Mode 2 - (0.5 lx precision, 120ms measurement time)

By default, this library uses Continuous High-Resolution Mode, but you can change this to a different mode by passing the mode argument to BH1750.begin().

When the One-Time mode is used your sensor will go into Power Down mode when it completes the measurement and you've read it. When the sensor is powered up again it returns to the default mode which means it needs to be reconfigured back into One-Time mode. This library has been implemented to automatically reconfigure the sensor when you next attempt a measurement so you should not have to worry about such low level details.

Usually you will get an integer value which represent the lux equivalent.

- Low Resolution Mode - (generic range: 0.0 up to 54612.5 lux)
- High Resolution Mode - (generic range: 0.0 up to 54612.5 lux)
- High Resolution Mode 2 - (generic range: 0.0 up to 27306.25 lux)

The sensor itself returns a 16 bit unsigned integer. Therefore the maximum value is limited in general. The standard conversion between the so called 'counts' to lux is 1/1.2, that means you get a smaller value. As we use float, if an error occurs you will get a negative value.

- -1 no valid data was transmitted from the sensor
- -2 device is not configured Otherwise the measured counts are converted to lux and returned. If no advanced parameters are changed the maximum lux value is 54612.5 lx

- **(For Arduino >= 1.5.x)** Use the way above, or Library Manager. Open Arduino IDE, click `Sketch -> Include library -> Add .ZIP library` and select the downloaded archive.
- **(For Arduino < 1.5.x)** Extract the archive to `<Your User Directory>/My Documents/Arduino/libraries/` folder and rename it to `BH1750`. Restart IDE.

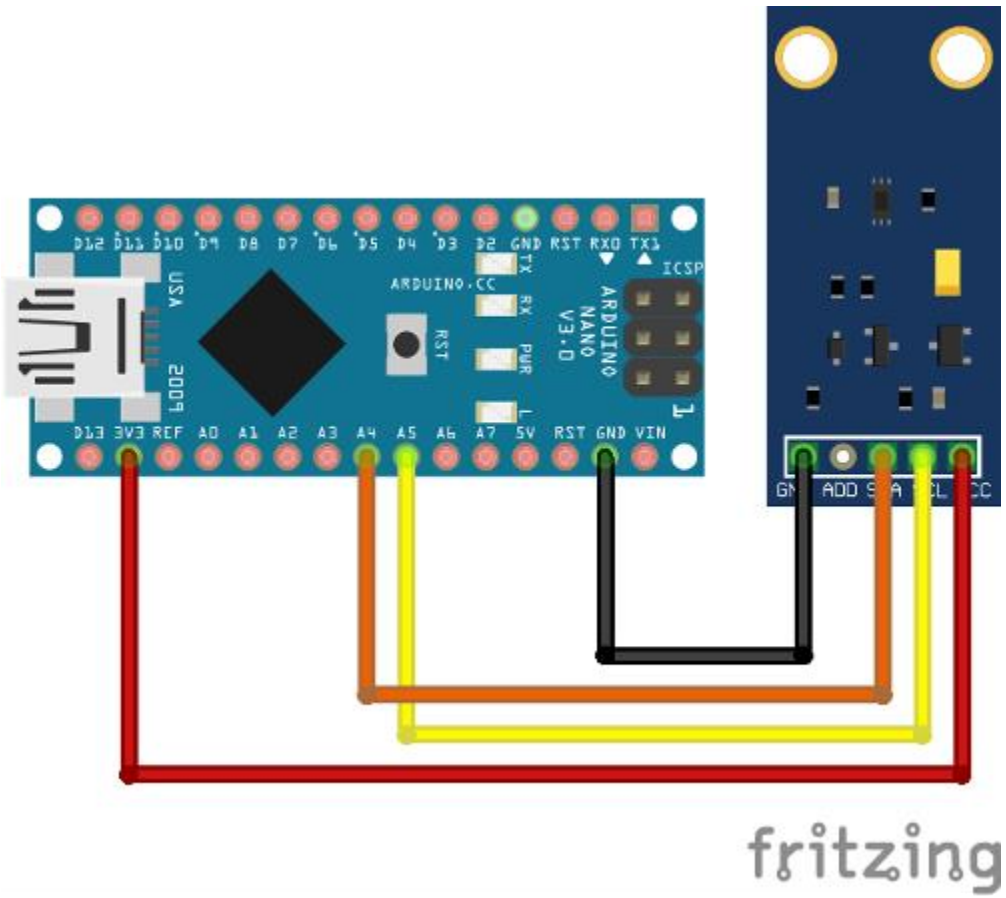
The following YouTube video (specifically from 7:20 onwards) provides a good overview of installing this library and loading an example using the Arduino IDE.

Connections:

- VCC -> 3V3 or 5V
- GND -> GND
- SCL -> SCL (A5 on Arduino Nano, Uno, Leonardo, etc or 21 on Mega and Due, on esp8266 free selectable)
- SDA -> SDA (A4 on Arduino Nano, Uno, Leonardo, etc or 20 on Mega and Due, on esp8266 free selectable)
- ADD -> NC/GND or VCC (see below)

The ADD pin is used to set the sensor I2C address. By default (if ADD voltage less than 0.7 * VCC) the sensor address will be 0x23. If it has voltage greater or equal to 0.7VCC voltage (e.g. you've connected it to VCC) the sensor address will be 0x5C.

Wiring up the GY-30 sensor board to an Arduino is shown in the diagram below.



Code

Upload the BH1750 test code to your Arduino.

```
#include <Wire.h>
#include <BH1750.h>

BH1750 lightMeter;

void setup(){
```

```
  Serial.begin(9600);

  // Initialize the I2C bus (BH1750 library doesn't do this automatically)
  // On esp8266 devices you can select SCL and SDA pins using Wire.begin(D4, D3);
  Wire.begin();

  lightMeter.begin();
  Serial.println(F("BH1750 Test"));

}

void loop() {

  float lux = lightMeter.readLightLevel();
  Serial.print("Light: ");
  Serial.print(lux);
  Serial.println(" lx");
  delay(1000);

}
```

Output

Moving the sensor to face more light results in the lux measurements increasing.

```
BH1750 Test
Light: 70.0 lx
Light: 70.0 lx
Light: 59.0 lx
Light: 328.0 lx
Light: 333.0 lx
Light: 335.0 lx
Light: 332.0 lx
```

There are more examples in the examples directory.

Wiper Motor:

The front wiper motor and the wiper transmission mechanism (linkage) are installed below the windshield inside the cowl panel.

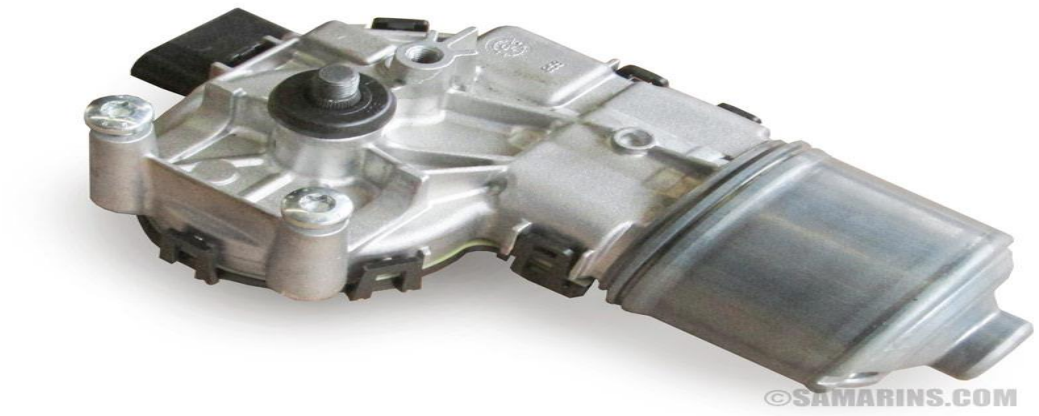


Fig 3.9 Wiper Motor

How the wiper system works: the wiper switch sends the signal to the control module. The control module operates the wiper relay that sends 12-volt power to the wiper motor. The motor rotates a little arm (see the diagram) that through links moves the wiper arms. Read more on how the wiper electrical system works below.

Working windshield wipers are vital for driver's visibility. A vehicle is considered unsafe if the wipers don't work. We found several recalls related to the windshield wipers.

If your wipers don't work, your mechanic or dealer will need to diagnose the problem first, then order a part. This means there is a chance your car won't be repaired in the same day. The repair cost depends on the problem.

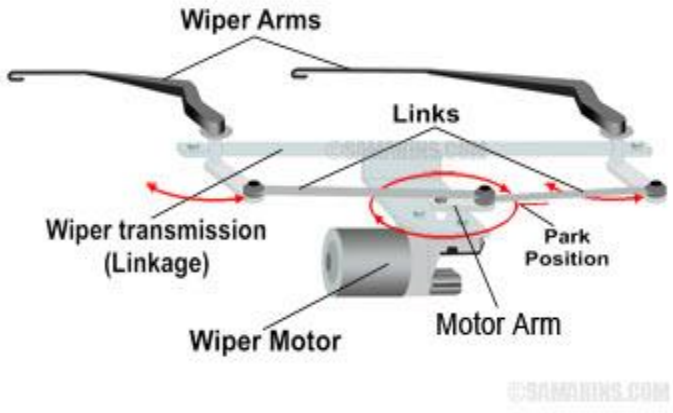


Fig 3.9 Wiper transmission mechanism

position. The fix is simple, the loose wiper arm needs to be repositioned correctly and both wiper arm nuts need to be re-tightened.

How the wiper motor and circuit work

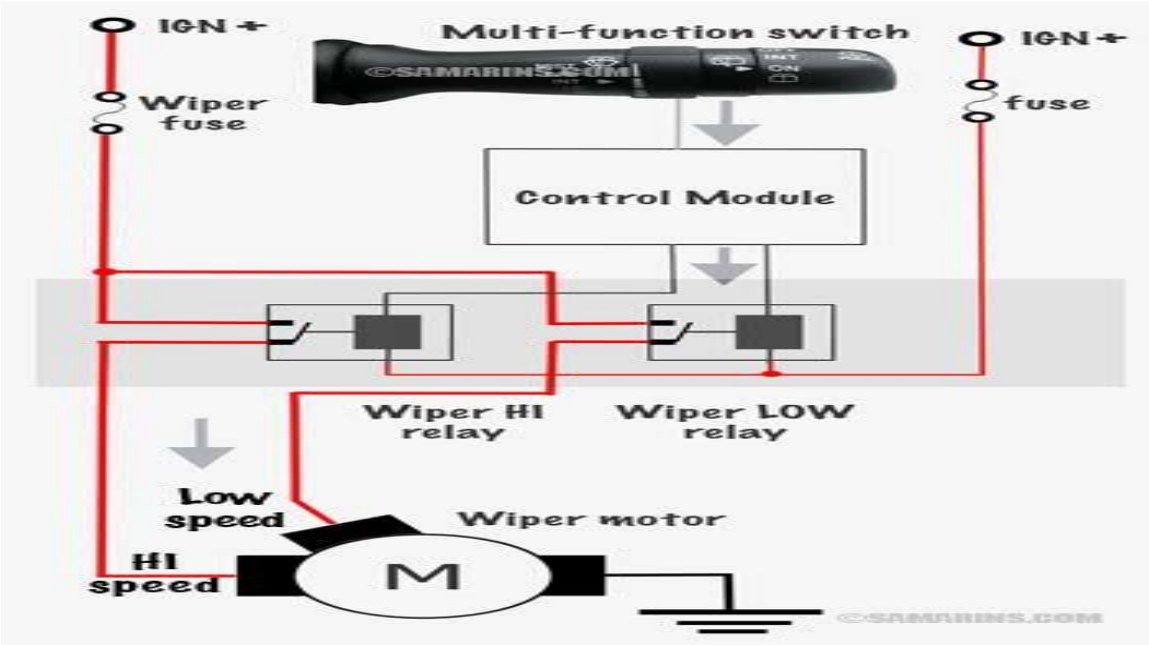


Fig 3.10: Circuit of Wiper Motor

When troubleshooting a problem with the wipers, mechanics at a dealership can access the control module with a scan tool that can show if the multifunction switch operates properly. A scan tool also allows an active test, which means a wiper motor can be activated from a scan tool.

The wiper motor is a DC (direct current) 12V motor that includes a set of gears and a park switch. The park switch allows the motor to stop when wipers are positioned at the bottom of the windshield. This position is called "park position."

TECHNICAL SPECIFICATIONS:

Rated torque: 53 in-lb

Stall torque: 177 in-lb

Unload high speed: 50rpm, 1.5A (12VDC)

Unload low speed: 35rpm, 1.0A (12VDC)

Maximum wattage: 50W/12VDC

Motor noise: <45dB

Spindle/Post thread size: M-6

Spindle rotates 360 degrees

Motor weight: 2.7 lbs

Approx. size: 7.25"x4"x3.5"

Wiper Motor Speed (Approximate)		
Power Supply	Terminal	Speed
12VDC 5Amps	Low	35 RPM
12VDC 5Amps	High	50 RPM
5VDC 5Amps	Low	15 RPM
5VDC 5Amps	High	20 RPM

Solar Panel

FF

Fig 3.11: Solar Panel

Solar Kit Contents

- 30 Watt Monocrystalline Solar Panel with 5M cable attached
- 2 Meter battery connection cable with crocodile clips
- PWM Solar Charge Controller including USB outlets
- 4X metal solar panel mounting brackets

In the event that the solar panel is in shade for a prolonged period, our solar panels either have one or two built-in bypass diodes which will enable the panel to continue generating.

Solar Charge Controller - Technical

- 10A max Rated Discharge Current and Rated Charge Current.
- Suitable for 12V or 24V systems, auto detecting & auto switching
- Only suitable for lead acid batteries: Sealed wet lead acid, AGM, GEL. This controller is not suitable for nickel metal hydride, lithium ion or other batteries.
- Maximum solar input; <50V
- Equalization; Sealed 14.4V, Gel 14.2V
- Float Charge; 13.7V (by default, value adjustable)
- Load outlet discharge stop – 10.7V (by default, value adjustable)
- * Discharge Reconnect – 12.6V (by default, value adjustable)
- USB outlet - 5V/3A maximum.
- Self-consumption <10ma 0="" 12w="" at="" 12v="" li="">
- working temperature range -35 to +60 Deg C
- Dimensions - 150 x 78 x 35 mm
- Weight - 150 grams

* Discharge reconnect meaning. This voltage is user adjustable. As the load consumes the power within the battery, the voltage eventually drops to 10.7V and the load output of the controller will automatically stop any further charge from protect the battery. If for example the next day maybe rainy or cloudy day and the battery charges slowly, if the voltage is still below 12.6V, the load output from the controller will still not work. If the sun comes out in the afternoon, or the next day is much sunnier conditions, once the battery voltage rises above 12.6V, the controller

load output will automatically start to work again. Discharge reconnect is set to 12.6V by default, although you may wish to set this perhaps 12.4V. Discharge reconnect is aimed at protecting the battery and reducing the depth of discharge cycling. Lead acid batteries last longer with shallow discharge.

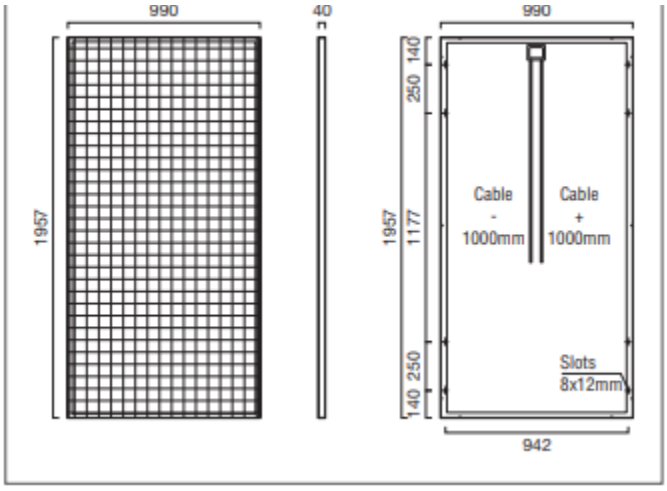
Metal Brackets (set of 4)

Aluminum, light weight, solar panel mounting brackets

Dimensions, 100mm long, full dimensions as per attached images.

Specification of solar panels mentioned in a data-sheet. They are as following-

1. **Physical Parameter**: It provide details about length, breadth and thickness of solar module along with its sub-components such as cable length and slot distance. It also mentions weight of module.



2. **Electrical parameters under STC & NOCT condition:-**

These parameters include:

	ENVIRO PVM6/PVC-75	ENVIRO PVM6/PVC-100	ENVIRO PVM6/PVC-150	ENVIRO PVM6-250	ENVIRO PVM6-315
Rated power (Pmax), Wp	75	100	150	250	315
Max power voltage (Vmp),V	19.12	19.12	18.61	31.02	36.92
Max power current (Imp),A	3.92	5.23	8.06	8.06	8.55
Open circuit voltage (Voc), V	22.68	22.68	22.19	36.99	46.15
Short circuit current (Isc), A	4.20	5.60	8.62	8.62	8.91
Module efficiency (%)	14.58	14.90	15.12	15.37	16.26

3. **Operating Condition**- These are the condition under which the PV module is operational.

Ambient temperature, °C	-40 to +85
Maximum system voltage, Vdc	1000
Hail impact velocity, m/sec	23
Maximum surface load capacity, Pascals	5400

4. **Cell Temperature Coefficients-** It means with each degree rise in temperate the value each parameter would vary.

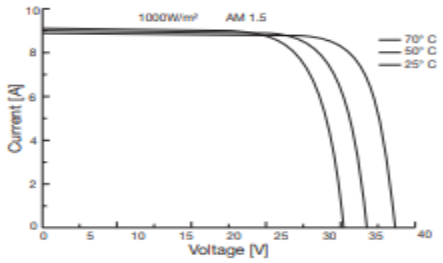
Open circuit voltage	-0.30 % / °C
Short circuit current	+0.05 % / °C
Nominal power	-0.40 % / °C

For example the temperature coefficient of a Suntech 190 W (monocrystalline) solar panel is – 0.48%. What this means is that for each degree over 25˚C … the maximum power of the panel is reduced by 0.48%

5. **IV Curve**

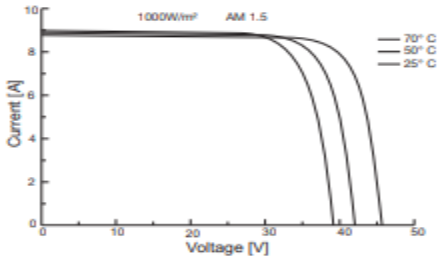
ENVIRO PVM6-250

IV-Curves



ENVIRO PVM6-315

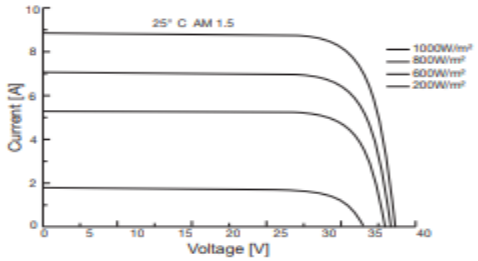
IV-Curves

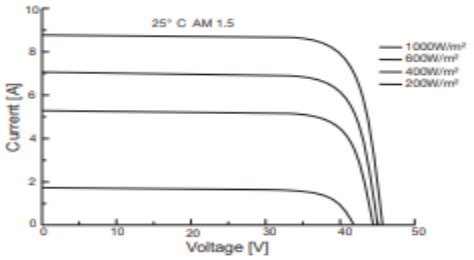


IV-CURVES of PV module

I-V Curves of PV Module

IV-CURVES of PV module





Chapter 4

Design Implementation

4.1 Introduction

The chapter gives us clear idea and view about the implementation and the steps we have taken for hardware and software implementation. For hardware implementation there are some specific hardware to build up inverter. The internal circuitry is built by hardware and developed by Arduino programming language. For the software part, we use MATLAB for schematic part and porticus PCB board or 3d design The whole procedure starting from building chassis to running codes and connecting hardware and software is done and discussed to take us near to the project.

4.2 List of necessary hardware

In this section we will describe the necessary tools and components for the hardware implementation of the designed rover.

4.2.1 Required tools for Design implementation

1. Crochet

2. Wire cutter

3. Drill machine

4. Screw and bolts

5. Glue gun

6. Steal

4.2.2 Required Material and components for internal circuitry

1. Arduino Mega

2. Wiper Motor

3. DC Motor Driver

4. Charger Controller

5. Inverter

6. Solar Panel

7. Battery

8. Light Intensity Sensor

4.3 Description of the Software

The rover is a microcontroller-based design. A microcontroller program is necessary for the functioning of the microcontroller. So, an IDE (Integrated Development Environment) is needed to program the Microcontroller. For the presence of an electrical circuitry in the system simulation has been done. For simulation purpose we used “PROTEUS ISIS” simulation software. In this section, each software will be discussed in details to clearly understand the design as well as the software implementation process.

4.3.1 Programming Software

The electronic circuitry of the rover is based on a central microcontroller. An AVR microcontroller from ATMEL has been used. The name of the microcontroller is ATMEGA 2560. Arduino

microcontroller platform of ATMEGA has been used. In this case Arduino Mega 2560 board has been used to implement the design.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in Java. It originated from the IDE for the Processing programming language project and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism for compiling and loading programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".

The Arduino IDE supports the C and C++ programming languages using special rules of code organization. The Arduino IDE supplies a software library called "Wiring" from the Wiring project, which provides many common input and output procedures.[26]

The Arduino Integrated Development Environment - or Arduino Software (IDE) - 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 and Genuino hardware to upload programs and communicate with them. [27]

The advantages of Arduino IDE have been discussed below.

- Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

- Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.
- Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
- Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money. [28]

Besides working with Arduino, a program was also written for Atmega32 microcontroller IC. But this was not done for hardware implementation purpose. This was done only for simulation purpose. The program was developed into ATMEL's own IDE called ATMEL STUDIO. Atmel Studio 7 is the integrated development platform (IDP) for developing and debugging Atmel® | SMART ARM®-based and Atmel AVR® microcontroller (MCU) applications. Studio 7 supports all AVR and Atmel | SMART MCUs. The Atmel Studio 7 IDP gives you a seamless and easy-to-use environment to write, build and debug your applications written in C/C++ or assembly code. It also connects seamlessly to Atmel debuggers and development kits.[29]

4.3.2 Simulation software

Computer simulation is a process of executing a real-world model inside a computer program. It represents the function of the whole system or model. This gives us the capability of analyzing and understanding of how individual element interact and affect the simulated environment.

As simulation provides a way in which alternative designs, plans and policies can be evaluated without having to experiment on a real system, which may be prohibitively costly, time-consuming, or simply impractical to do it is a powerful and important tool for engineering.

In this section, we will discuss on which software and how we successfully simulated the several part of the robotic system.

We used “Proteus” for circuit simulation. Proteus is an application that allows the user to make schematic captures, simulate microprocessors and develop PCB (printed circuit board) designs. Most of the users download this software because its interface simplifies the different tasks. It comprises several modules that are combined to offer distinct services. This software combines ARES PCB layout and ISIS schematic capture to provide a powerful design program

Another remarkable module that is integrated in Proteus is ARES (Advanced Routing and Editing Software) is a tool that allows you to route, edit and locate components used to for the production of printed circuit boards. The 3D viewer gives the customer the opportunity of having a view of the board as it would be in the real life. It generally gives you the option of editing the welding and surface layers.

Compared to other similar applications, Proteus provides the user with various tools that work in a simple and intuitively way. Maybe that's why this tool is frequently used in the education field.

It is very friendly for novice users who are interested on obtaining high level simulation, schematics and board designs. You can download a free version to try it out.

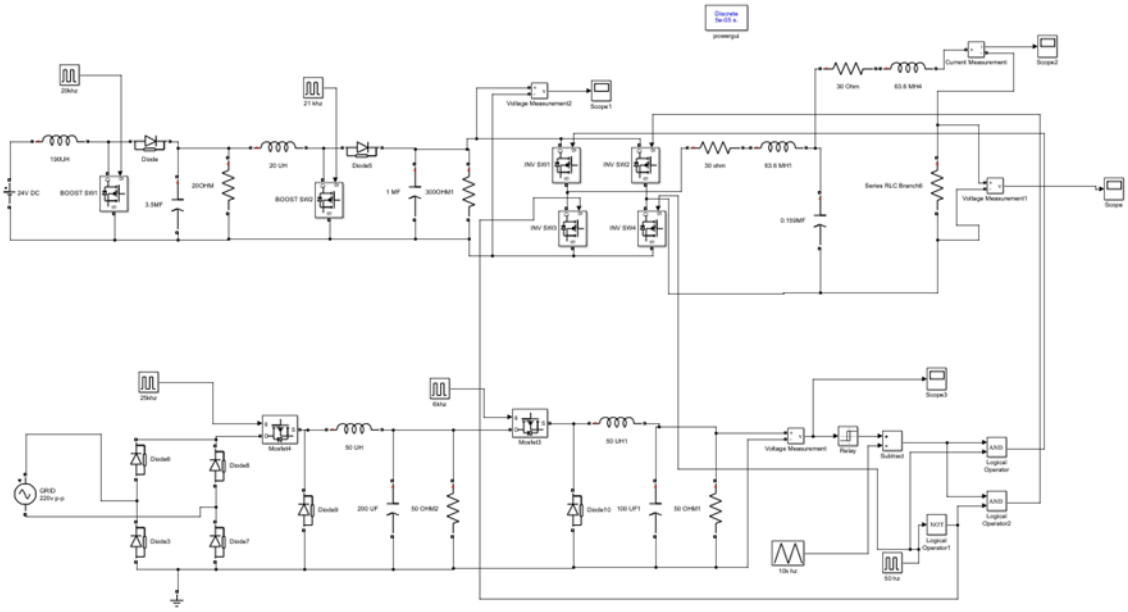
Another positive feature of Proteus is that the developer provides free material to manage this software. In the official website there are several video demonstrations about Proteus VDM simulation and PCB design. There is also more support information to download and discussion forums that could help the user to utilize the application and share information.

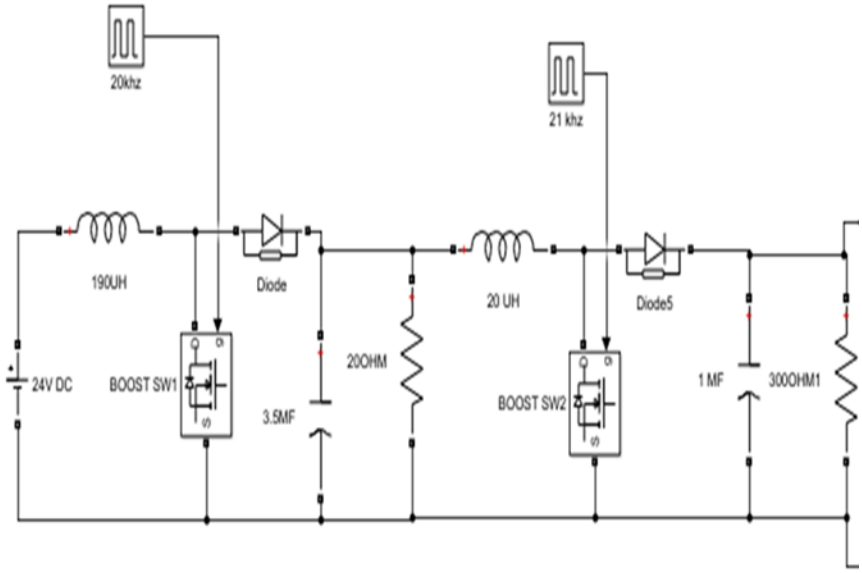
Proteus 8 Features have been discussed below.

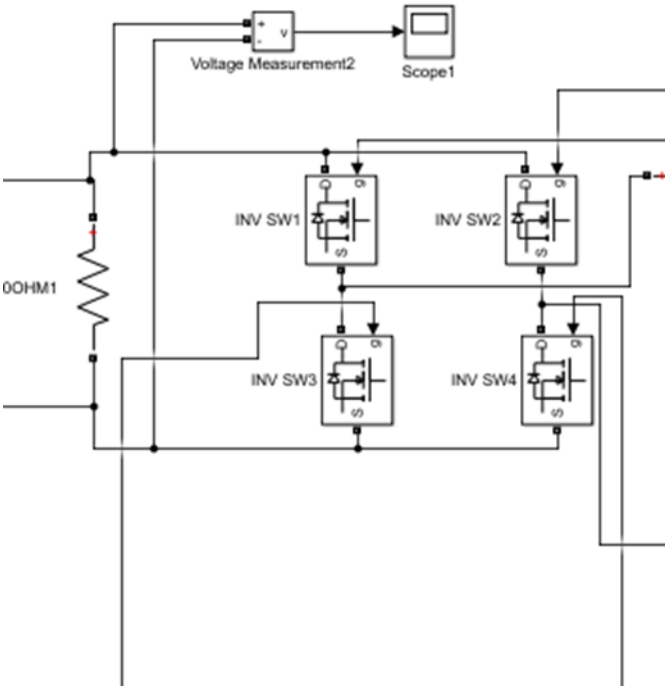
- Proteus incorporates a tool that automatically places a component in the netlist into the board.
- Make a basic simulation.
- Proteus has a Schematic capture module, PBC Layout module and a display technology that accelerates hardware.
- It is possible to execute the integrated based router loading custom scripts or using an interactive mode.
- Proteus provides a 3D visualization (VSM) of the board. It includes navigation and a 3D data footprints user application.
- Manage and configure dynamic teardrops.
- Export layouts using ODB++ CAD/CAM format.
- Proteus gives an automatic gate-swap optimization.
- There are unlimited shape-based power planes per each layer.
- Unlimited number of pins in a netlist.

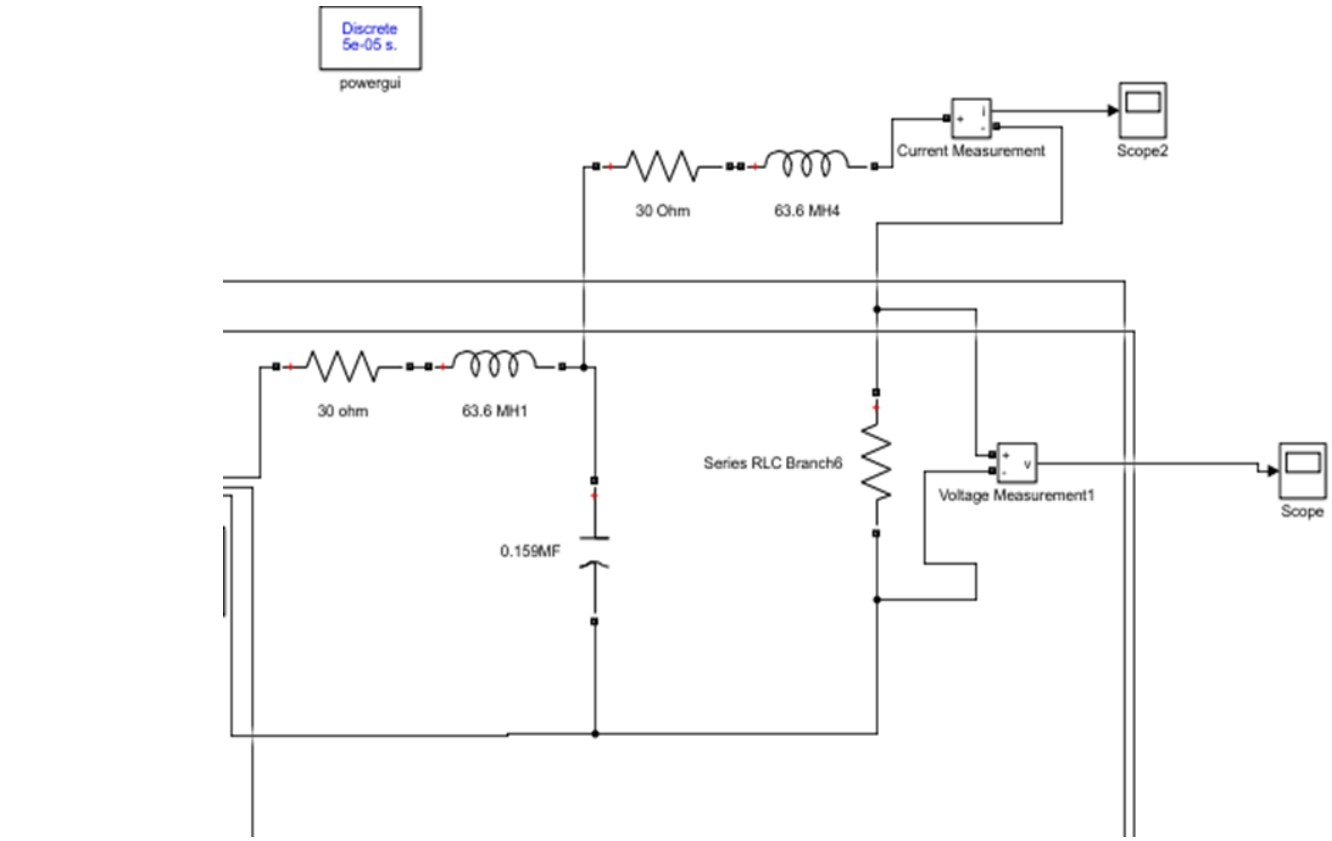
4.4 Hardware Implementation

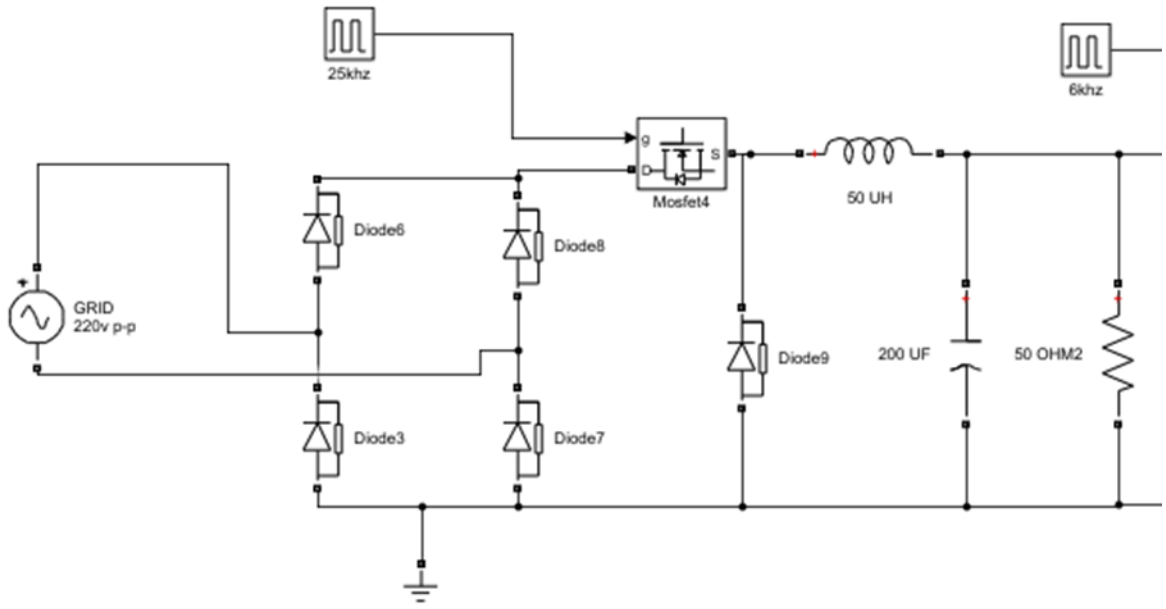
In the hardware implementation part, we made an inverter and set up the internal circuitry for the dual axis solar panel system. In this section the whole process of building the solar panel system will be described in details as well as the internal circuitry setup will also be described.




20khz
21 khz
190UH
Diode
20 UH
Diode5
24V DC
BOOST SW1
3.5MF
20OHM
BOOST SW2
1 MF
300OHM1


Voltage Measurement2
Scope1
INV SW1
INV SW2
0OHM1
INV SW3
INV SW4


Discrete
5e-05 s.
powergui
Current Measurement
Scope2
30 Ohm
63.6 MH4
30 ohm
63.6 MH1
Series RLC Branch6
Voltage Measurement1
Scope
0.159MF


25khz
6khz
Mosfet4
50 UH
Diode6
Diode8
GRID
220v p-p
Diode9
200 UF
50 OHM2
Diode3
Diode7

4.5 Software implementation

In the software implementation part we will describe the process of developing the inverter sinusoidal wave Programming the microcontroller, and simulation using PROTEUS.

4.5.2 Programming the central Microcontroller

As a central microcontroller we are using ATMEGA 2560 which is based on an Arduino platform. Arduino uses a C language -based programming language called “Wiring”. All the programming codes have to be written on the Arduino IDE. There is a text editor in the Arduino IDE. This text editor is used to write the programming codes on it. There are two main parts of a typical Arduino program. One is “void setup()” and the other is “void loop()”. “void setup()” is a function that runs once at the start of a program and that can initialize settings. “void loop()” is a function called repeatedly until the board powers off.

To declare a pin of the Arduino as a input “pinMode(pin number, INPUT)” is used. An to declare as a output “pinMode(pin number, OUTPUT)” is used. To get a digital data on an output pin “digitalWrite(pin number)” command is used. If we want to read a value from a sensor which is connected to an analog pin we use “analogRead(pin number)”. If we have some conditional situation we can use “if” conditional statement. We have used all these things to write program for the Arduino.

There are many libraries for the Arduino. The Arduino environment can be extended through the use of libraries, just like most programming platforms. Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. We have used libraries for Motor shield, Ethernet shield, SPI communication etc

After writing the whole code on the Arduino IDE editor, we compiled it through the compiler. To do this we select “Sketch” file menu on the Arduino window. Then we select “Verify/compile”. This will compile the code. If there is any error it will show that.

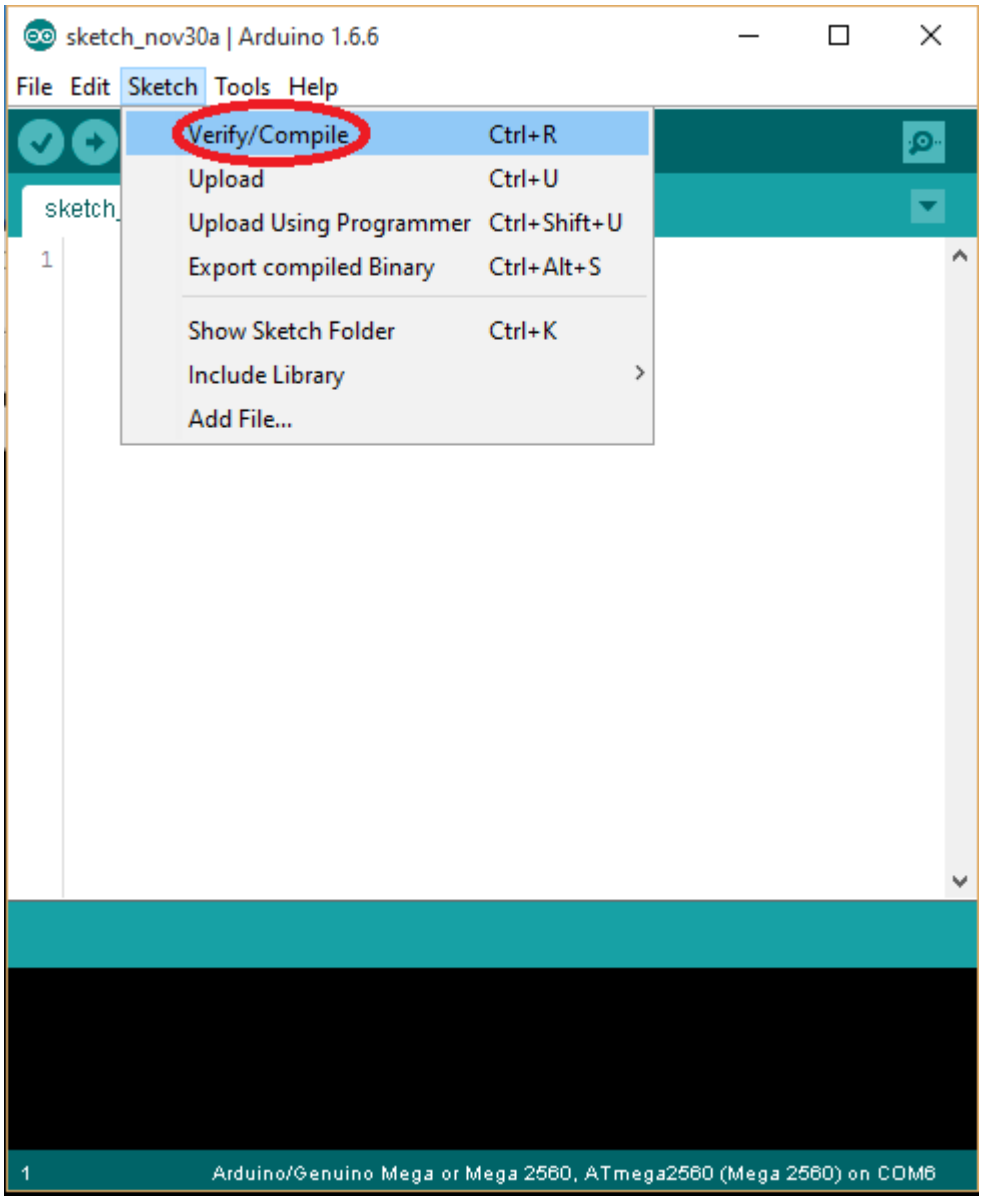


Fig. 4.12. Compiling Arduino code.

Another important thing should be remembered that for which board the codes will be compiled. For our case, it is Arduino Mega 2560. So, we need to select the appropriate board. To do this we go to Tools > Board > Arduino/Genuino Mega or Mega 2560.

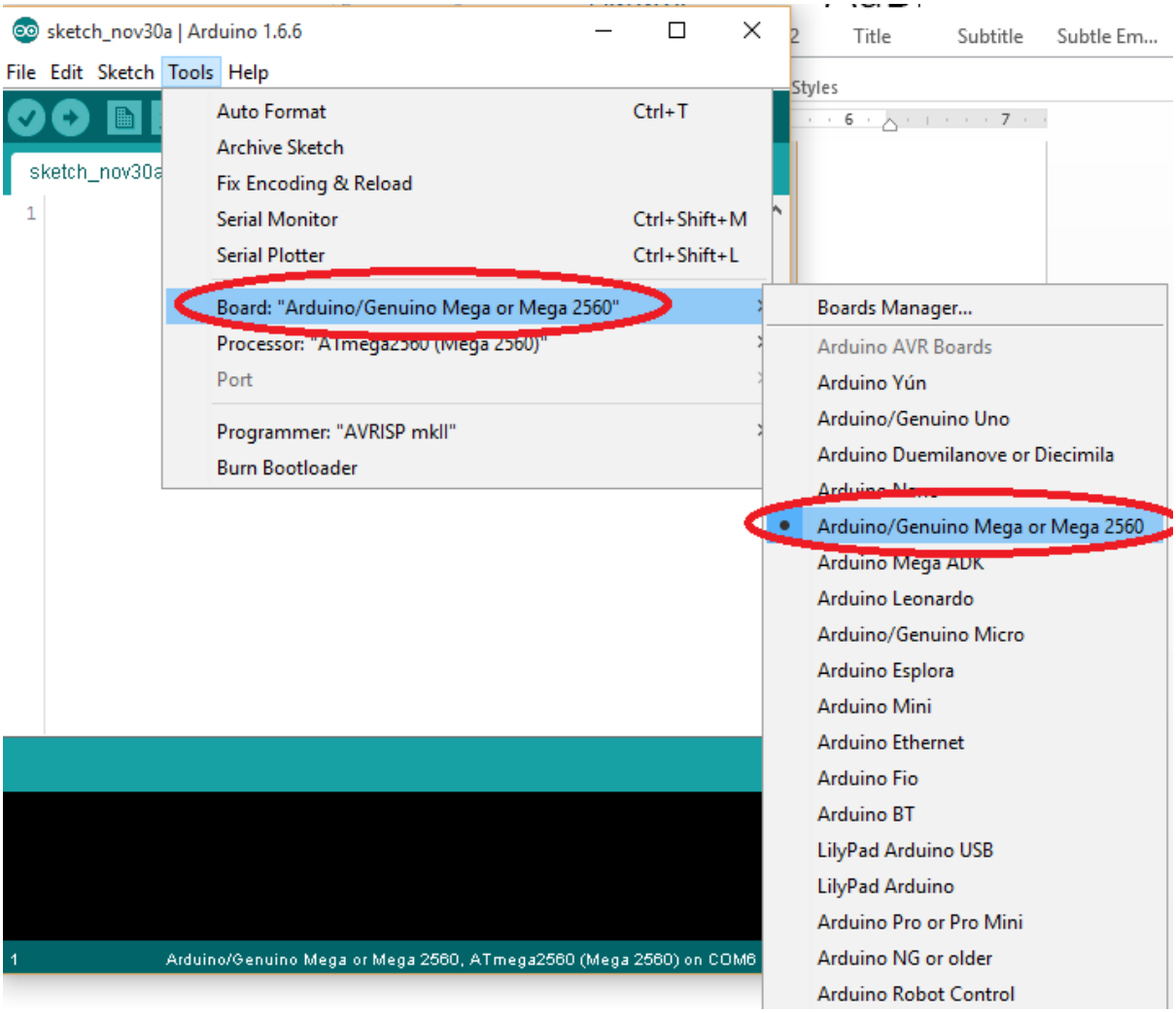


Fig. 4.13. Board selection.

After compiling it we have to upload the program to the Arduino. First we need to connect the Arduino board to the USB port through an USB cable provided with the Arduino. Then we need to select “Upload” at the top left corner on the Arduino IDE. If the program is uploaded successfully it will show it through a message. Now the central microcontroller is programs. The whole programming code of the system is in APPENDIX A.

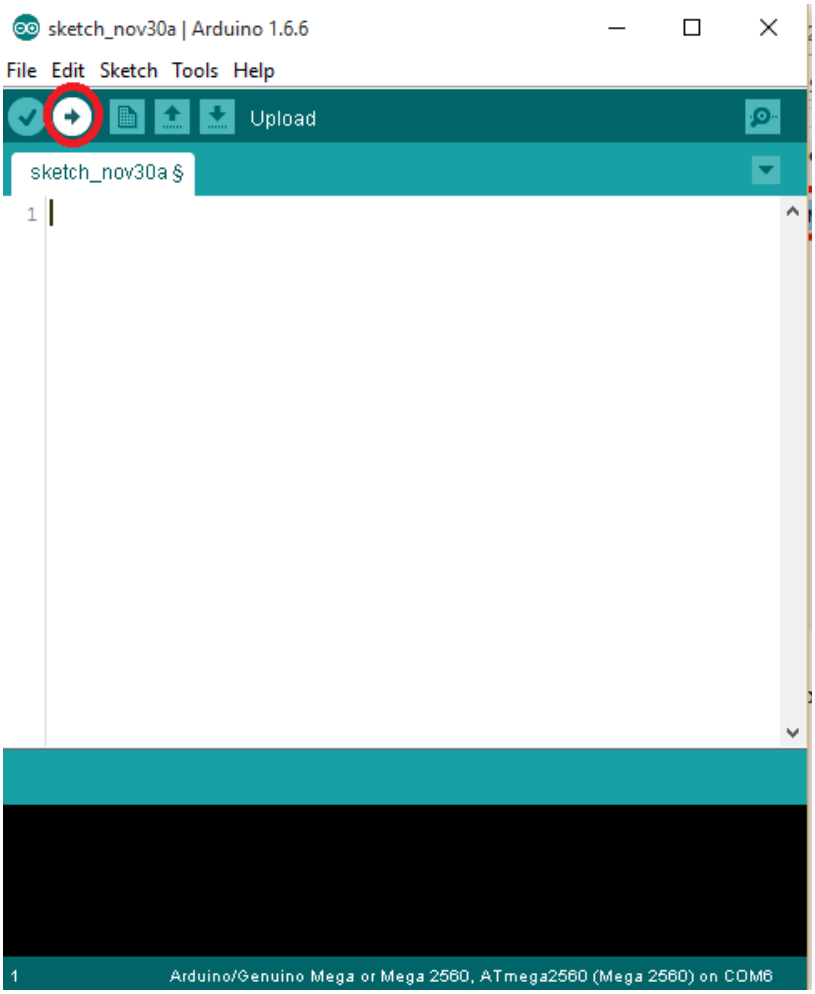


Fig. 4.14. Uploading program to an Arduino.

BH1750advanced | Arduino 1.8.9

File Edit Sketch Tools Help

BH1750advanced

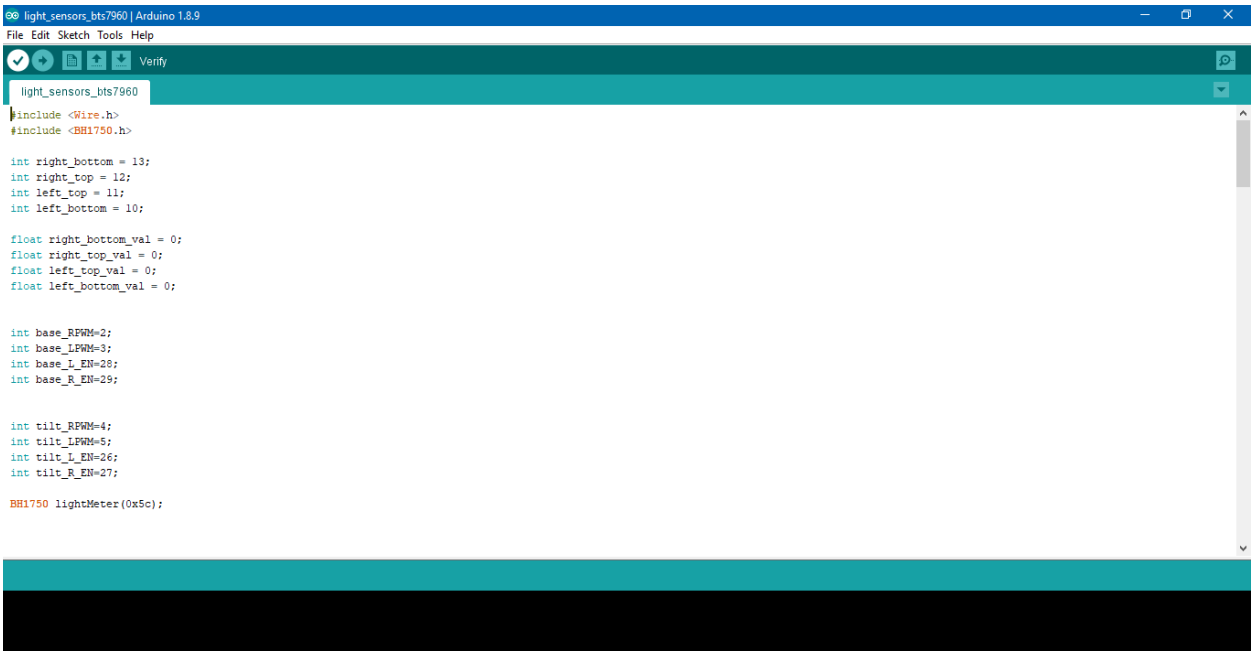
```
#include <Wire.h>
#include <BH1750.h>

/*
  BH1750 can be physically configured to use two I2C addresses:
    - 0x23 (most common) (if ADD pin had < 0.7VCC voltage)
    - 0x5C (if ADD pin had > 0.7VCC voltage)

  Library uses 0x23 address as default, but you can define any other address.
  If you had troubles with default value - try to change it to 0x5C.

*/
BH1750 lightMeter(0x23);

void setup(){

  Serial.begin(9600);

  // Initialize the I2C bus (BH1750 library doesn't do this automatically)
  Wire.begin();
  // On esp8266 you can select SCL and SDA pins using Wire.begin(D4, D3);

  /*

    BH1750 has six different measurement modes. They are divided in two groups;
    continuous and one-time measurements. In continuous mode, sensor continuously
    measures lightness value. In one-time mode the sensor makes only one
    measurement and then goes into Power Down mode.
```

master_reader | Arduino 1.8.9

File Edit Sketch Tools Help

master_reader

```
// Wire Master Reader
// by Nicholas Zambetti <http://www.zambetti.com>

// Demonstrates use of the Wire library
// Reads data from an I2C/TWI slave device
// Refer to the "Wire Slave Sender" example for use with this

// Created 29 March 2006

// This example code is in the public domain.


#include <Wire.h>

void setup() {
  Wire.begin();        // join i2c bus (address optional for master)
  Serial.begin(9600);  // start serial for output
}

void loop() {
  Wire.requestFrom(8, 6);    // request 6 bytes from slave device #8

  while (Wire.available()) { // slave may send less than requested
    char c = Wire.read(); // receive a byte as character
    Serial.print(c);         // print the character
  }

  delay(500);
}
```


light_sensors_bts7960 | Arduino 1.8.9
File Edit Sketch Tools Help
Verify
light_sensors_bts7960
#include <Wire.h>
#include <BH1750.h>
int right_bottom = 13;
int right_top = 12;
int left_top = 11;
int left_bottom = 10;
float right_bottom_val = 0;
float right_top_val = 0;
float left_top_val = 0;
float left_bottom_val = 0;
int base_RPWM=2;
int base_LPWM=3;
int base_L_EN=28;
int base_R_EN=29;
int tilt_RPWM=4;
int tilt_LPWM=5;
int tilt_L_EN=26;
int tilt_R_EN=27;
BH1750 lightMeter(0x5c);


ldr_bts_test | Arduino 1.8.9
File Edit Sketch Tools Help
ldr_bts_test
float right_bottom_val = 0;
float right_top_val = 0;
float left_top_val = 0;
float left_bottom_val = 0;
int base_RPWM=2;
int base_LPWM=3;
int base_L_EN=28;
int base_R_EN=29;
int tilt_RPWM=4;
int tilt_LPWM=5;
int tilt_L_EN=26;
int tilt_R_EN=27;
void setup() {
for(int i=2;i<6;i++){
pinMode(i,OUTPUT);
pinMode(i+24,OUTPUT);
}
digitalWrite(base_R_EN,HIGH);
digitalWrite(base_L_EN,HIGH);
digitalWrite(tilt_R_EN,HIGH);
digitalWrite(tilt_L_EN,HIGH);

4.6 Summary

For equipment execution there are some particular durable goods to develop chassis for the product part. The entire methodology beginning from building case to running codes and associating equipment and programming is done and talked about to take us close to the task. The whole chapter emphasizes the procedures which includes hardware and software and gives a better idea to implement and run device with code.

Chapter 5
Design Impact

5.1 Economic Impact

The economic advantages of solar power include:

- Lower your electric bills.
- Net metering allows you to sell your excess electricity to the utility company for even lower energy bills!
- Increase your home’s resale value.
- Take advantage of tax credits from the federal and state government.

Grid Cost Savings

Currently, the majority of electricity is produced in large scale power plants and transported hundreds of miles to houses, businesses and other buildings. All of this infrastructure costs a lot of money to build and maintain. As local solar energy takes off, it will reduce the costs of infrastructure. Communities will not have to build new large-scale transmission lines, since electricity will be transported much shorter distances within a community.

The whole system is low power consuming which makes it cost efficient. By making market price low and produce more products it can benefit and serve economical purposes as well.

5.2 Environmental Impact

Solar energy systems/power plants do not produce air pollution, water pollution, or greenhouse gases. Using solar energy can have a positive, indirect effect on the environment when solar energy replaces or reduces the use of other energy sources that have larger effects on the environment. Solar energy systems are also silent, and usually have no loud moving parts so they do not release any sort of disturbing noise pollutions. Transportation of solar panels will also have a negative impact on the environment if fossil fuels are used during transportation.

Every solar panel that is built and successfully used as a substitute for fossil fuels is reducing the amount of pollutants released into the atmosphere. Overall, using solar energy as a substitute for fossil fuels will have a positive impact on the environment.

5.3 Social Impact

The Initial research on the Solar Grid System was related to an evaluation of its present circumstances in Bangladesh. Afterwards, considering its increasing demand, a significant research study was conducted to find standardized qualification testing procedures for SHS components. A combination of qualitative and quantitative methodological tactics, were used to provide descriptive evidence concerning electricity's impact on the assessable socio-economic

data. To finalize this information with field-level data, a pervasive household survey and individual short interviews with shop-keepers were performed in a rural area near Dhaka city. The implementation of Solar Grid System in rural Bangladesh, causes optimistic impacts, particularly in the areas of education, health, information, communication, social security and household works.

5.4 Political Impact

Political leaders can be innovations of new ideas and new concepts. They can introduce new things to their people to reduce the burden of them by implementing new systems. Saving people in rescue mission by our rover political leaders can help and gain trust of his people.

5.5 Ethical Impact

The system has no ethical dilemma rather by saving lives it serves to humanity. The system makes life easier, saving electricity, money and reuse the power.

5.6 Health and Safety Impact

One of the best things of our system is completely safe and can be used taking any safety measures.

5.7 Manufacturability

Manufacturing of the system is easy and less complex. The parts of the system are easily available and it is easy to construct. When it will be manufactured commercially the cost will be reduced a lot.

5.8 Sustainability

Our system has good it is easy to use, saving money and energy. It is resistant to excessive heat and other extremities, body made of enduring steel so that it doesn't damage in external pressure.

Chapter 7

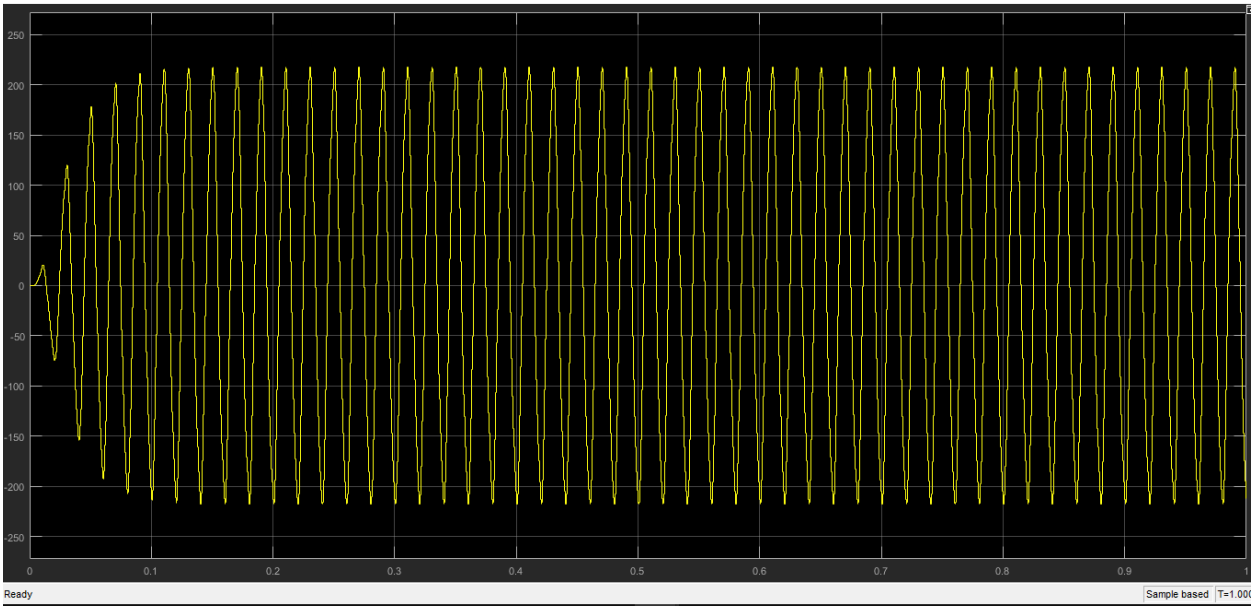
Total Cost for Implementation

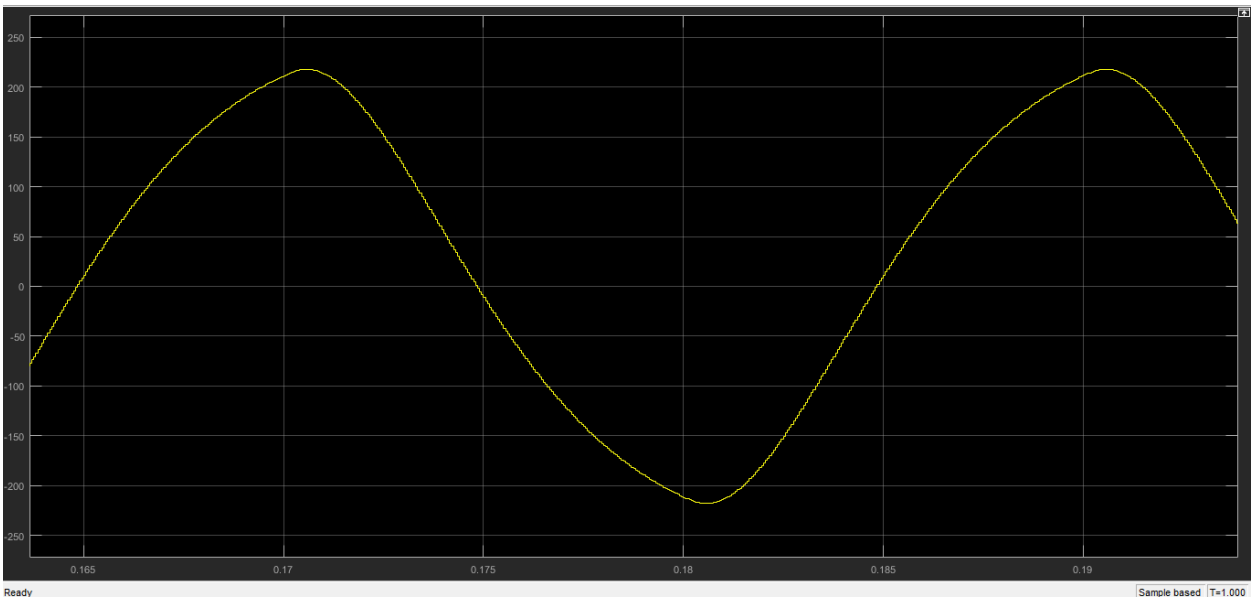
Here is our total cost for implementation of the project. We tried our best to reduce the cost as much as possible. We think we are successful to implement the solar panel system within a limited cost.

Name of Components	Cost
Wiper Motor (2)	1000
Solar Panel (30W)	1450
Charger Controller	250
Battery (20A)	2700
L293D Motor Driver (2)	1600
Light Density Sensor (4)	1400
Other Equipment's for Inverter	4000
Total	11900

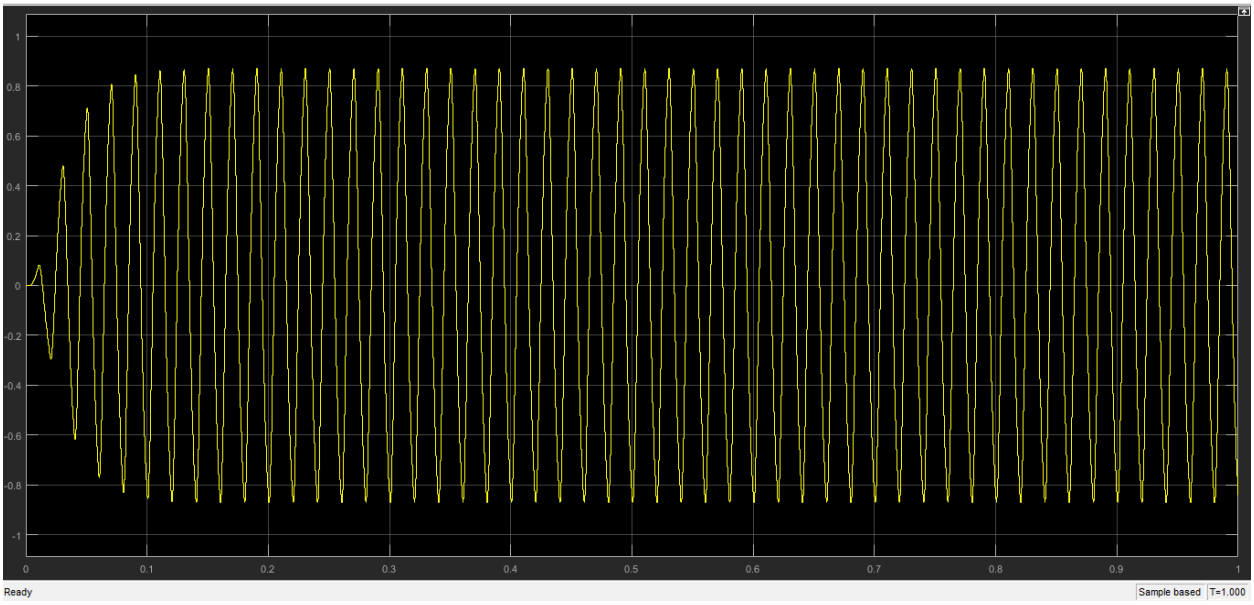
Table: Cost of the components.

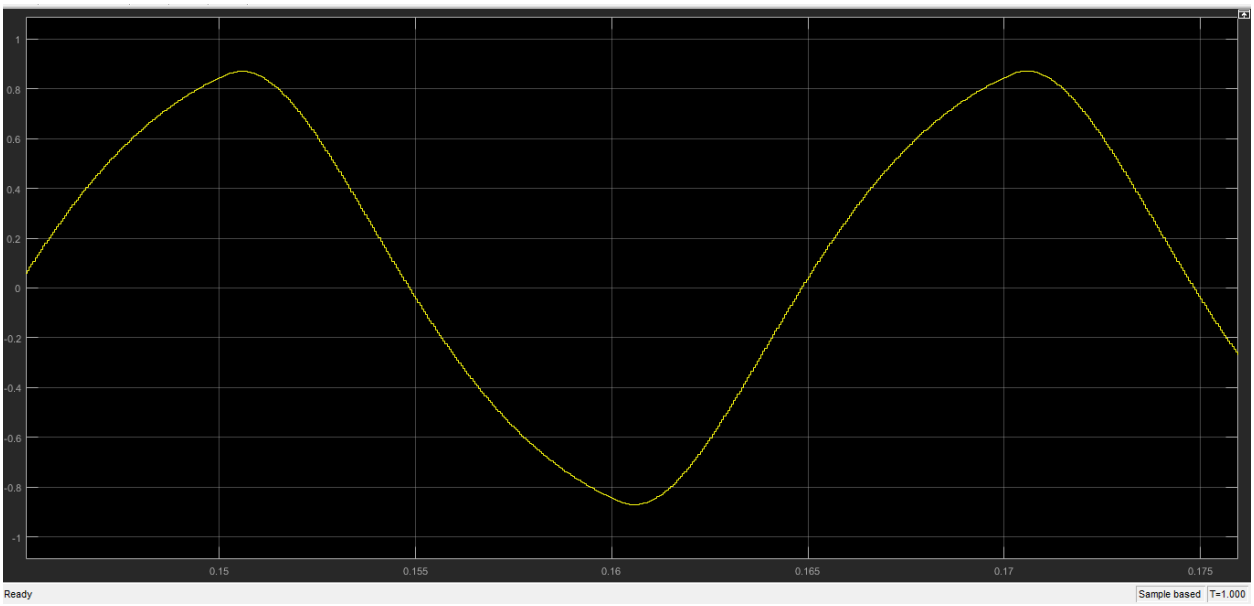
Chapter 8
Result


250
200
150
100
50
0
-50
-100
-150
-200
-250
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Ready
Sample based
T=1.00

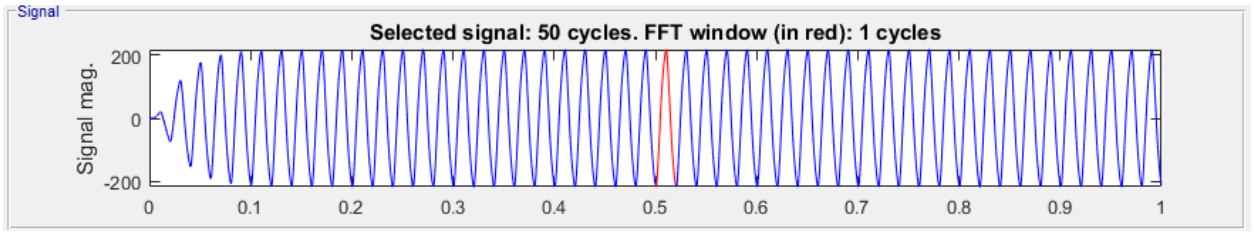

250
200
150
100
50
0
-50
-100
-150
-200
-250
0.165
0.17
0.175
0.18
0.185
0.19
Ready
Sample based
T=1.000

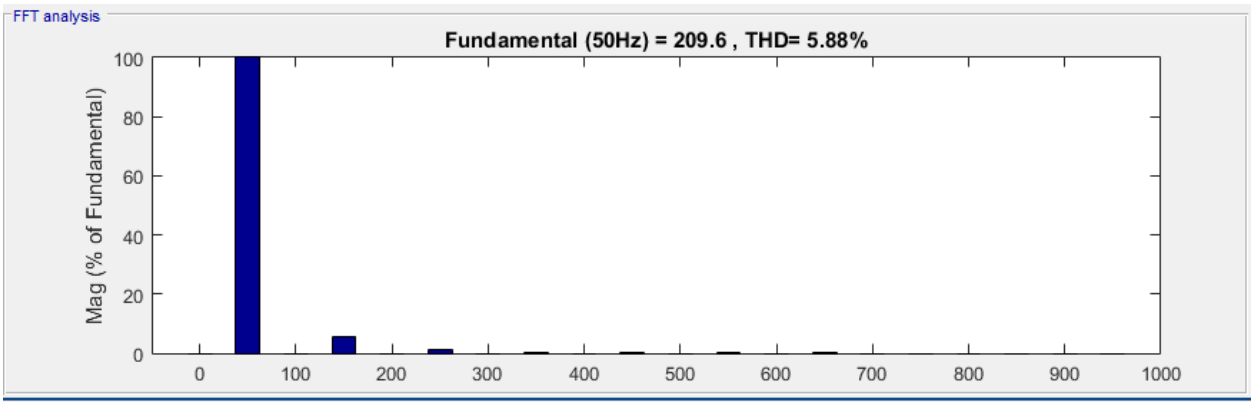
Voltage

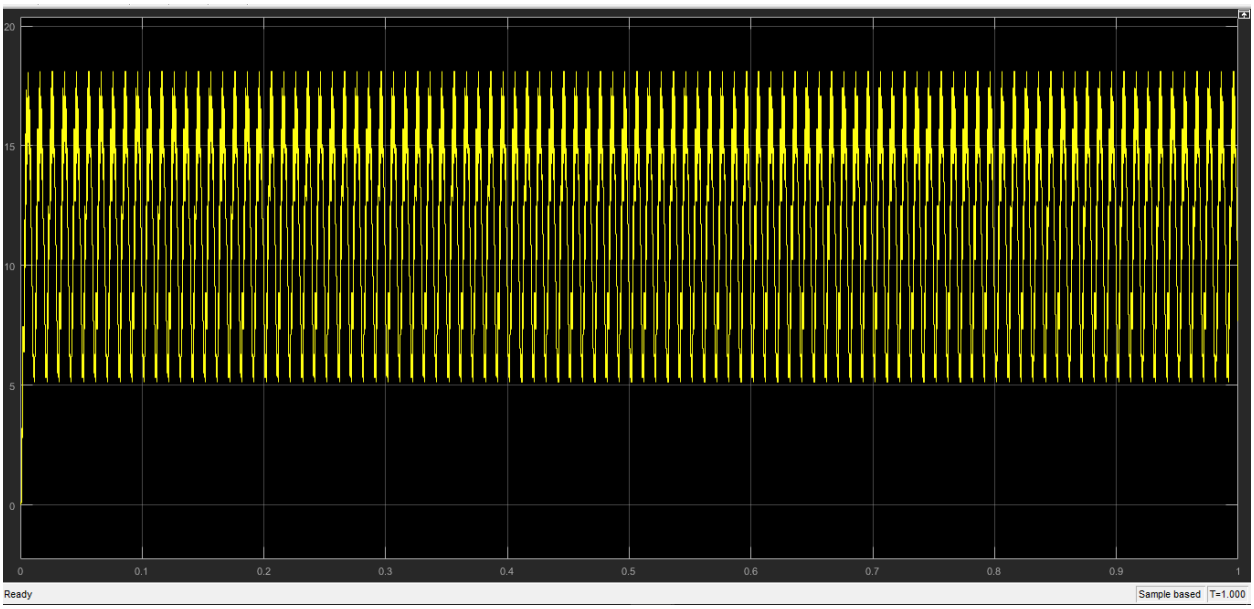

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Ready
Sample based
T=1.000

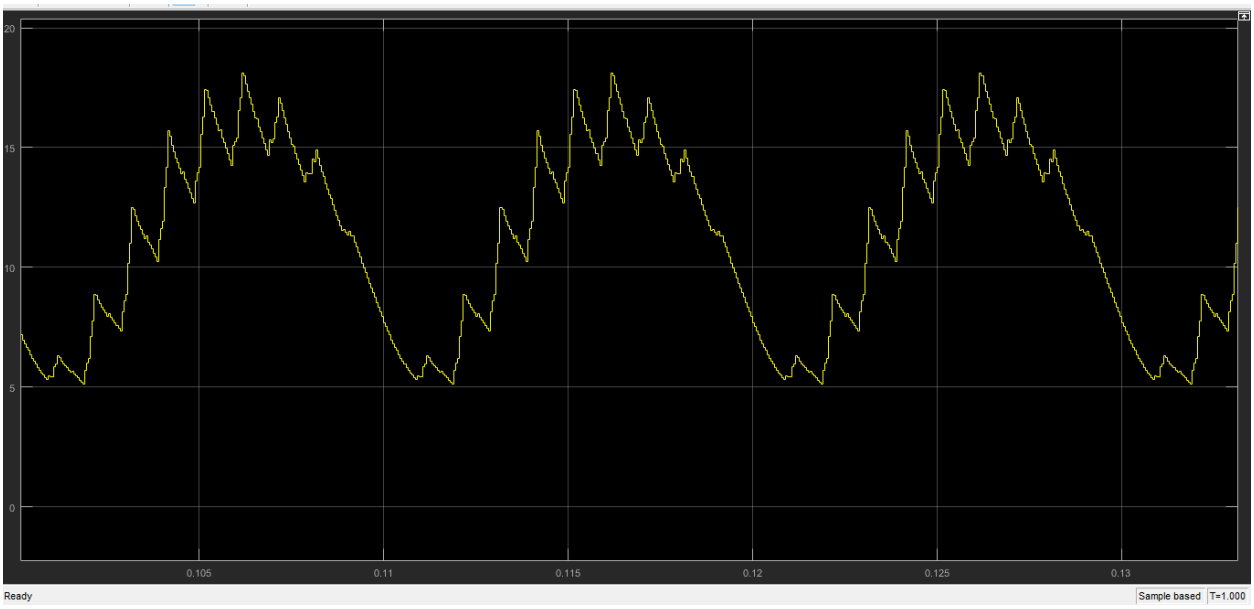

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0.15
0.155
0.16
0.165
0.17
0.175
Ready
Sample based
T=1.000

Current

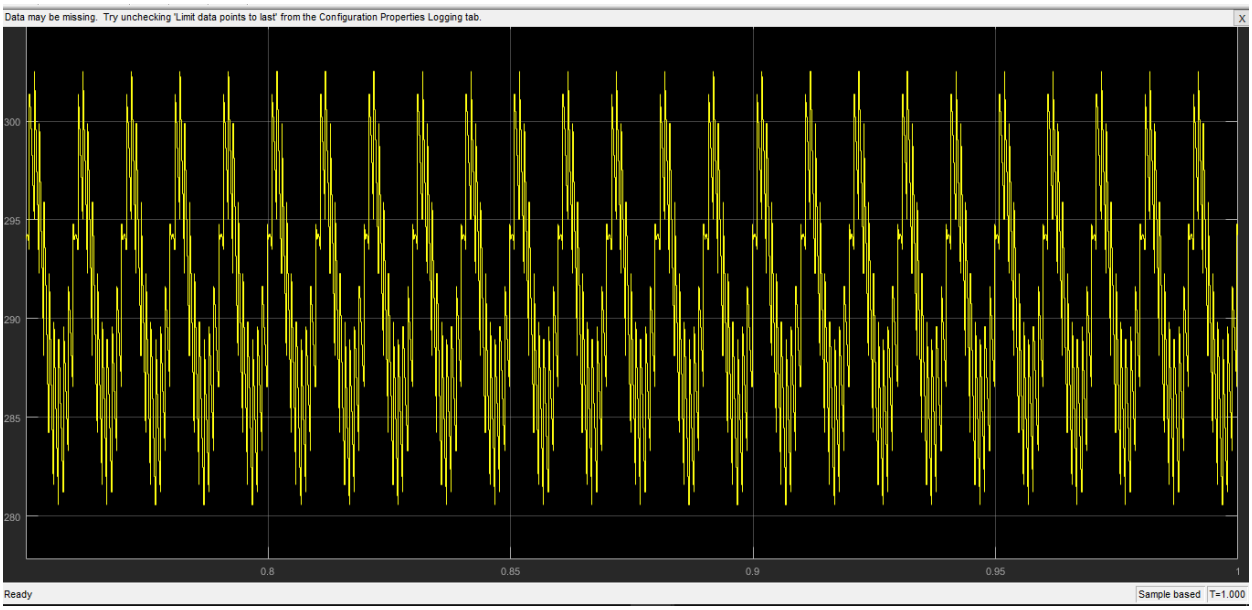

Signal
Selected signal: 50 cycles. FFT window (in red): 1 cycles
Signal mag.
200
0
-200
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

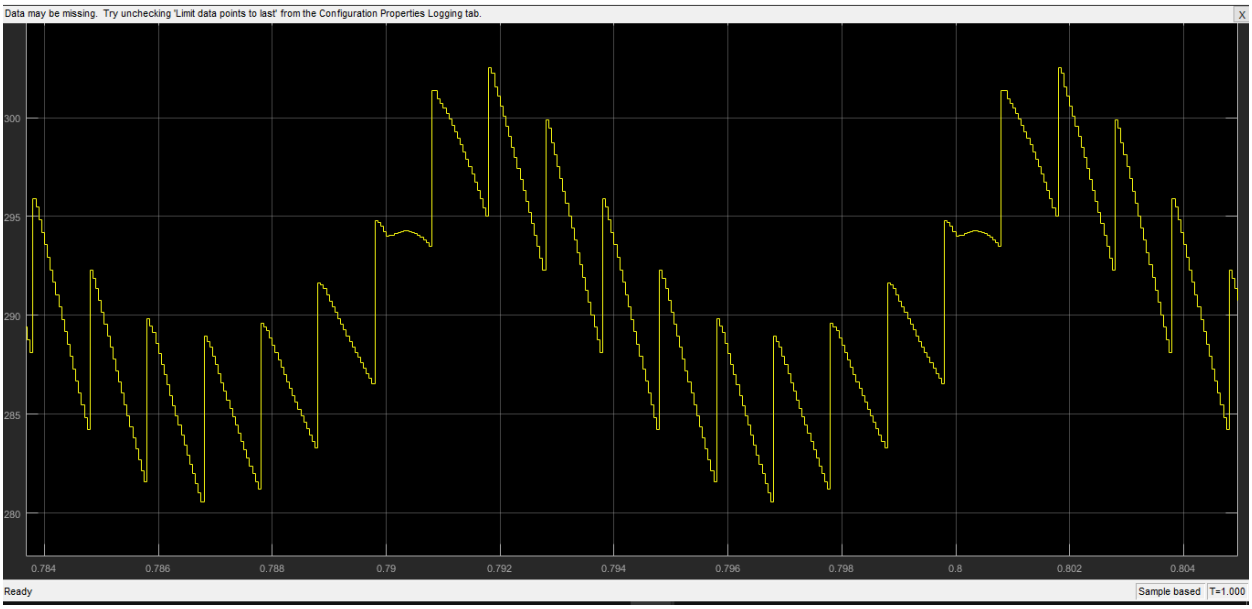

FFT analysis
Fundamental (50Hz) = 209.6 , THD= 5.88%
Mag (% of Fundamental)
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
900
1000

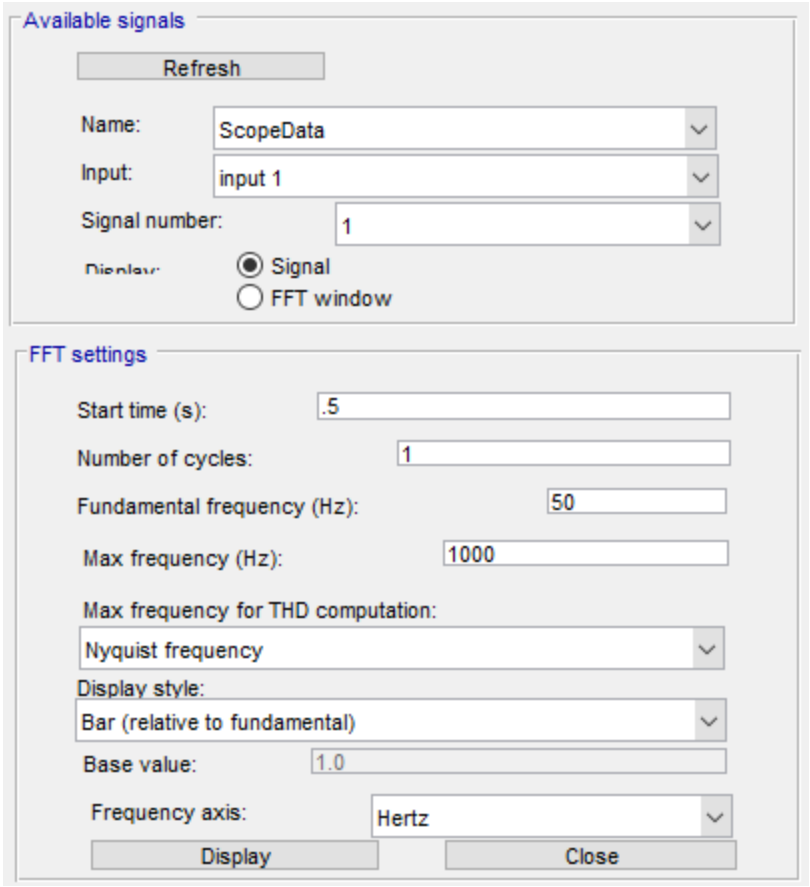

20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Ready
Sample based
T=1.000

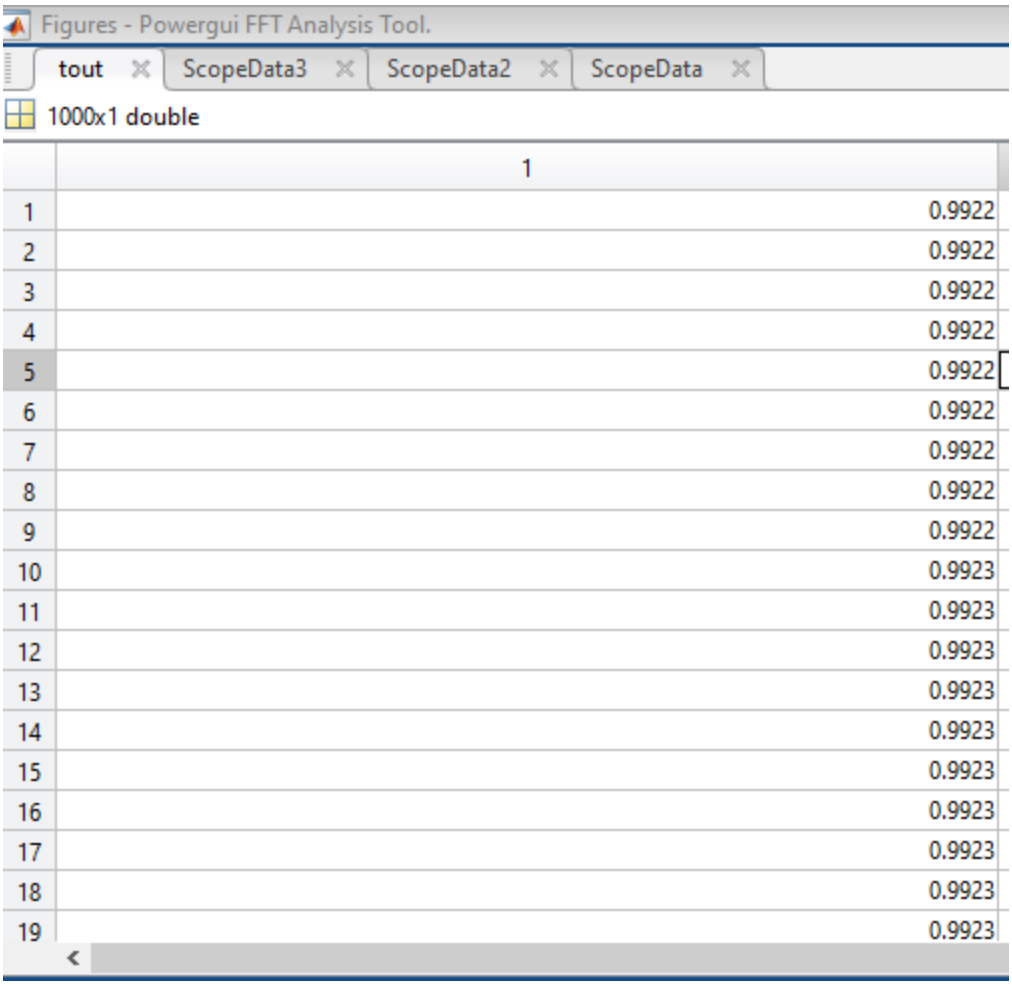

20
15
10
5
0
0.105
0.11
0.115
0.12
0.125
0.13
Ready
Sample based
T=1.000

Voltage 2


Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.
300
295
290
285
280
0.8
0.85
0.9
0.95
1
Ready
Sample based
T=1.000


Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.
300
295
290
285
280
0.784
0.786
0.788
0.79
0.792
0.794
0.796
0.798
0.8
0.802
0.804
Ready
Sample based
T=1.000


Available signals
Refresh
Name:
ScopeData
Input:
input 1
Signal number:
1
Signal
FFT window
FFT settings
Start time (s):
.5
Number of cycles:
1
Fundamental frequency (Hz):
50
Max frequency (Hz):
1000
Max frequency for THD computation:
Nyquist frequency
Display style:
Bar (relative to fundamental)
Base value:
1.0
Frequency axis:
Hertz
Display
Close



	1
1	0.9922
2	0.9922
3	0.9922
4	0.9922
5	0.9922
6	0.9922
7	0.9922
8	0.9922
9	0.9922
10	0.9923
11	0.9923
12	0.9923
13	0.9923
14	0.9923
15	0.9923
16	0.9923
17	0.9923
18	0.9923
19	0.9923

Chapter 9

Conclusion

In this project we implemented a cost-effective solar panel system which made low costing and save the energy for reuse. The grid connect inverter converts the DC electricity produced by the solar panels into 240 V AC electricity, which can then be used by the property/household. With the help this wipe motor the solar panel move to any axis. The power generated by this solar panel will send the electricity to the grid, and we will able to use the electricity produced by solar. Through this solar system many of our electricity and money will be saved. Our solar can detect the sunlight, so that it can rotate in the sun so that electricity will be more produce. We have connected each of our machine separately so that if there is a damaged can do another damage.

We have achieved our goal of implementing a cost effective and more produce the electricity solar system which can detect the sunlight by monitoring its heat. Multiple ways were found to implement the project but the best and effective method was chosen, where the main objective was to make a better and useful the system within a limited cost.

Appendices

Appendix A

Using Light intensity sensor

```
#include <Wire.h>

#include <BH1750.h>



int right_bottom = 13;

int right_top = 12;
```

```
int left_top = 11;

int left_bottom = 10;



float right_bottom_val = 0;

float right_top_val = 0;

float left_top_val = 0;

float left_bottom_val = 0;




int base_RPWM=2;

int base_LPWM=3;

int base_L_EN=28;

int base_R_EN=29;



int tilt_RPWM=4;

int tilt_LPWM=5;

int tilt_L_EN=26;

int tilt_R_EN=27;
```

```
BH1750 lightMeter(0x5c);


void setup() {
  for(int i=2;i<14;i++){
    pinMode(i,OUTPUT);
    digitalWrite(i,LOW);
  }
  for(int i=26;i<30;i++){
    pinMode(i,OUTPUT);
    digitalWrite(i,LOW);
  }
  digitalWrite(base_R_EN,HIGH);
  digitalWrite(base_L_EN,HIGH);
  digitalWrite(tilt_R_EN,HIGH);
  digitalWrite(tilt_L_EN,HIGH);


  Serial.begin(9600);
```

```
  Wire.begin();


delay(1000);
  init_sensors();


}


void loop() {
  read_sensors();


    Serial.println(right_bottom_val);
    Serial.println(right_top_val);
    Serial.println(left_top_val);
    Serial.println(left_bottom_val);
    Serial.println();
    delay(1000);


  float right_difference = right_top_val  -  right_bottom_val;
```

```
  float left_difference = left_top_val  -  left_bottom_val;




    if(right_difference>80 || left_difference>80){
      analogWrite(tilt_RPWM, 50);
//      delay(100);
//      analogWrite(tilt_RPWM, 0);

    }
    else if(right_difference<-80 || left_difference<-80){
      analogWrite(tilt_LPWM, 50);
//      delay(100);
//      analogWrite(tilt_LPWM, 0);
    }
    else{
      analogWrite(tilt_RPWM, 0);
      analogWrite(tilt_LPWM, 0);
    }
```

```
  float bottom_difference = right_bottom_val  -  left_bottom_val;
  float top_difference = right_top_val  -  left_top_val;

    if(bottom_difference>80 || top_difference>80){
      analogWrite(base_LPWM, 50);
//      delay(100);
//      analogWrite(base_LPWM, 0);
    }
    else if(bottom_difference<-80 || top_difference<-80){
      analogWrite(base_RPWM, 50);
//      delay(100);
//      analogWrite(base_RPWM, 0);
    }
    else{
      analogWrite(base_RPWM, 0);
      analogWrite(base_LPWM, 0);
    }
```

```
}

void read_sensors(){

//  digitalWrite(right_bottom, HIGH);

//  right_bottom_val = lightMeter.readLightLevel();

//  digitalWrite(right_bottom, LOW);

//  delay(100);


  digitalWrite(right_top, HIGH);

  right_top_val = lightMeter.readLightLevel();

  digitalWrite(right_top, LOW);

  delay(100);


 digitalWrite(left_top, HIGH);

  left_top_val = lightMeter.readLightLevel();

  digitalWrite(left_top, LOW);

  delay(100);
```

```
  digitalWrite(left_bottom, HIGH);
  left_bottom_val = lightMeter.readLightLevel();
  digitalWrite(left_bottom, LOW);
  delay(100);

  right_bottom_val = left_bottom_val;
}

void init_sensors(){
//   delay(100);
//  digitalWrite(right_bottom, HIGH);
//  delay(100);
//  if (lightMeter.begin(BH1750::CONTINUOUS_HIGH_RES_MODE)) {
//    Serial.println(F("BH1750 Advanced begin"));
//  }
//  else {
//    Serial.println(F("Error initialising BH1750"));
//  }
```

```
//  digitalWrite(right_bottom, LOW);
//  delay(100);


  digitalWrite(right_top, HIGH);
  if (lightMeter.begin(BH1750::CONTINUOUS_HIGH_RES_MODE)) {
    Serial.println(F("BH1750 Advanced begin"));
  }
  else {
    Serial.println(F("Error initialising BH1750"));
  }
  digitalWrite(right_top, LOW);
  delay(100);



  digitalWrite(left_top, HIGH);
  if (lightMeter.begin(BH1750::CONTINUOUS_HIGH_RES_MODE)) {
    Serial.println(F("BH1750 Advanced begin"));
  }
```

```
  else {
    Serial.println(F("Error initialising BH1750"));
  }
  digitalWrite(left_top, LOW);
  delay(100);



  digitalWrite(left_bottom, HIGH);
  if (lightMeter.begin(BH1750::CONTINUOUS_HIGH_RES_MODE)) {
    Serial.println(F("BH1750 Advanced begin"));
  }
  else {
    Serial.println(F("Error initialising BH1750"));
  }
  digitalWrite(left_bottom, LOW);
  delay(100);
}
```

Using LDR

```
float right_bottom_val = 0;

float right_top_val = 0;

float left_top_val = 0;

float left_bottom_val = 0;


int base_RPWM=2;

int base_LPWM=3;

int base_L_EN=28;

int base_R_EN=29;



int tilt_RPWM=4;

int tilt_LPWM=5;

int tilt_L_EN=26;

int tilt_R_EN=27;
```

```
void setup() {
  for(int i=2;i<6;i++){
    pinMode(i,OUTPUT);
    pinMode(i+24,OUTPUT);
  }
  digitalWrite(base_R_EN,HIGH);
  digitalWrite(base_L_EN,HIGH);
  digitalWrite(tilt_R_EN,HIGH);
  digitalWrite(tilt_L_EN,HIGH);

  Serial.begin(9600);

  delay(1000);
}
void loop() {
  Serial.println(analogRead(A0));
  Serial.println(analogRead(A1));
  Serial.println(analogRead(A2));
```

```
  Serial.println(analogRead(A3));
  Serial.println();
  //delay(500);


  left_bottom_val = analogRead(A0);
  left_top_val = analogRead(A2);
  right_top_val = analogRead(A3);
  right_bottom_val = analogRead(A1);


  float right_difference = right_top_val  -  right_bottom_val;
  float left_difference = left_top_val  -  left_bottom_val;


    if(right_difference>70 || left_difference>70){
      analogWrite(tilt_RPWM, 50);
//      delay(100);
//      analogWrite(tilt_RPWM, 0);


    }
```

```
    else if(right_difference<-70 || left_difference<-70){
      analogWrite(tilt_LPWM, 50);
//      delay(100);
//      analogWrite(tilt_LPWM, 0);
    }
    else{
      analogWrite(tilt_RPWM, 0);
      analogWrite(tilt_LPWM, 0);
    }

  float bottom_difference = right_bottom_val  -  left_bottom_val;
  float top_difference = right_top_val  -  left_top_val;

    if(bottom_difference>70 || top_difference>70){
      analogWrite(base_LPWM, 50);
//      delay(100);
//      analogWrite(base_LPWM, 0);
    }
```

```
    else if(bottom_difference<-70 || top_difference<-70){
      analogWrite(base_RPWM, 50);
//      delay(100);
//      analogWrite(base_RPWM, 0);
    }
    else{
      analogWrite(base_RPWM, 0);
      analogWrite(base_LPWM, 0);
    }
}
```