PIMPRI CHINCHWAD EDUCATION TRUST'S

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING
(SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE)

A

Project Report

On

Data Acquisition of Solar Panel

By

Saadain Shaikh	B190333204
Vipulkumar Patil	B190333163
Aditya Karale	B190333103

Under the Guidance of
Prof. Ajit Patil

Department Of
ELECTRONICS & TELECOMMUNICATION

B.E.(E&TC)2022 - 2023

CERTIFICATE

Project Phase -II Report
On
Data Acquisition of Solar Panel

Submitted for Complete Fulfillment of the Requirements for the Degree of Bachelor of Engineering in the Department of Electronics & Telecommunication Engineering Pimpri Chinchwad College of Engineering, Savitribai Phule University of Pune, Pune

By

Saadain Shaikh	**B190333204**
Vipulkumar Patil	**B190333163**
Aditya Karale	**B190333103**

Prof. Ajit Patil	**Dr. M. T. Kolte**	**Dr. Govind N. Kulkarni**
(Project Guide)	**(H.O.D)**	**(Director)**

Pimpri Chinchwad College of Engineering,
Savitribai Phule University of Pune, Pune.

2022-23

CONTENTS

ACKNOWLEDGEMENT

We are deeply indebted to our Guide, **Prof. Ajit Patil**, department of **Electronics and Telecommunication** engineering for Guiding us to successfully accomplish this work. It was our privilege and pleasure to work under her able Guidance. We are indeed grateful to her for providing us helpful suggestions from time to time. Due to her continuous encouragement and inspiration, we are able to present this work. Again, we extend our sincere appreciation and great pleasure to express our gratitude to our **H.O.D. Dr. M. T. Kolte** and Project coordinator **Dr. Rajani. P. K** for providing us this opportunity, motivation and moral support. We are very much thankful to all the technical and non-technical staff members of **Electronics and Telecommunication Engineering Department, Pimpri Chinchwad College of Engineering, Pune** for their kind cooperation during this course of dissertation. Completing the project is not an individual task, it needs good cooperation, Guidance and support from many. It gives us great pleasure to thank all those who supported us thoroughly in the existence of this project.

ABSTRACT

Renewable energy has vast potential in modern technologies. Coal, oil, and gas resources will soon be so little that a greater proportion of the world's energy needs will come from renewable sources. It is a cost-free, sustainable, and clean source of electricity. Smart applications for renewable energy will come under increasing demand in the future. Solar energy is an example of renewable energy. Solar energy now becoming a common energy source for household consumption, battery chargers, and public illumination. A PV solar cell or a module is frequently utilized as a power source. Solar cells or modules are used as the energy source in an increasing number of applications. For the rapid evolution of today, a straightforward and precise mathematical model that defines the characteristics of the photovoltaic solar cell is necessary.

New markets are becoming more accessible as technology for PV cells and systems advances. The need for utility interactive PV devices and systems' operating technology has surged as a result. To accurately anticipate the solar PV energy potential under varied climatic circumstances, solar PV system designers require a reliable model. The performance of photovoltaic cell module is elaborated by using mathematical model in this work. Solar radiation, the surrounding temperature, and the temperature of the solar modules are the variables that determine solar power generation; these variables have an impact on the output parameters (V&I) and are thus in charge of the output that is produced. These factors are treated as variables in mathematical modelling.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

Introduction

Chapter 1: Introduction

1.1 Motivation

The goal of this project is to precisely estimate the mathematical model parameters and model and simulate PV modules. The model shown here may be used to forecast how solar PV modules would perform in various weather scenarios. The reasons for measuring the parameters and modelling involve, but are not confined to: choosing the best photovoltaic system, locating the best location, tracking system parameters, increasing operational performance, and for accurate performance computations. They offer tips for the best power point tracking as well.

1.2 Background

In today's expanding sector of renewable energy, solar energy is crucial. Despite all of the advancements, commercial silicon-based photovoltaic modules still have an efficiency far below 30%. Prior to building a PV energy system, it's critical to understand the amount of energy the project may possibly capture the irradiance and to pinpoint the causes of dropping, which are often heat, pollution, and cloud cover. Therefore, if it occurs, it's crucial to extract as much energy as you can. As a result, choosing the right model for a solar cell is crucial, whether it's for designing an effective array system or accurately assessing the PV phenomenon. For today's dynamic evolution, a straightforward and precise mathematical model that represents the characteristics of the PV solar cell is necessary.

1.3 Problem Statement

To acquire the real-time data of various parameters related to solar panel and compare it with the simulated data.

1.4 Objectives

1. To simulate the solar panel system using MATLAB-Simulink.
2. To implement the hardware system required for demonstrating the solar panel system.
3. To measure the various parameters such as generated voltage, current, lux, and power.
4. To compare the real-time data with simulated results.

CHAPTER 2

Introduction to Solar Power

Chapter 2 Introduction to Solar Power

2.1 Renewable and non-renewable resources

Renewable resources can naturally regenerate themselves, but non-renewable resources cannot, which is how these two types of resources vary from one another.

Renewable resources

Renewable energy, often called clean energy, is derived from renewable natural resources or processes. The sun and wind are shining and blowing, depending on the time of day and the weather.
Harnessing the power of nature for purposes such as transportation, lighting and heating has long been studied, but renewable energy is often considered a relatively new technology. The wind was used to propel ships across the sea and power mills. The light warmed the day and helped start the flames that lasted into the evening.

- Tidal energy
- Hydro energy
- Wind energy
- Solar energy

A. Non - Renewable resources

A source of energy that is not replenishable & will ultimately run out e.g., Coal, gas, and oil. These natural resources represent a significant source of energy for a wide range of sectors, but there are several drawbacks to non-renewable energy, including their detrimental effects on the environment and their scarcity.

- Coal
- natural gas
- oil

2.2 Solar Energy

The Earth intercepts solar energy at a pace that is around 10,000 times larger than the rate at which people use energy. Solar technologies can use photovoltaic panels or solar radiation-concentrating mirrors to turn sunlight into electrical energy.

Solar panels are now not only accessible, but frequently the cheapest source of power because to a sharp decline in the price of solar panel production beyond the past ten years

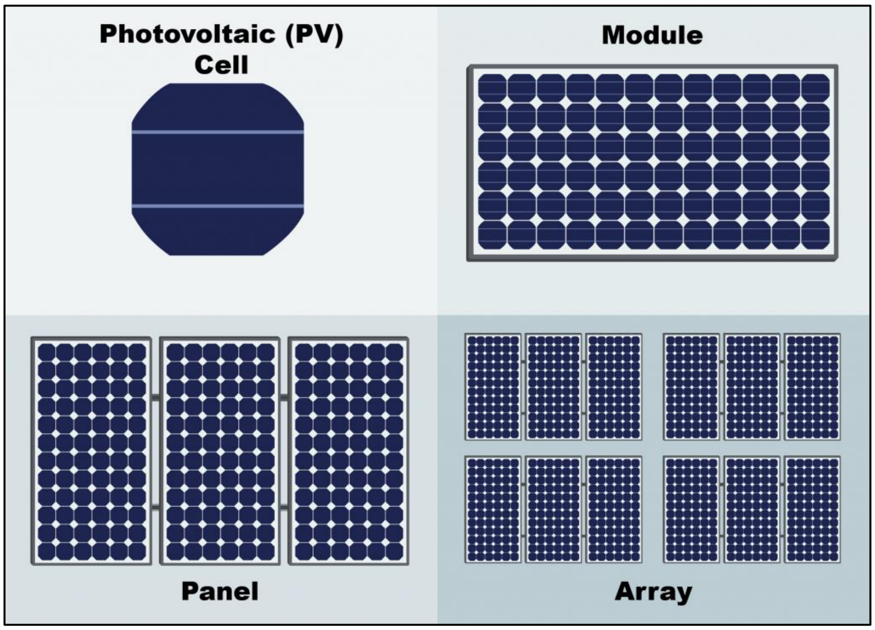


Fig. 2.1 Progression from solar cell to solar array

2.3 Solar Cell

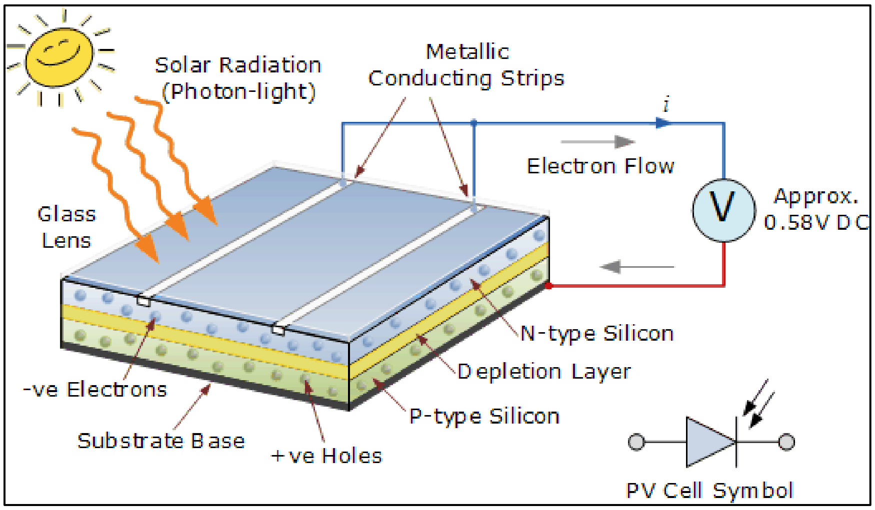


Fig. 2.2 Photovoltaic solar cell construction

2.4 How a Solar Cell Works

P-type silicon and N-type silicon are two types of semiconductors used in solar cell. Boron and gallium are used as doping elements in N-type silicon. The outer energy level of these atoms has one less electron. An atom with extra electrons on the outer surface than silicon, such as phosphorus, is used to create n-type silicon. At its outer energy levels, phosphorus has five electrons instead of four. It connects with neighbouring silicon, but electrons are not involved in the connection process. A p-type silicon layer next to an n-type silicon layer is present in solar cell (Figure 1). An electron through the n-type on one side of the junction moves to a hole on the opposite side of the junction near the intersection of the two layers (the p-layer). A depletion layer is created around junction. Holes are formed and electron are ejected when solar cell is hit by sunlight. In this case, the holes are transported by electric field to the p-type layer and electrons to n-type. Electrons move from n-type layer across depletion layer to p-type layer, pass through external wiring behind n-type, and when there is connection between n-type and p-type layer, an electric current is generated.

2.5 Characteristics of Solar Cell

A. Photovoltaic Solar Cell I-V

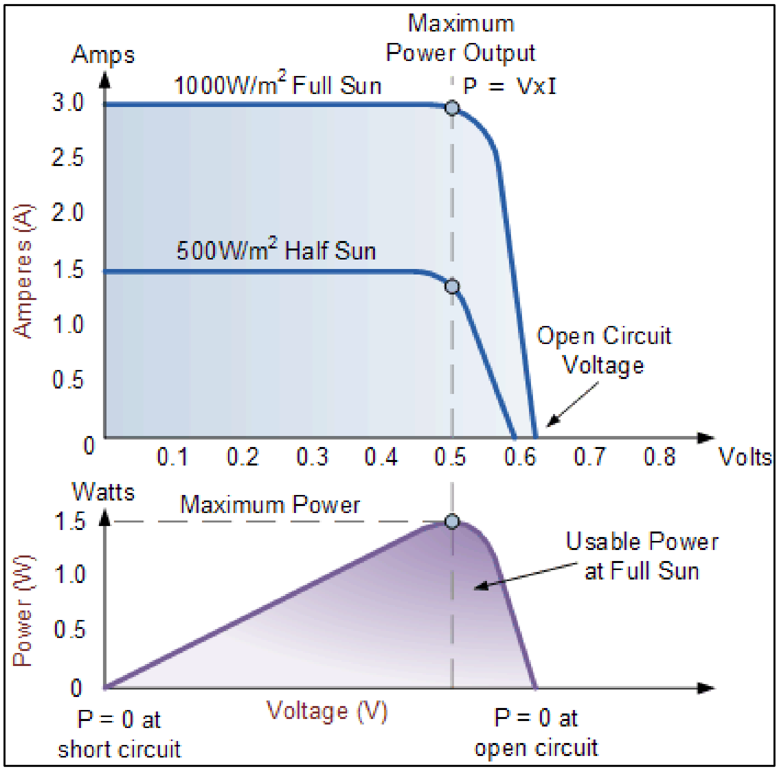


Fig. 2.3 Variation of parameters according to voltage.

B. Solar Cell Voltage

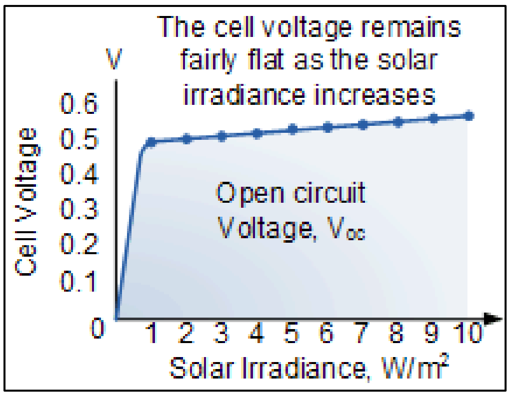


Fig. 2.4 Solar Cell Voltage

A single PV cell is able to generate an "Open Circuit Voltage" (VOC) of between 0.5 and 0.6 volts at 25°C. The cell voltage at output decreases as temperature rises because heated temperatures reason the cell to go to pot. Therefore, for each 25°C rise in mobile temperature in direct daylight, the output voltage drops by round 5%.

C. Solar Cell Current

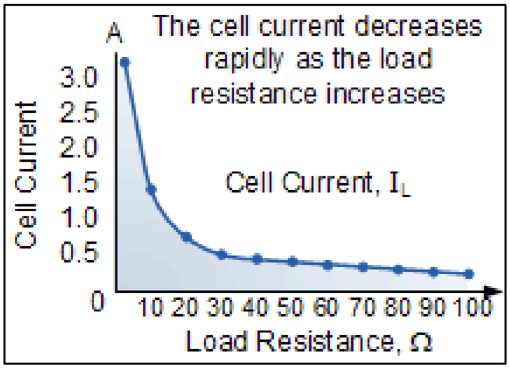


Fig. 2.5 Solar Cell Current

While a PV cell's potential difference is unaffected by the quantity or intensity of sunshine (photon energy) hitting its surface, the output DC current (I) does fluctuate.

D. Maximum Power Point of cell

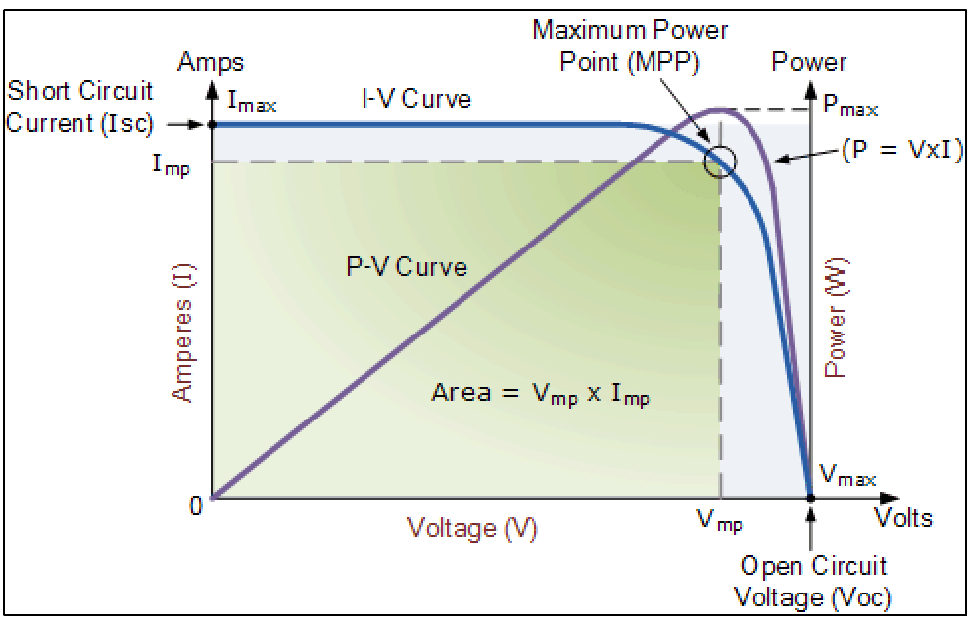


Fig. 2.6 Maximum Power Point of cell

The MPP stands for "maximum energy factor." consequently, the maximum power factor is described because the point at which there is optimal operation of PV cell. A solar cell's maximum electricity factor (MPP) is situated near the bend in the I-V characteristics curve. From the open

I_{oc} and the fast circuit modern-day, the calculation of the ideal values of Vmp and Imp as follows: Vmp (0.80-0.90) Voc and Imp (0.85-0.95) Isc.

E. Photovoltaic Cell Power

A typical photovoltaic solar cell's production of power may be computed as follows:
power (P) = V x I.
Independent solar PV cells can be linked in parallel or in series to generate the necessary voltage or current as parallel currents accumulate.

F. Temperature Coefficient of a PV Cell

It is the amount by which a solar cell's output voltage, current, or power varies as an outcome of a physical shift in the surrounding ambient temperature conditions, but before the array has started to warm up.

Standard Conditions

the panel and cells must be at a standard ambience 25°C with an air mass of 1.5 at sea level. The irradiance must be 1000 W/m2 (1 kW/m2) of full solar midday sunlight (1 sun). VOC = Voltage of open circuit and ISC = current when short circuited at STC.

2.6 Common Types of PV Fabricated from Si

1. Mono-crystalline Silicon
2. Poly-crystalline Silicon
3. Thin Film Silicon

Mono-crystalline Silicon

The conversion efficiency for those styles of photovoltaic mobile stages among 10% and 20%. Mono-crystalline because the complete shape is made from a single crystal that has been produced, silicon is a sort of photovoltaic cell material that has a constant form. A mono-crystalline cellular has a conversion performance of 15% to 20%.

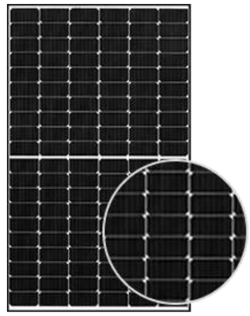


Fig. 2.7 Mono-crystalline Silicon Panel

Poly-crystalline Silicon

Poly-crystalline multi-crystalline silicon is another name for silicon. The boundaries that separate the various smaller batches of crystals that make up the silicon molecular structure. The energy conversion efficiency of a poly-crystalline photovoltaic cell is limited to 10 and 14%. However, because to their reduced production costs, these forms of solar cells are cheap to create than the prior single mono-crystalline silicon.

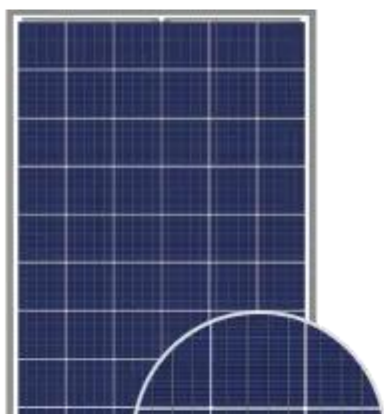


Fig. 2.8 Poly-crystalline Silicon Panel

Thin Film Silicon

Another form of photovoltaic cell, known as a thin film solar cell, was first created for space uses and has a higher power density and are lighter than the earlier crystalline silicon gadgets. Fine photovoltaics films are made from spraying a layer of photovoltaic silicon material above the supporting substrate made of glass, metal, or plastic foil, as their name suggests.

2.7 Connections of Photovoltaic Cell

A. Series Connected Photovoltaic Cells

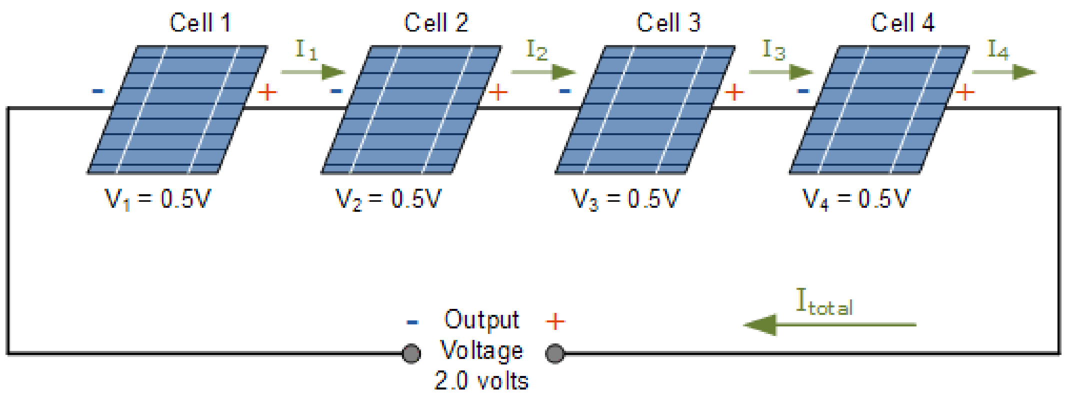


Fig. 2.9 Series Connected Photovoltaic Cells

In the series connection while there is malfunction in single cell, receives disturbance, or is partially or absolutely protected from solar, an unwanted impact consequence. The impact is similar to all the coupled cells are shaded, resulting to total loss of power manufacturing. One so-called bypass diode is hooked up in parallel with each PV cellular as depicted with a purpose to save you electric damage to the cells.

- **Bypass Diode Protection**

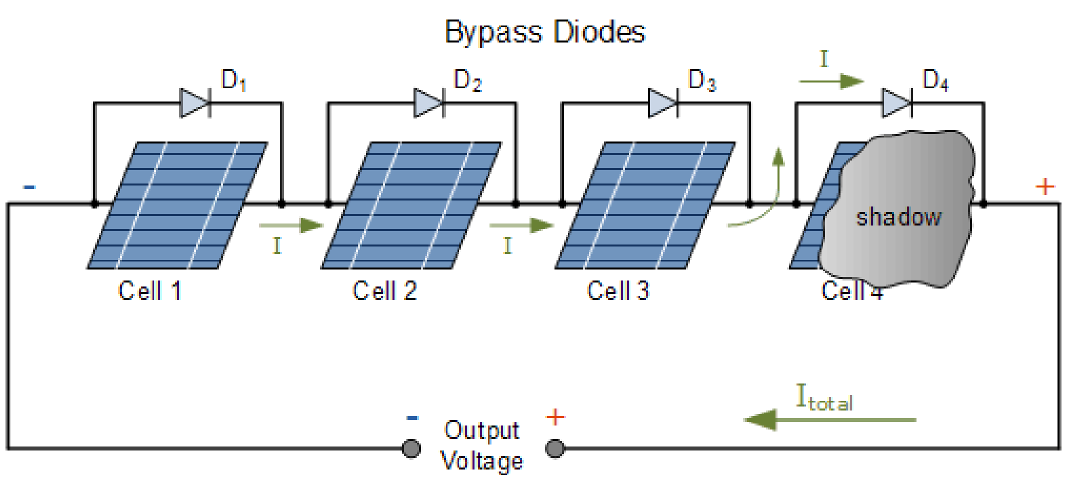


Fig. 2.10 Bypass Diode Protection

If the damaged cell is reverse biased, the voltage in damaged cell is limited by the bypass diode and it allows current to flow. The conductivity of the bypass diode allows current to flow from the working solar cell to the external connected circuitry.

Parallel Connected Photovoltaic Cells

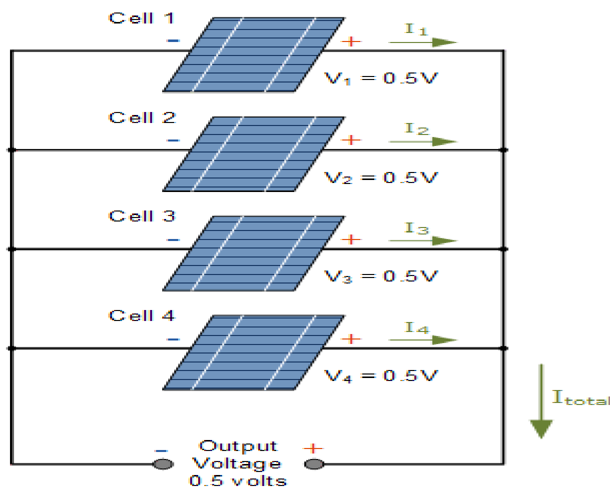


Fig. 2.11 Parallel Connected Photovoltaic Cells

To increase current production, photovoltaic solar cells can be joined in parallel. The addition of power produced through a discrete cell, or result of multiplying potential by output current, is the combined power. A voltage mismatch might be more severe in solar photovoltaic panels that are linked in parallel. The faulty cell ceases producing power as the panel current rises and instead dissipates or absorbs energy

Since we need to increase the output voltage, the majority of cells are really linked in series.

2.8 Cells Needed for A Solar Photovoltaic Panel

Usage of 32 or 36 discrete cells, joined in a series configuration, a representative 12-volt PV panel produces a peak output of roughly 18.5 to 20.8 V (considering 0.58V cell potential), which is sufficient to charge a conventional 12 V storage.

Solar Panel:

The panel is necessary to combine and send the energy production of several solar cells to your inverter and house, even though a single photovoltaic cell may convert sunlight into electricity on its own.

Typical 36 Cell Photovoltaic Panel:

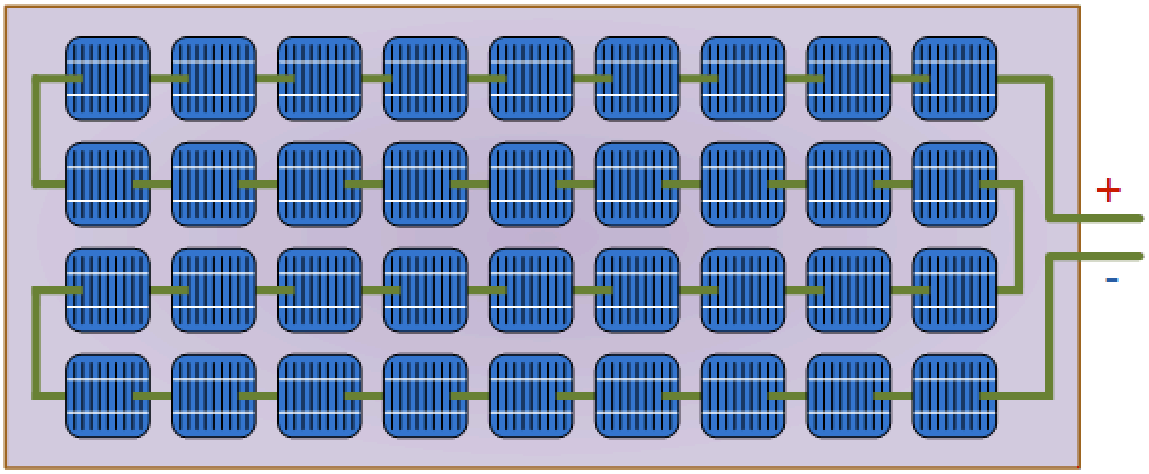


Fig. 2.12 Photovoltaic Cells

A 36-cell module is the chosen panel for the majority of applications. This module provides around 21 V V_{oc}, considering a maximum cell potential of 0.58 volts, and drops approximately to 16.5 volts because complete load. The photovoltaic cells are put in a glass-layered and sealed to protect them from corrosion, moisture, pollution, and weathering. They are attached in parallel and produce the required current and coupled like series to get appropriate voltage. The PV Panel can be worked upon discretely or in combination of parallel & series to create a bigger array that produces higher output of current and voltage.

2.9 Solar Panel I-V Characteristic Curves

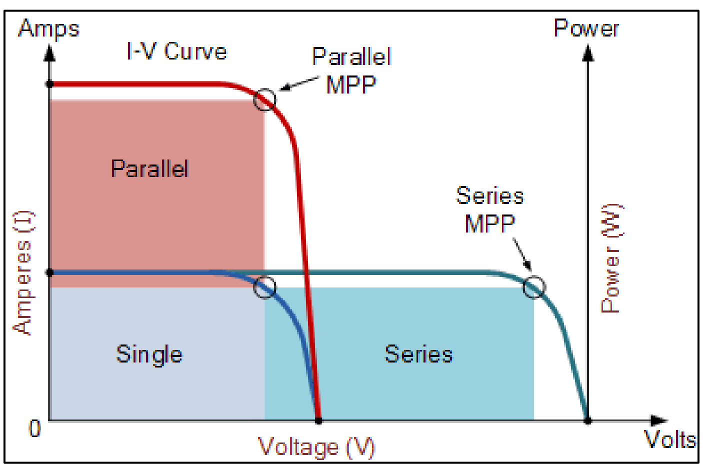


Fig. 2.13 I-V Characteristic Curves

How so ever, the solar panels are arranged, the upper right-hand corner will at all times be the MPP of array.

2.10 Electrical Characteristics

The PV array's output voltage (V) is influenced by the operating temperature of the solar cells, while the PV array's output current (I) is controlled by the amount and intensity of solar irradiance. **VOC = open-circuit voltage** refers to the array's highest voltage when the terminals are not connected to any load. This number is significantly greater than Vmax, which has to do with how the PV array operates and is fixed by the load.
I SC = short-circuit current – The PV array's maximum current when the output connections are shorted together. This figure exceeds Imax, which refers to the typical working circuit current, by a significant amount.
P max = maximum power point – This refers to the moment at which the array's output power, Pmax, which is calculated as Pmax = Imax x Vmax.
FF = fill factor – The connection between the array's maximum practical power under typical operating circumstances and the product of the open-circuit voltage and the short-circuit current, (Voc x Isc), is known as the fill factor.
% eff = percent efficiency is the ratio between the maximum electrical power and the solar radiation that hits the array. A typical solar array typically has a low efficiency of 10-12%.
Open-Circuit Voltage Temperature Coefficient – The open-circuit voltage of a pv panel will increase as the panel's temperature decreases.

2.11 The Solar Photovoltaic Array:

It is a structure of solar panels attached together. An array is just a collection of panels that have been connected to create an array. Generally speaking, higher is surface area of array, greater solar power will produce. The array will generate the required amount of power by joining numerous individual panels in series (for a greater voltage) and parallel (for a greater current requirement).

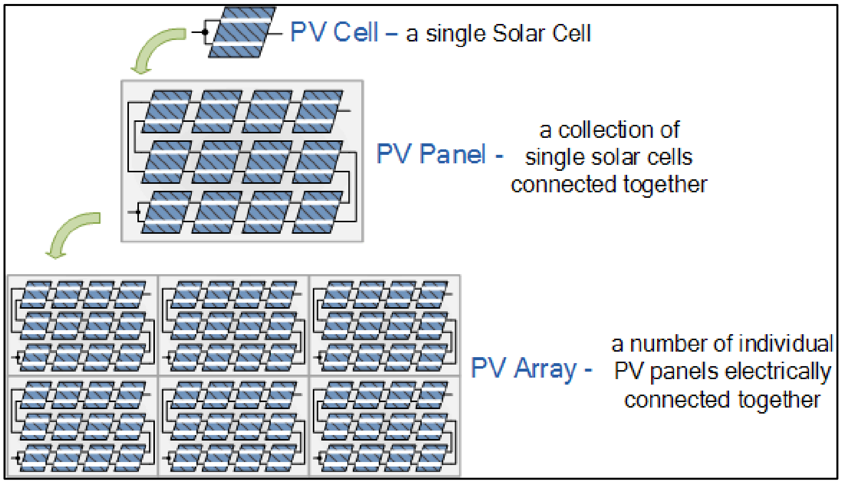


Fig. 2.14 Photovoltaic Solar Array

2.12 Photovoltaic Array Connections

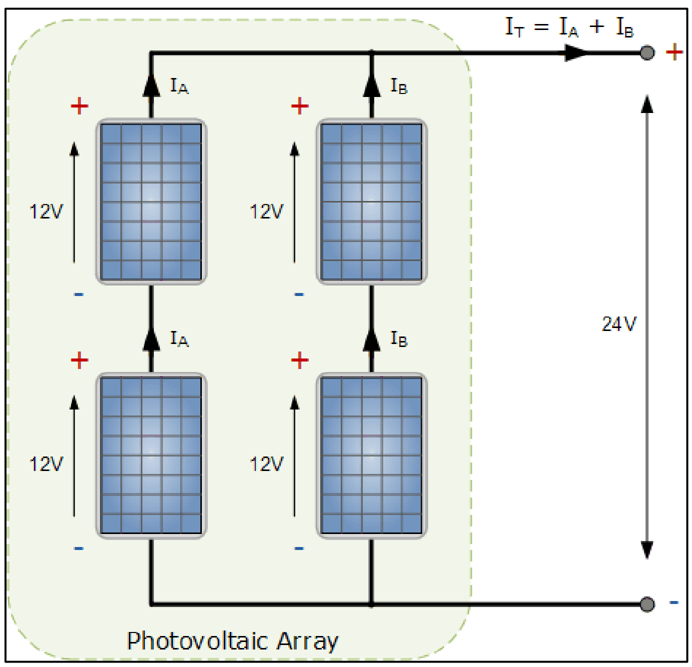


Fig. 2.15 Photovoltaic Array Connections

The actual maximum output power is typically much lower than the estimated value due to various amounts of solar radiation, temperature impact, electrical losses, etc.

CHAPTER 3

Literature Survey

Chapter 3: Literature Survey

3.1 Literature Survey

Sr. No.	Title of the Paper	Year of Publication	Publisher	Methodology	Conclusion
1	**Data Acquisition System for Solar Panels**	2019	International Spring Seminar on Electronics Technology	Utilizing Grafana and Influx DB, clear sky radiation forecast and time series data visualisation.	It laid the basic structure for open-source environmental watch system designed solely to maximize solar energy production.
2	**Design Of Photo Voltaic Solar Cell Model for Standalone Renewable System**	2014	IEEE International ELEKTRO Conference	PV solar cell single diode comparable circuit modelling in MATLAB	This PV solar panel model was created using the basic circuit equations for PV solar cells. For verification he used simulations in MATLAB.
3	**Five-Parameter Model of Photovoltaic Cell Based on STC Data and Dimensionless**	2012	IEEE 27th Convention of Electrical and Electronics Engineers	Consider the following variables: bandgap energy, temperature coefficient of photogenerated current, ideality factor, photocurrent, reverse saturation current, series resistance, and shunt resistance.	The following variables are considered: Bandgap energy, photocurrent, saturation current in reverse bias, factor of ideality, resistance in series, resistance in parallel, temperature coefficient of photogenerated current.

4	**PV Panel Model Based on Datasheet Values**	2007	IEEE International Symposium on Industrial Electronics	Building a PV Panel Model Using a Single-Diode 5-Parameter Model Based on Datasheet Parameters Only	Making a Single-Diode 5-Parameter PV Panel Model Based Only on Datasheet Parameters
5	**A Simple and Accurate Model of Photovoltaic Modules For Power System Design**	2007	IEEE International Symposium on Industrial Electronics	To assess the accuracy, simulation results from two models with five and four lumped parameters, as well as manufacturers' curves, are compared.	A modelling approach for designing devices powered by PV panels has been put out and thoroughly examined.

3.2 Summary of Literature Survey

1. Data Acquisition System for Solar Panels

A free, multi-ruled environmental watch system that maximises the production of solar energy was built on the groundwork provided by this study. Future research will concentrate on creating more precise weather forecast models given the enormous amount of data that which can be collected from wireless sensor nodes and other sensors that can be added to existing structures through RS485 networks.

2. Design of Photo voltaic Solar Cell Model for Standalone Renewable System

Globally, solar energy usage is rising. The biggest disadvantage is that it depends on the weather. To replicate this dependence, a mathematical model has been put forth. This model of a PV solar panel is depending on the fundamental electrical equations for PV solar cells. Validation was done using MATLAB simulations. By contrasting the generated I-V curves with the Sharp NU-245 (J5) 245Wp datasheet, the model's accuracy is demonstrated. Researchers looked at how temperature and sunshine affected people. Temperature is less important than sun radiation, particularly when efforts are made to lower solar radiation. Even more negatively affected is the output power.

Five-Parameter Model of Photovoltaic Cell Based on STC Data and Dimensionless

The characteristics of the single-diode solar cell model were determined in this work using an improved methodology. This approach combines reducing the discrepancy between theoretical and experimental data by solving a set of algebraic equations which contains parameters like Rs, Rsh, and the fifth parameter. The information supplied by the producer in the panel data sheet of STC is included in the collection of experimental data needed for model parameter extraction. The experimental data accuracy of 3% of manufacturer-supplied data is often insufficient due to the substantial dependence of the derived parameters of the model on the correctness of the inputs.

3. A Simple and Accurate Model of Photovoltaic Modules for Power System Design

The characteristics of the solar cell containing single diode model were determined in this study using an improved methodology. With this approach, a set of parametric algebraic equations' solutions are combined. As a consequence of reducing the discrepancy between theoretical and experimental data, Rs, Rsh, and the fifth parameter are achieved. For the STC, these parameters were acquired. A set of algebraic equations which have temperature coefficients TC Voc and TC Isc were solved to generate two further parameters. Only the values listed in the manufacturer's STC panel datasheet are included in the collection of experimental data needed for model parameter extraction. Because the precision of the model parameters that are derived depends so heavily on input correctness, the practical accuracy of manufacturer-provided data (usually 3%) is not always adequate.

4. PV panel model based on datasheet values

The design of a single-diode PV panel, five-parameter model based solely on datasheet parameters is described in this study. The model accounts for the panel's series and parallel resistance (shunt). For a Photovoltaic cell or panel under STC, equivalent circuit designs and fundamental equations are provided, along with the extraction of parameters from datasheet values. Another equation that provides a better match with the datasheet power temperature dependency figures provides the dark saturation current of the cell's temperature dependence. In order to forecast module behaviour under varied temperature and radiation situations, PV module models based on these equations are created and evaluated.

CHAPTER 4

Methodology

Chapter 4: Methodology

4.1 Block Diagram

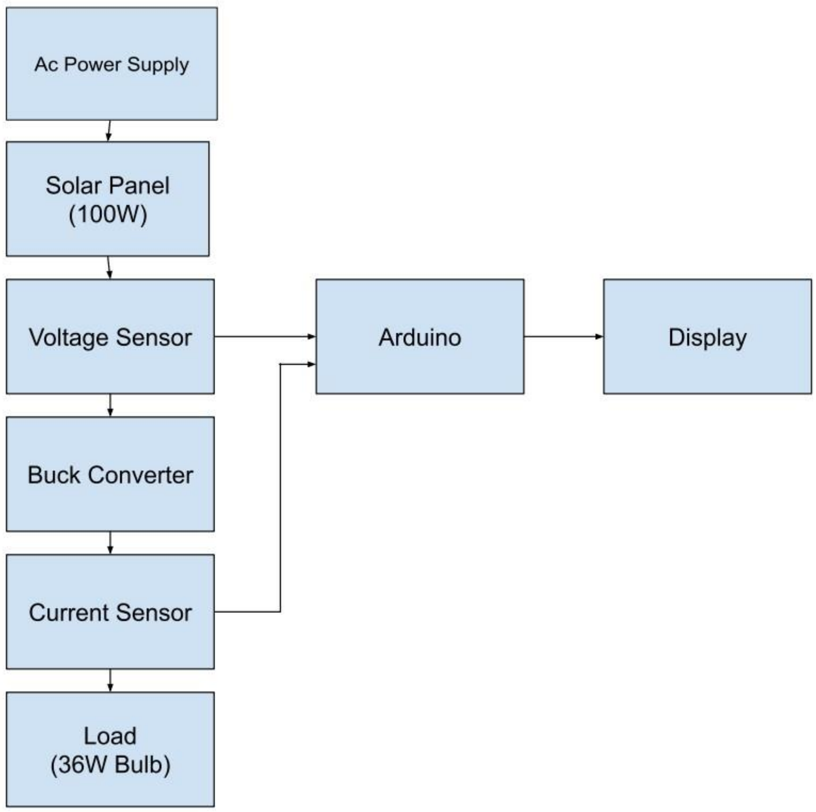


Fig. 4.1 Block Diagram

4.2 Elements Of Block Diagram

AC Power Supply

AC power supply is required to power the LED flood light which acts as light source for the Solar panel. It is 220V input voltage supplied to the light source. A voltage regulator can be used

to control the voltage to the LED light.

Solar panel

Solar panel generates power by using the light energy from the source. PV panels are collections of solar cells. Electrical equipment is powered by solar energy from photovoltaic arrays.

voltage sensor(0-25V)

It's a voltage detection module, A 0-25 DC voltage detector, is built using a resistive voltage divider circuit. When the analogue output voltage is divided by 5, it equals the signal of the input voltage.

Buck converter-

This module is used to step down the input voltage to desired value. The output can be set as per the requirement of the load. This is done by setting up the potentiometer.

Current sensor (ACS-712)

The ACS712 is a fully integrated linear current sensor that uses the Hall effect and has 2.1 kVrms of voltage isolation and a built-in low resistance current conductor. Current is now flowing through the IC's internal Hall sensor circuit.

Load

The load used here are 3 LED DC bulbs of 12W each. They consume the power and help to test the system. They are connected in parallel combination.

Arduino Uno

Arduino Uno is used as a central controller for the system. It is used to interface the various sensors that are being used to acquire the data in real time. Sensors are connected with Arduino Uno and real time data is being displayed on GUI using it. Arduino Uno performs the configuration and interfacing of sensors in the system. It powers the sensors through its 5V pin.

Display (GUI)

This is useful as it helps to visually understand the data. For solar panel we need to display various parameters such as current, voltage and Power generated using a computer-based GUI.

4.3 Parameters

Output Voltage

It is the voltage obtained at the output terminal. It changes as the solar irradiance changes. It has an immediate impact on the overall power produced.

Output Current

It is the current obtained at the output terminal of the circuit. Its value change as the light intensity changes. It has an immediate impact on the overall power produced.

Power Generated

Electric power is the rate at which energy is transformed into a circuit that conducts electricity or is utilized to drive a machine. The solar panel utilizes the photonic energy and generates the potential difference at its end terminal and powers the system.

Irradiance

It refers to solar energy per unit area. The solar panel output value is dependent on the solar irradiance value. Increase in irradiance also increases the panel output and vice versa is also true.

4.4 Block Diagram Explanation

The hardware setup attempts to signify the power generating capability of a solar panel. The output power of the model is determined by the irradiance received by the solar panel. To provide light energy, a 100w floodlight is used. By varying the irradiance received by the panel the subsequent output power is varied. A buck converter is used to step down its input voltage to suite the load requirement. A range of sensors is interfaced with the system. These sensors include those for measuring output voltage, output current and measuring irradiance. Arduino uno, a microcontroller board, is employed to gather data from the sensor. The GUI serves as a visualization tool, presenting the Collected data in a user-friendly manner, facilitating analysis and interpretation of the system's Performance. Overall, this hardware testing setup enables comprehensive evaluation and characterization of the Solar panel module, and other system parameters. The integration of Sensors, Arduino uno, and the GUI contributes to efficient data acquisition, monitoring, and Analysis in the lab environment.

CHAPTER 5

Software Implementation

Chapter 5 Software Implementation

5.1 Software Used

MATLAB & SIMULINK

Multidomain simulation, automatic code generation, and Modelled Design for embedded system testing along with verification are supported by MATLAB. Whereas Simulink is a simulation and modelled design platform for embedded & dynamic systems connected to MATLAB. It is a MATLAB led graphical programming space for dynamic multidomain systems that enables modelling, simulation, and analysis. The main user interface consists of a block diagram tool and a collection of customizable libraries. It can be used to be driven or programmed from MATLAB and allows a tight connection with the remaining MATLAB space. Simulink is widely used in digital signal processing and automated control for multidomain simulation and Model-Based Design.

Easy EDA

It is an online EDA toolset that helps hardware engineers to create, simulate, share PCB simulations and schematics. further features involve development of parts lists, Gerber files, pick-n-place files, and document output in various formats. EasyEDA allows you to create and modify schematics, SPICE simulations with mixed analog and digital circuits, create and edit PCB layouts, and optionally his PCB fabrication.

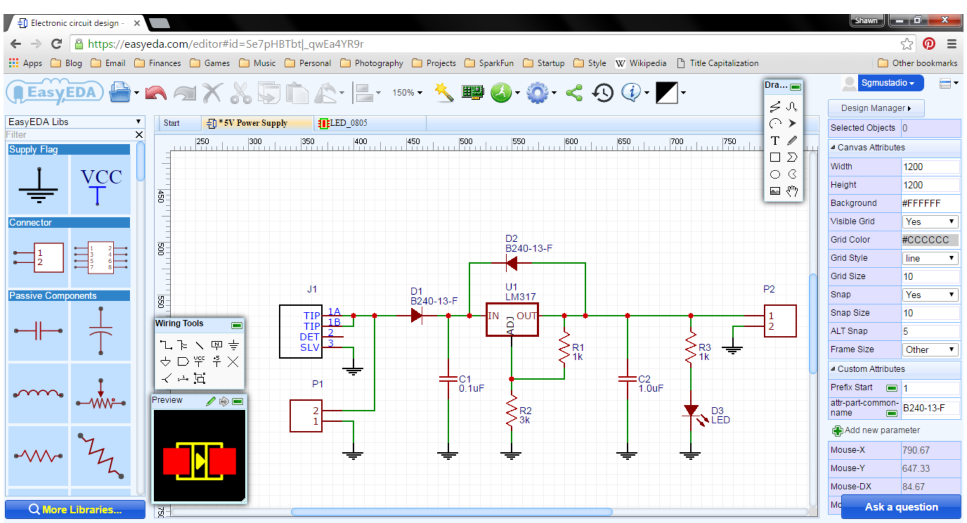


Fig 5.1 EasyEDA

Arduino IDE

The Arduino IDE is a software used to program Arduino microcontrollers. It allows you to write, compile, and upload code to your Arduino board. You can download the IDE from the official Arduino website and install it on your computer. Once installed, connect your Arduino board via USB and select the correct board and port in the IDE. You can then write your code in the editor window, compile it, and upload it to the Arduino board for execution. The Arduino IDE provides a simple and user-friendly interface for programming Arduino devices.

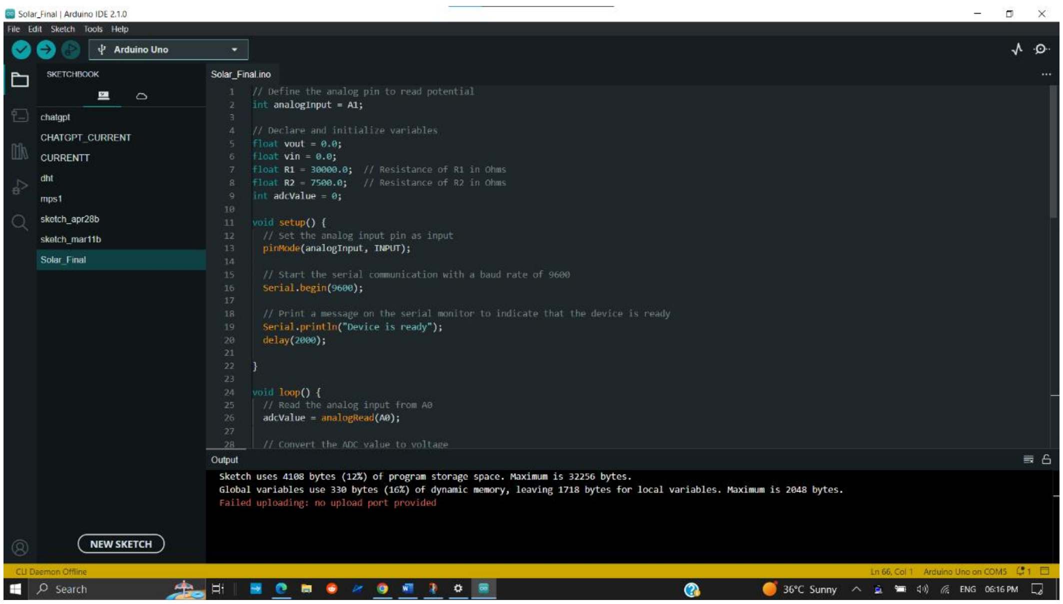


Fig 5.2 Arduino IDE

Putty

Putty is a free and open-source terminal emulator, serial console, and network file transfer application. It is primarily used on Windows operating systems to establish secure shell (SSH) connections to remote servers or devices. Putty allows users to remotely access and manage systems through a command-line interface. The software provides a simple, lightweight, and easy-to-use interface for connecting to servers or devices using various protocols, including SSH, Telnet, rlogin, and raw socket connections. It supports a wide range of network protocols and encryption algorithms, making it a versatile tool for network administrators, developers, and anyone who needs to access remote systems securely.

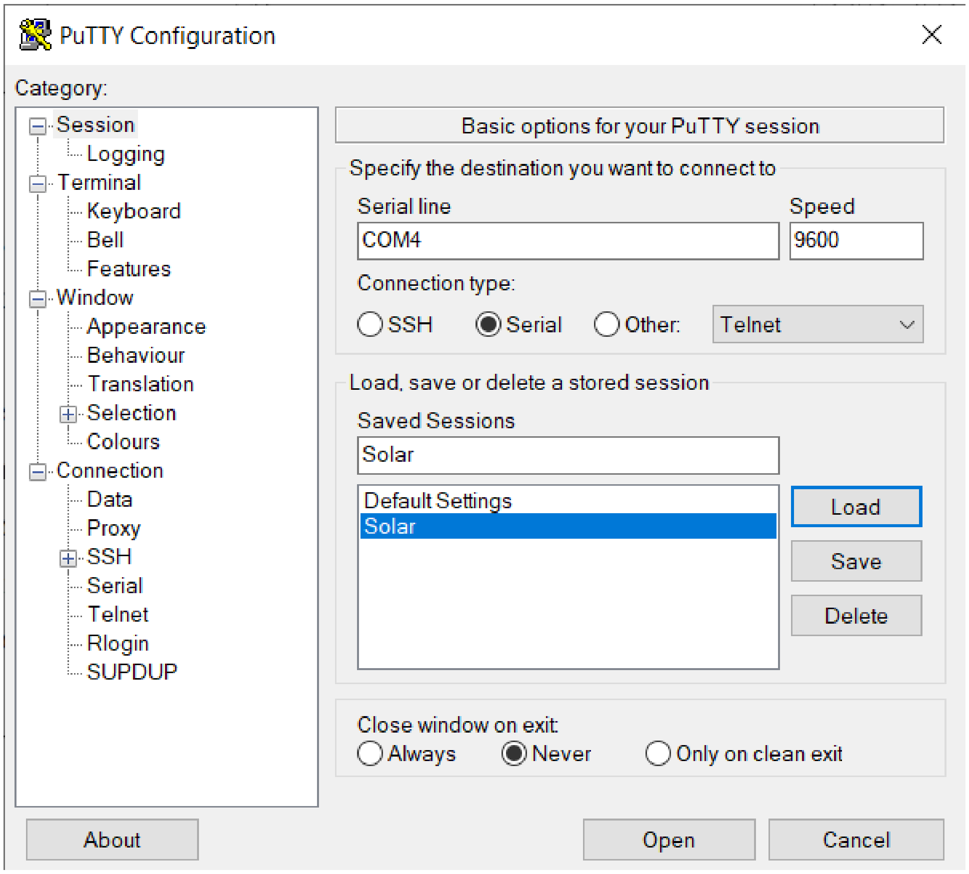


Fig 5.3 PuTTy Software

5.2 MATLAB Simulations

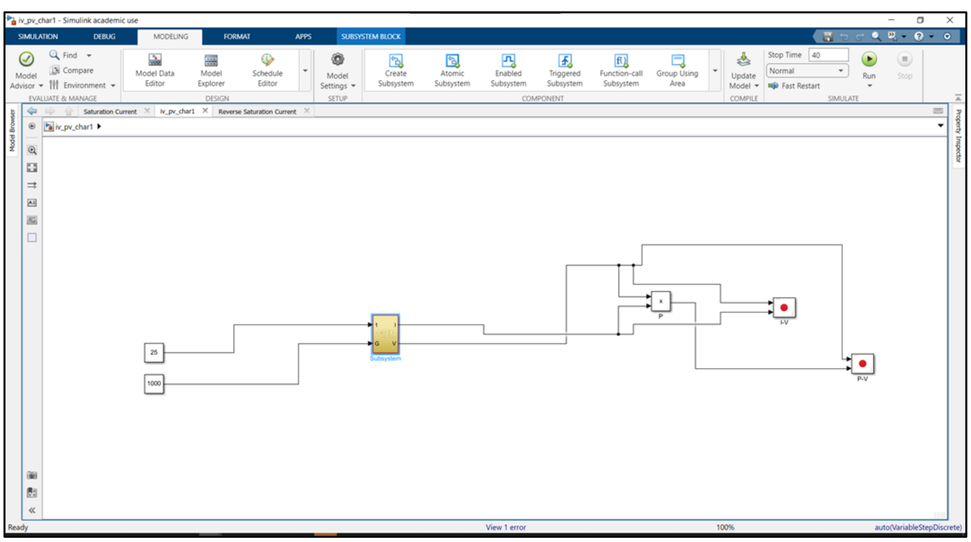


Fig 5.4 MATLAB Simulation

The figure shows the mathematical modelling of equations mentioned above, here we have used the constant block (To provide an input port for the subsystem) for input to a solar panel input parameter irradiance is provided through a constant block. The constant irradiance we can change manually to observe the changes in various plots.

In our model we have treated temperature as a constant parameter whose value we have given as normal temperature that is 250C.

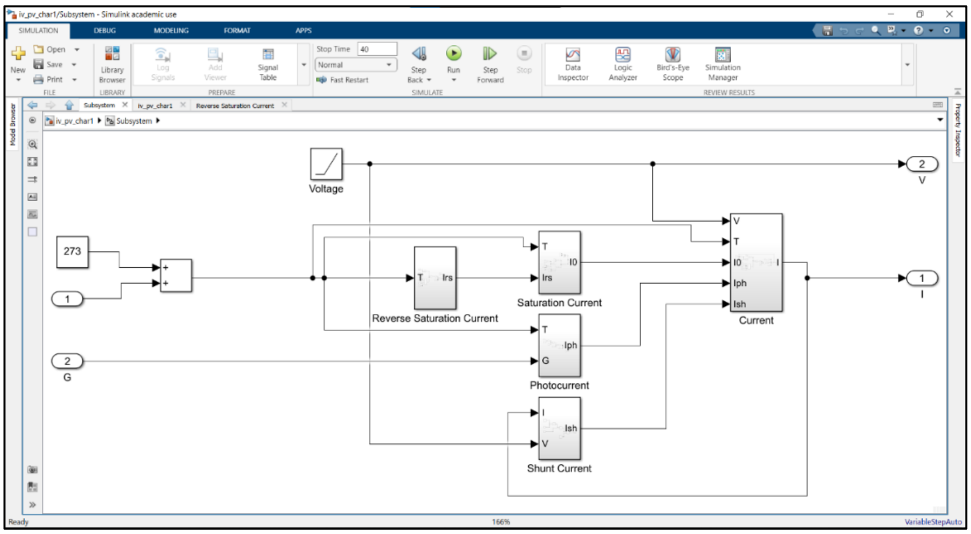


Fig 5.5 Subsystem

The subsystem is then divided in 4 major blocks the blocks are as follows:

1. Saturation Current
2. Reverse saturation Current
3. Photo Current
4. Shunt Current

These four constitutes total current.

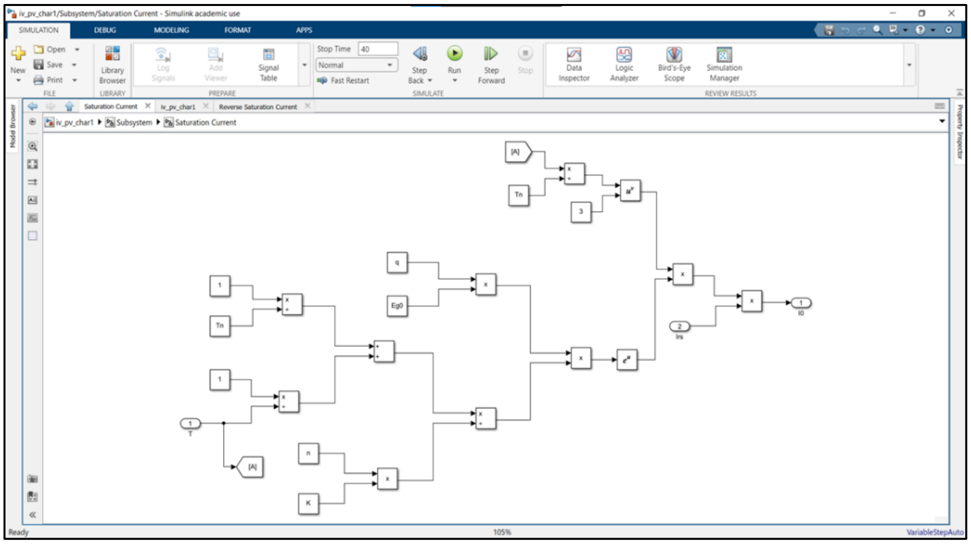


Fig 5.6 Saturation Current

$$I_{sh} = [v*(N_p/N_s)+(I*R_s)]/R_{sh}$$

$V_t = K*T/q$

N_p = number of PV modules connected in parallel;

R_s = series resistance (Ohm);

R_{sh} = Shunt resistance (Ohm);

V_t = diode thermal voltage(V)

By using above equation, we are able to calculate the Saturation Current

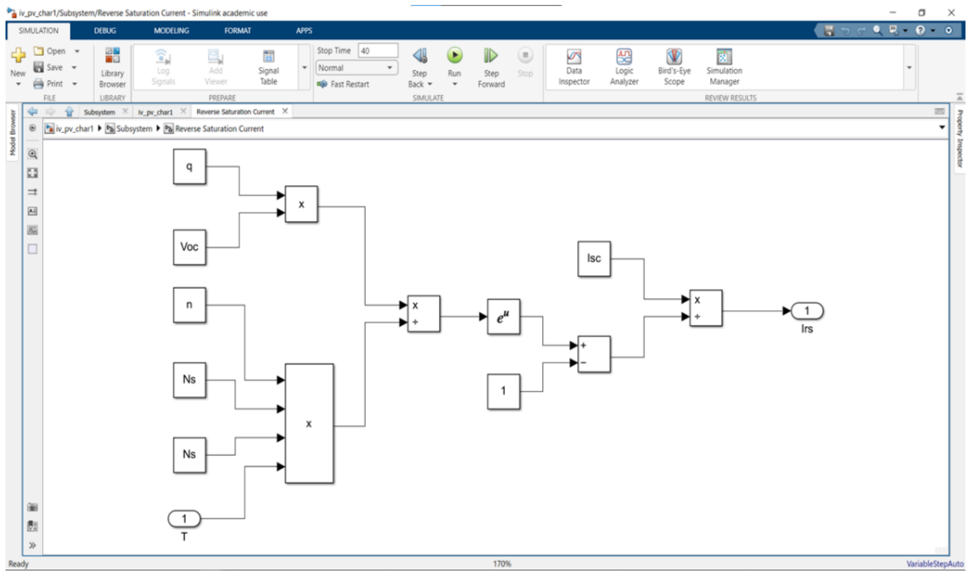


Fig 5.7 Reverse Saturation Current

By using below equation, we are able to calculate the Reverse Saturation Current

$$\mathbf{I_{rs} = (I_{sc})/(e^{(qV_{oc}/N_s K n T)} - 1)}$$

q = electron charge;

V_{oc} =Open circuit voltage(V);

N_s =Number of cells connected in series;

n= ideality factor of diode;

k=Boltzmann Constant

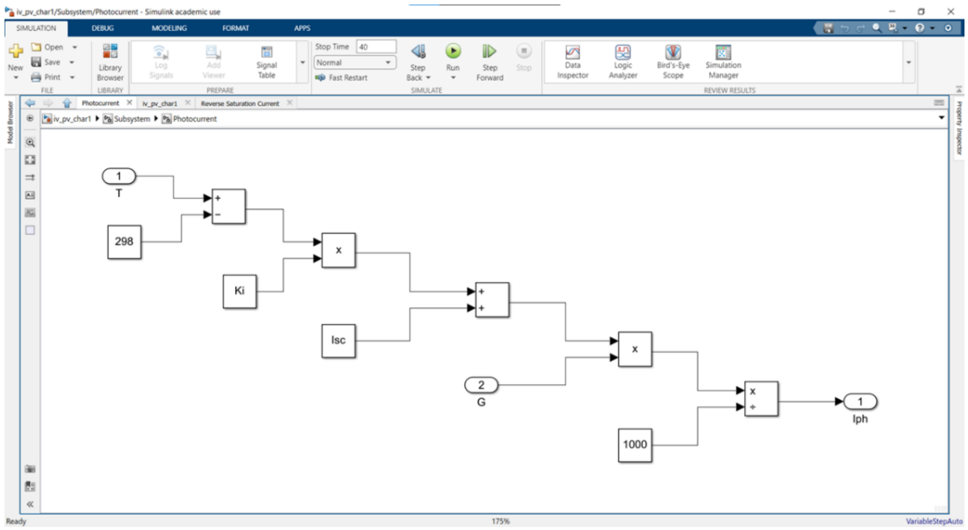


Fig 5.8 Photo-Current

By using below equation, we are able to calculate the Photo-Current

$I_{ph} = [I_{sc} + K_i (T-298)] * (I_r / 100)$

I_{ph} = Photo-current (A);

I_{sc} = Short circuit current (A);

K_i = Short circuit current of cell at 25 ˚ C and 1000W/m 2

T= Operating temperature(K);

I_r = Solar irradiation (W/m 2)

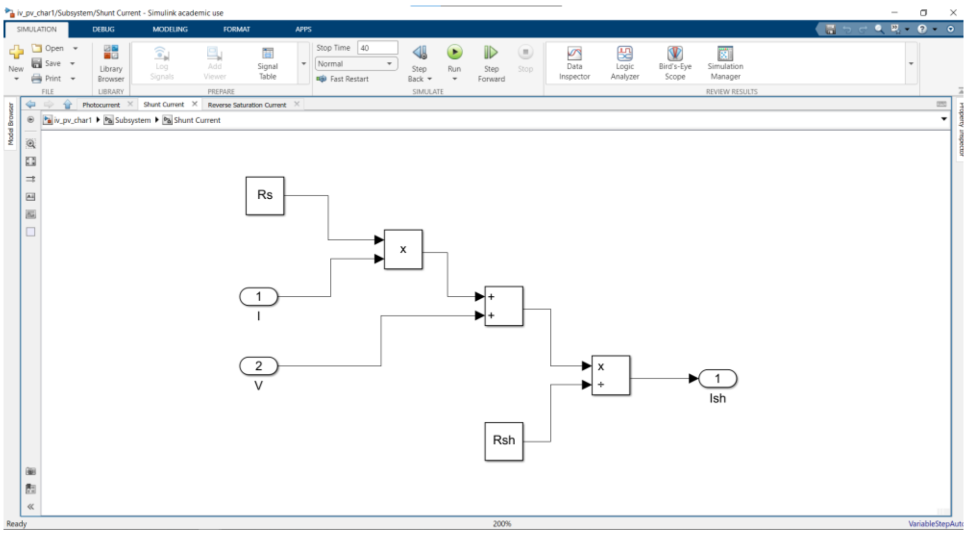


Fig 5.9 Shunt-Current

By using below equation, we are able to calculate the Shunt Current

$$\mathbf{I_o = \{I_{rs}\,[T/T_r]^3\}\{e\,[(q*E_{go})/nk(1/T-1/T_r)]\}}$$

T_r= Nominal Temperature

E_{g0} =Bandgap energy of the semiconductor

$$\mathbf{I=N_p*I_{ph} - N_p*I_0*\{e\,[(V/N_s)+I+(R_s/N_p)]/n*V_t\,]-1\}}$$

Constant Values:

K= $1.3805*10^{-23}$ J/K

E_{g0} =1.1eV

T_r =298.15 K

Reverse saturation current, Saturation current, Shunt current, Photocurrent collectively constitute the total current. The net current collectively produced is the photocurrent I_L (the current generated by the incident light is directly proportional to the solar irradiation) minus I_D (the diode current) and minus the current due to losses Ip.

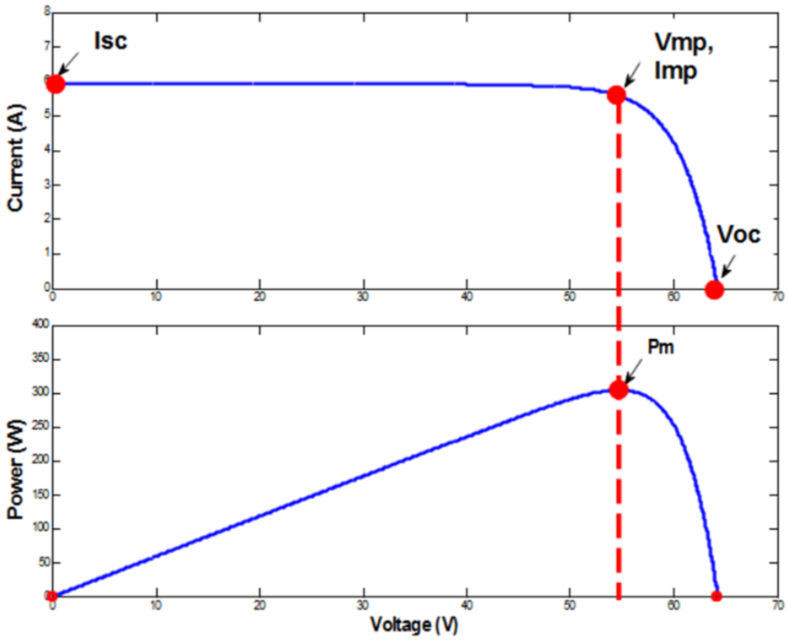


Fig 5.10 IV and PV Curves

This is the ideal characteristics of a solar PV array. According to the configuration of the solar panel we get the values of current and voltage by using those values we can define the power output of the respective panel. We get the maximum voltage at open circuit and as the load value increases the voltage value decreases and the current value increases. At short circuit we get the maximum value of current.

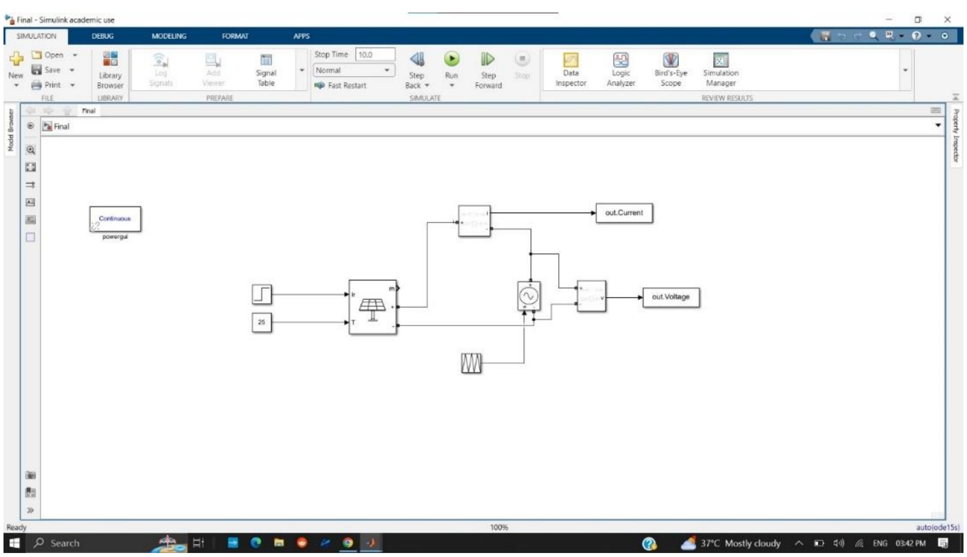


Fig 5.11 MATLAB Simulation

In the above model, we have provided step input to the PV array as irradiance and the step value we have provided is 1000 and other constant block is used to give temperature value and its value is 250C.Then the array is connected to the current and voltage measurement block as a temperature block and values then calculated with the help of controlled voltage source. The repeating sequence is provided to the controlled voltage source.

By using plot (out.Voltage, out.Current) the output V-I characteristics are plotted as well power can be calculated as power=(out.Current.*out.Voltage) and the calculated power is used to plot the power Vs voltage plot and power vs Current plot by using the command as follows:

plot(out.current, power); *for current vs power plot*

plot(out.voltage, power); *for voltage vs power plot*

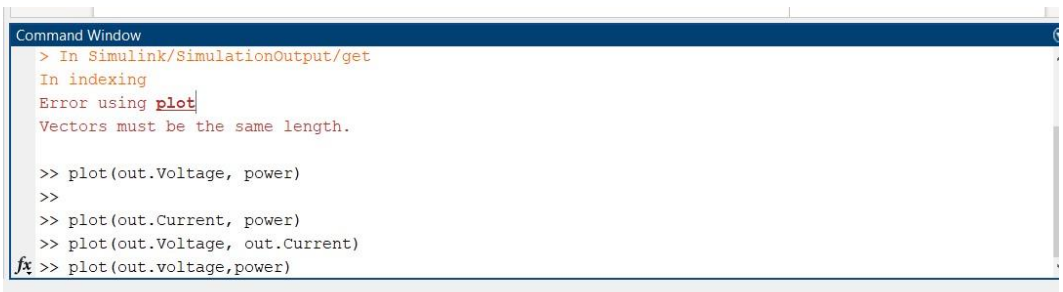


Fig. 5.12 Commands

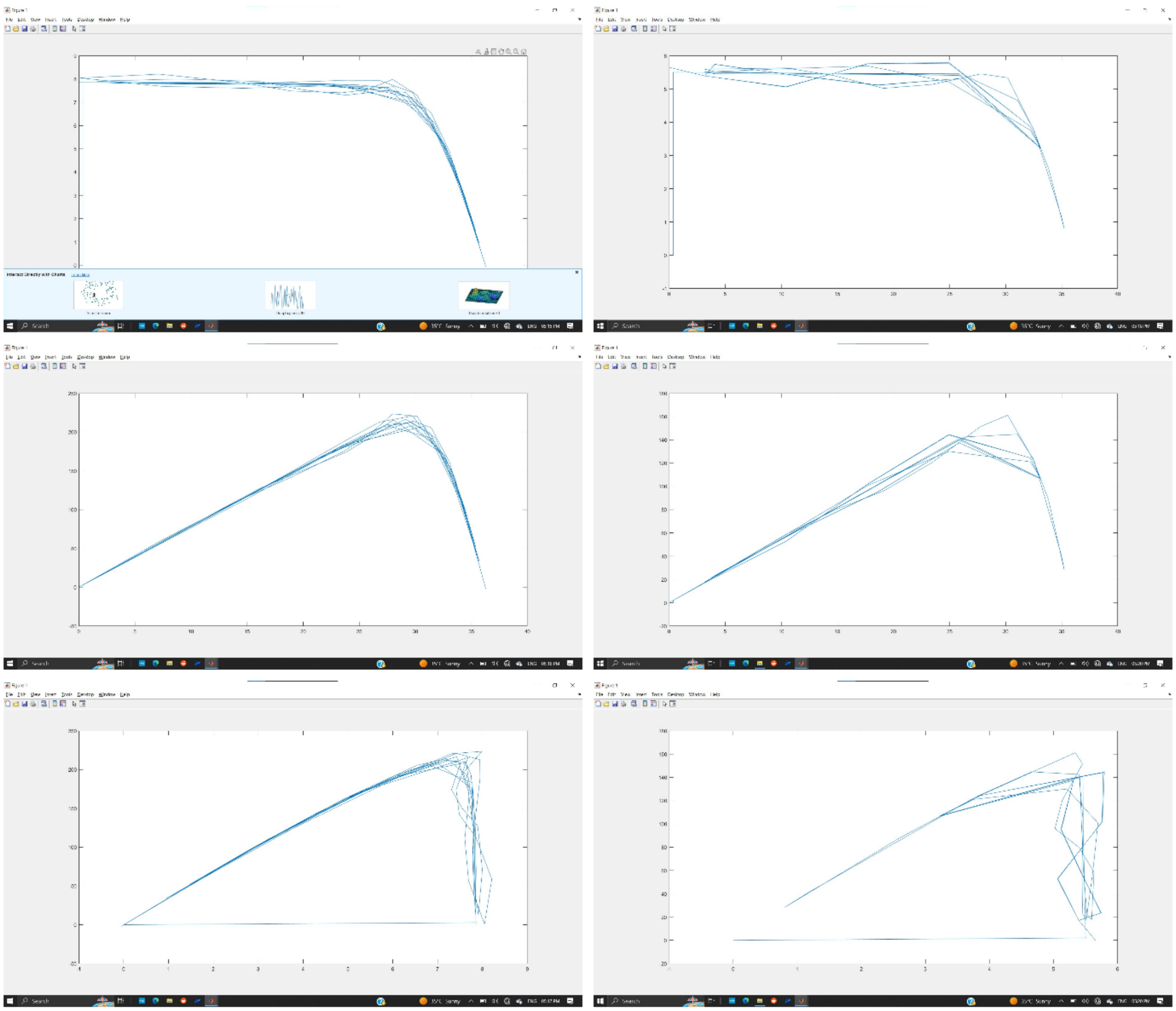


Fig. 5.13 Simulation Results (Voltage vs Current)

5.3 Graphical User Interface (GUI)

Graphical User Interfaces (GUIs) provide a user-friendly way to interact with electronic devices and display real-time data. In this note, we will explore how to use the PuTTY software, along with serial communication, to create a GUI for displaying parameters such as current, voltage, and power values.

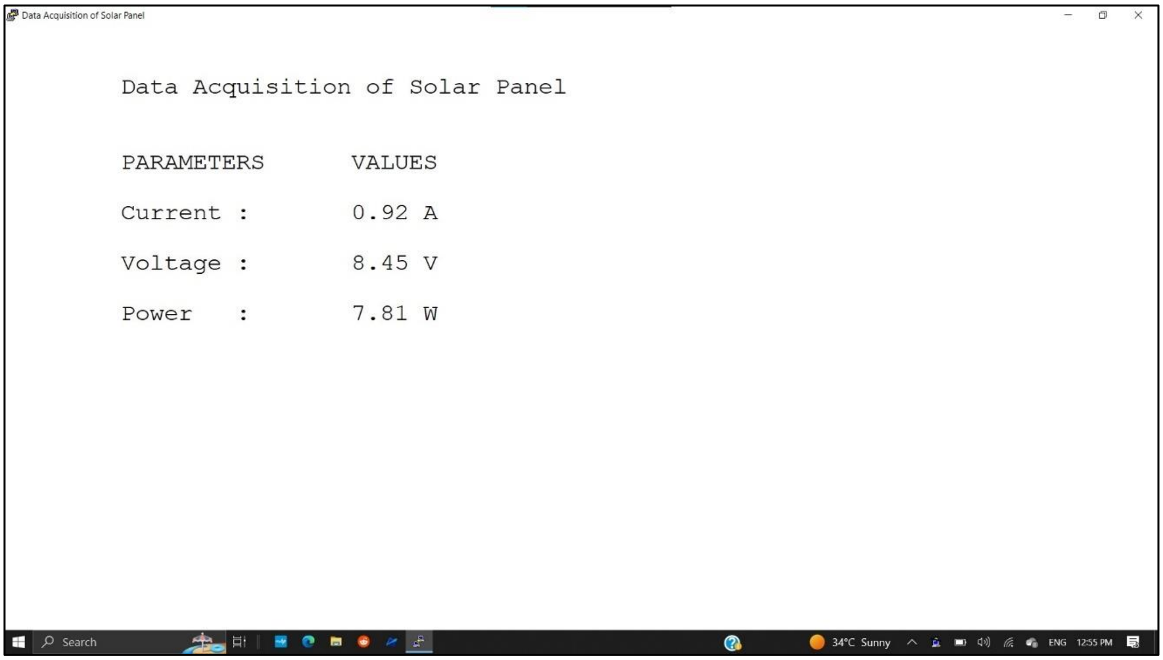


Fig. 5.14 Graphical Interface using Putty Software

CHAPTER 6

Hardware Implementation

Chapter 6: Hardware Implementation

6.1 Circuit Diagrams

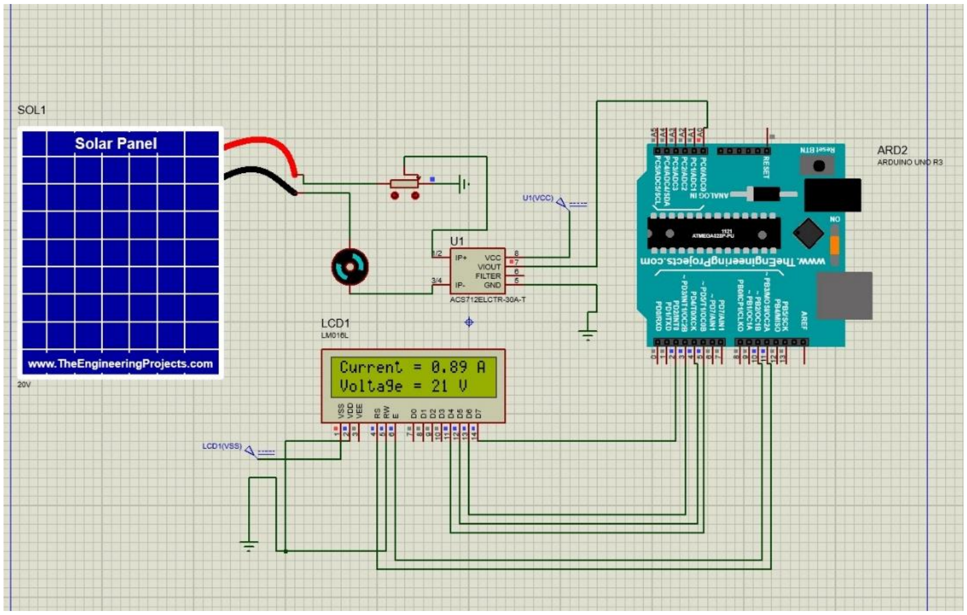


Fig. 6.1 Circuit Diagram

6.2 Hardware Specification

Arduino UNO:

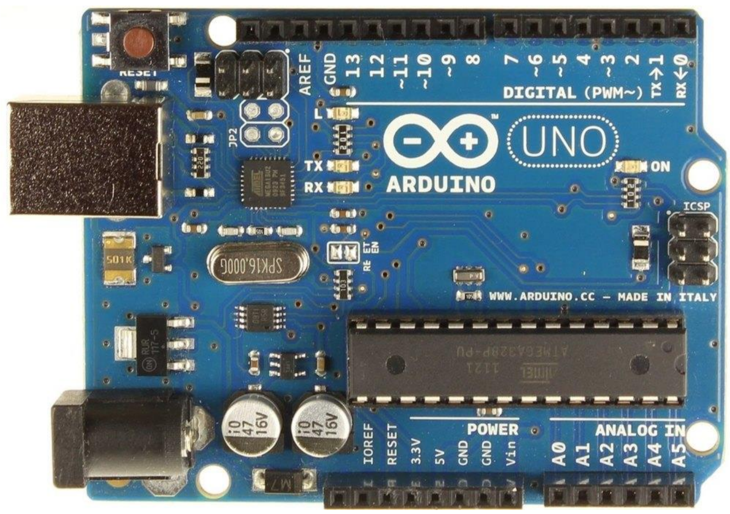


Fig. 6.2 Arduino UNO Board

The Arduino Uno is a popular and widely used microcontroller board based on the ATmega328P chip. It is part of the Arduino family of open-source hardware and software platforms, designed for beginners and professionals alike to create interactive projects and prototypes.

Current Sensor (ACS712):

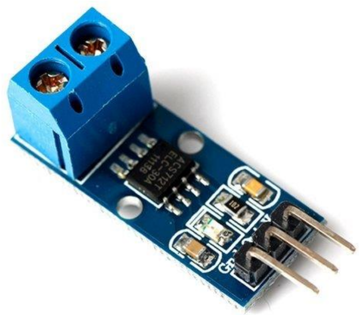


Fig. 6.3 Current Sensor (ACS712)

The fully integrated ACS712 is Hall-effect based linear current sensor with a built-in low resistance current conductor and 2.1 kVRMS voltage isolation. Without jargon, simply called a current sensor, it detects and measures the level of current applied through a conductor.

Voltage Sensor:

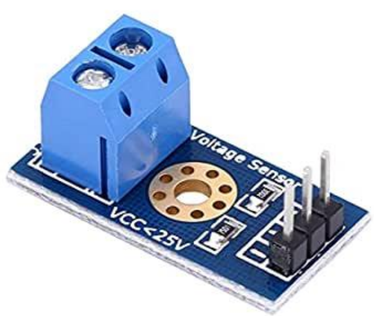


Fig. 6.4 Voltage Senor

This simple but very practical module uses a voltage divider to reduce the input voltage by a factor of 5. The 25V Voltage Sensor Module allows you to monitor much higher voltages than your microcontroller can monitor through its analog inputs. A 0-5V analogue input range, for instance, allows you to measure voltages up to 25V. Convenient screw terminals are also included with this voltage sensor module to make connecting a wire simple and safe.

Solar Panel (GTK-100W-36P**):**

Fig. 6.5 Solar Panel

Maximum use of the sun's energy. Very little deterioration. Solar cells bonded between a high transmission toughened glass surface and a UV resistant polymer (eva). Nylon terminal box for output connections that is tough and weatherproof. Monocrystalline and polycrystalline silicon cells with high efficiency. Environmental protection is provided by laminating with tedlar, crane glass, and eva. Anodized aluminum frame offers mounting support and shock absorption. Produced under strict quality controls.

6.3 Hardware Testing

Hardware testing is done with the solar panel module which produces output power depending on the irradiance of flood light. The flood light was used to provide the panel with irradiance. The irradiance received by the solar panel is varied and hence panel produces the variable output as per the irradiance received. A set of 12W led bulb were used as load across the output terminal. Various sensors are interfaced to measure the parameters such as output voltage, output current and measuring irradiance. Arduino UNO is used to collect the data from the sensors and provide it to the Putty based GUI for displaying.

The block diagram of hardware setup used for the testing purpose is as follow:

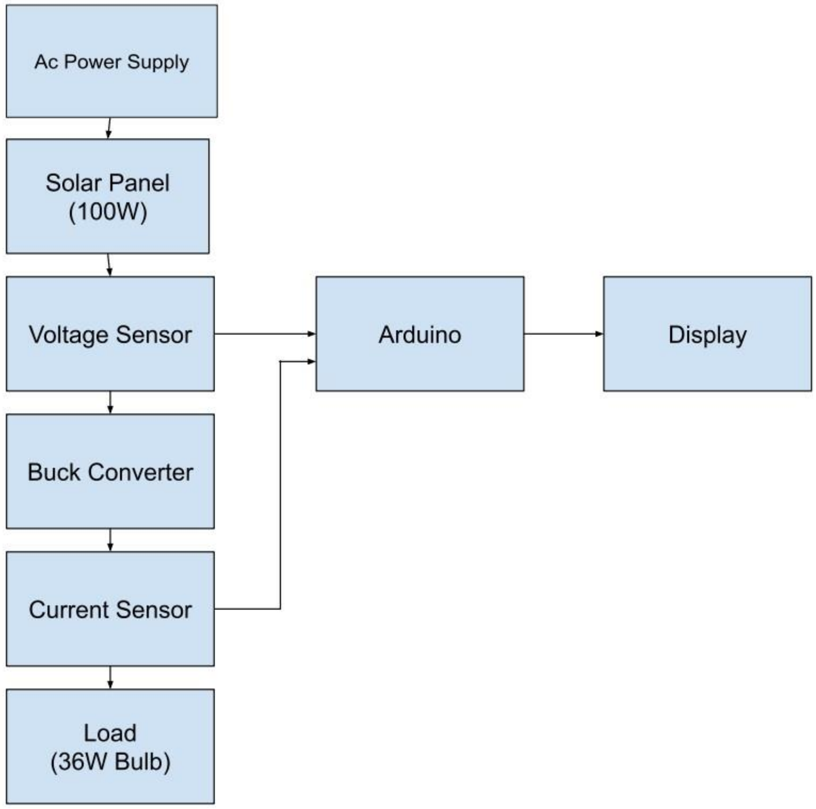


Fig 6.6 Hardware Implementation Block Diagram

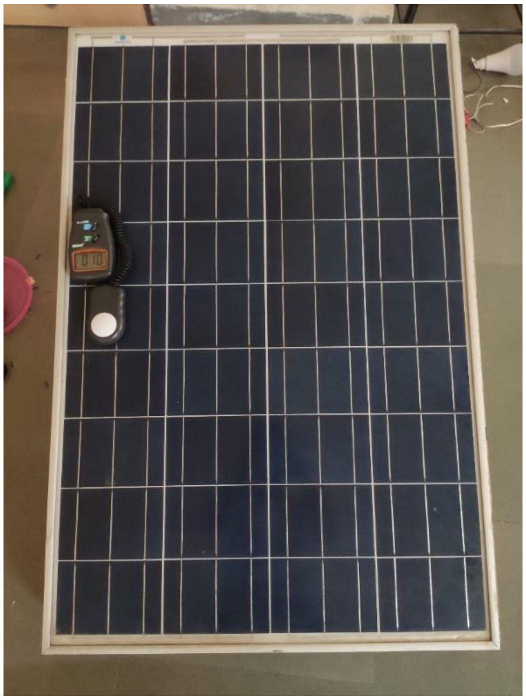


Fig 6.7 Solar Panel & Lux Meter

Fig 6.7 shows the setup of solar panel which is used to generate the power. Irradiance is provided to the panel to generate the power. Lux meter is attached to panel to measure the irradiance.

Fig 6.8 Light Intensity Measurement

Fig 6.8 shows the lux meter measuring the irradiance. This value varies according to the variation in irradiance. It is further used to calculate the theoretical value of the power.

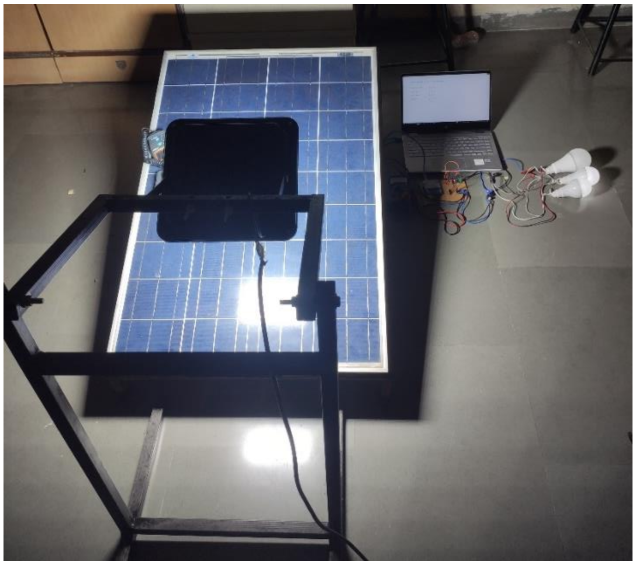


Fig 6.9 Solar Panel Testing

Fig 6.9 shows the setup where solar panel receives light from the flood light which further generates the power in Watts.

Fig 6.10 Setup Testing

Fig 6.10 demonstrates amount of irradiance received by the solar panel thus the value showcased by the luxmeter is the least.

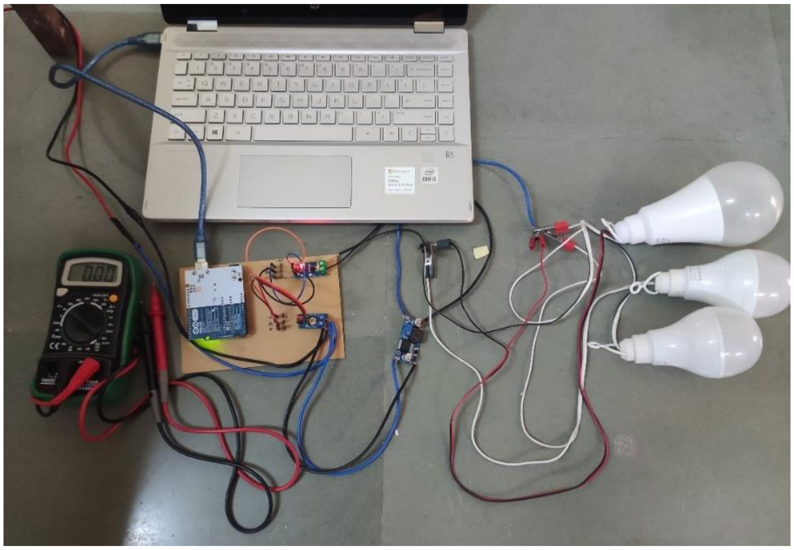


Fig 6.11 Hardware Implementation

Fig 6.11 shows the setup for no irradiance received by the solar panel. The multimeter shows 0A current generated by the system. The loads show no result.

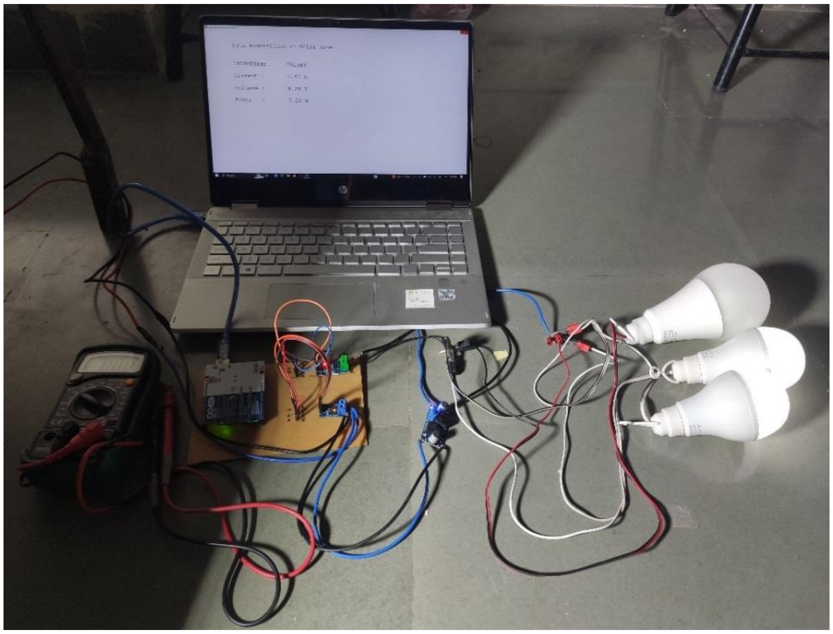


Fig 6.12 Testing All Sensors

Fig 6.12 shows the setup for significant irradiance received by the solar panel. The GUI shows significant output generated by the system. The loads also satisfy the result by glowing.

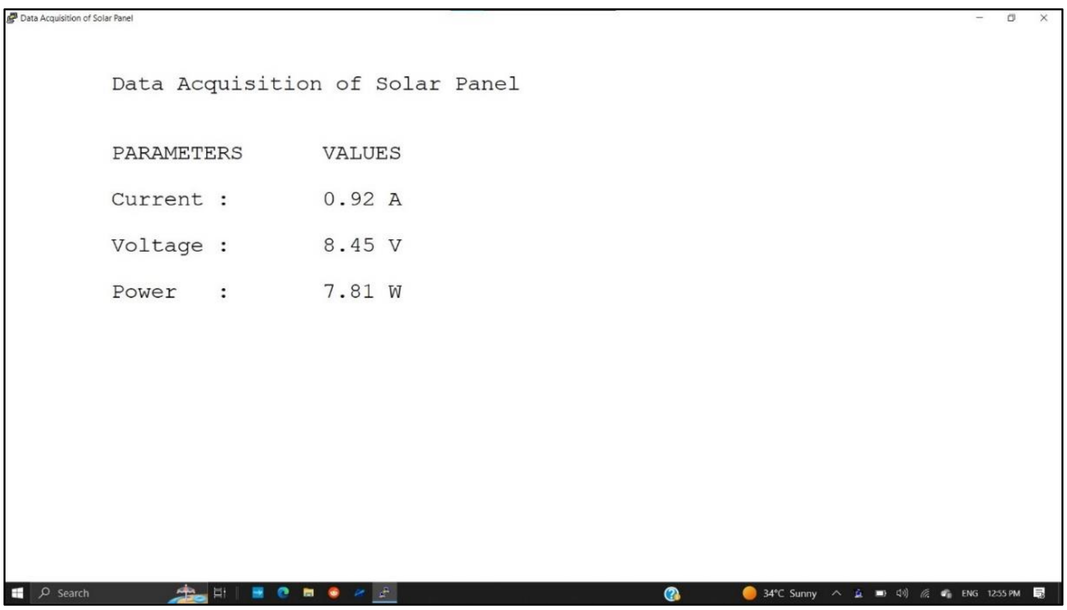


Fig 6.13 Results on GUI

Figure 6.13 shows the GUI that displays the data acquired from the system. All the data from sensors is displayed in the real-time.

6.4 PCB Designing for Arduino Sensors Interfacing

Easy Eda software is used for designing the PCB. The process involves creating a new project, adding a schematic design template, and selecting components from the manufacturer part search. The circuit design is completed by making the necessary connections and annotating the components. A PCB template is added, and after updating the PCB design, the components are placed according to the designer's placement pattern. Finally, tracks are routed on both the top and bottom sides if required. This process allows for efficient and accurate PCB design and implementation

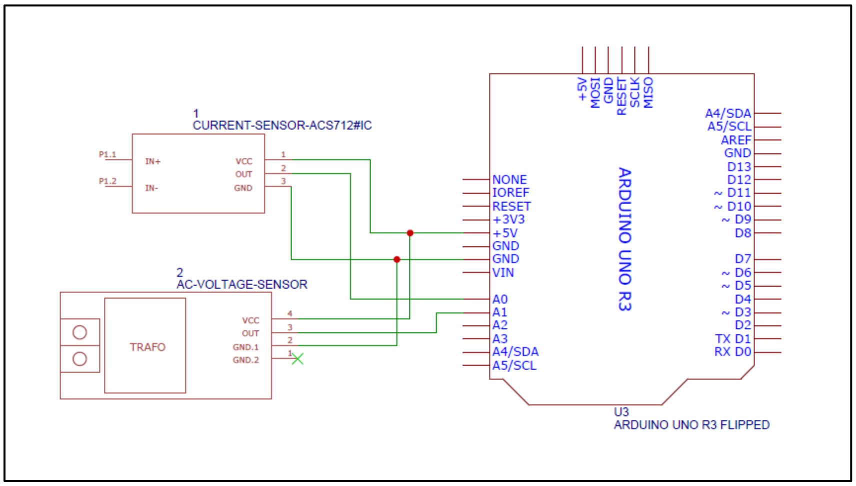


Fig 6.14 PCB circuit diagram

Figure 6.14 shows the connection diagram of all the sensors and Arduino uno. we have used EasyEDA online software to make it. This schematic is then used to route the PCB.

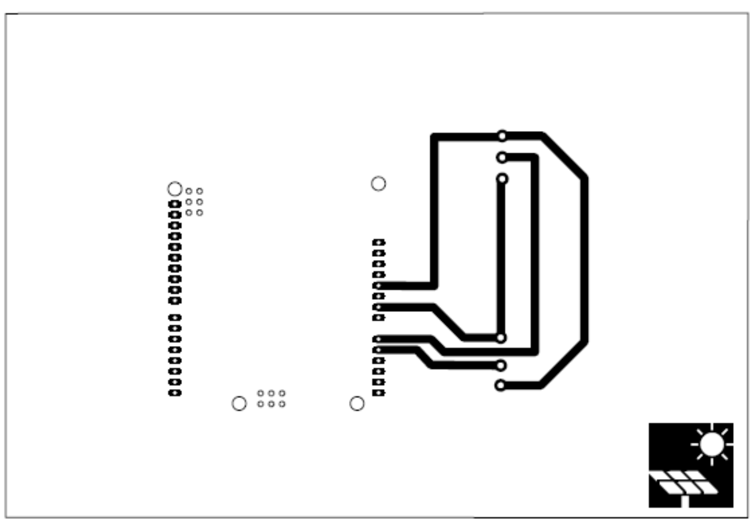


Fig 6.15 PCB Layout

After all the process of PCB designing is done print the design with actual size on photo paper using laser jet printer. Attach this printed paper to copper clad without any air gap and heat it for about 30 mins. After 30 mins due to heat the printed portion on paper will be pasted on copper clad. Then put this printed copper clad in Itching solution ($FeCl_3$). This will remove the unwanted copper on the copper clad. Thus, the PCB is manufactured. Fig shows the final PCB. After this soldering of components is done.

6.5 Testing Results

After the successful testing of given model, it was observed that the power generated is according to the change in the irradiance received by the solar panel.

The equation for power -

P = V. I

Where,

P = Power

V = Output Voltage

I = Output Current

Irradiance (in W/m^2) = Light Intensity (in Lux x 100) x 0.0079

Table 6.1 Generated Power vs Irradiance

Sr. No.	Light Intensity (In LUX x 100)	Irradiance (In W/m2)	Voltage (In Volts)	Current (In Amps)	Practical Power (In Watts)	Simulated Power (In Watts)
1	10	7.9	2.33	0.01	0.03	0.17
2	20	15.8	3.93	0.05	0.19	0.39
3	30	23.7	5.17	0.23	1.2	1.23
4	40	31.6	6.8	0.37	2.65	1.66
5	50	39.5	7.96	0.40	3.18	2.8
6	60	47.4	8.45	0.45	3.80	3.59

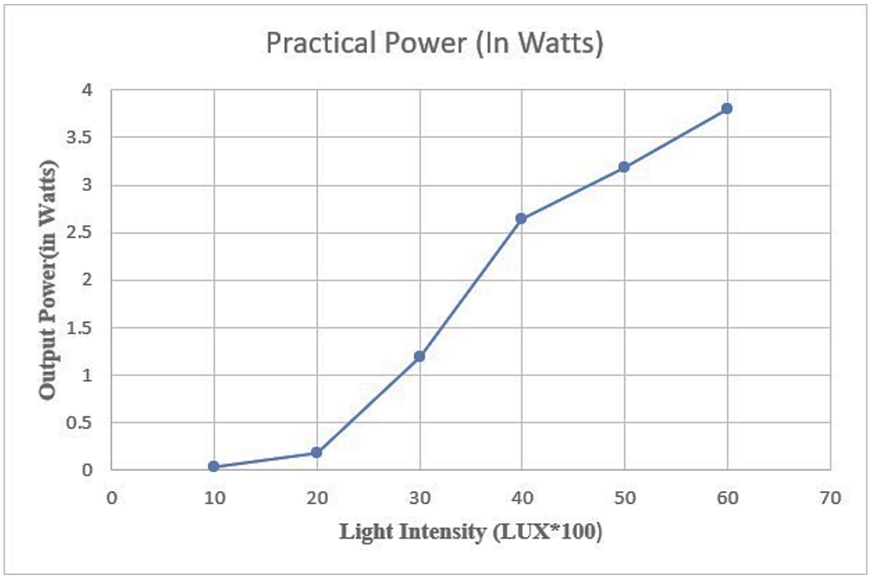


Fig 6.16 practical vs intensity

The graph is on the basis of practical values measured from the hardware setup. They represent the real-time output of the setup and can vary from the simulation data.

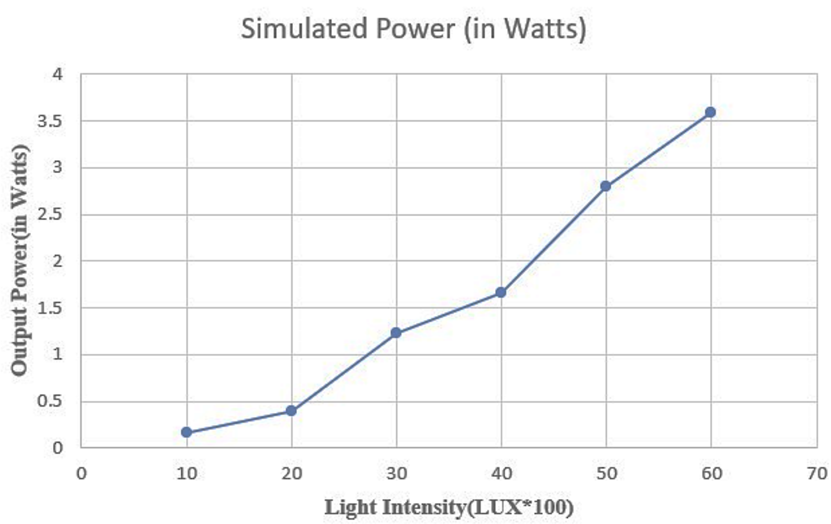


Fig 6.17 simulated vs intensity

The graph is plotted according to the data received from Simulink simulation. The model receives irradiance as an input. As the irradiance received by the solar panel increases , the output power also increases.

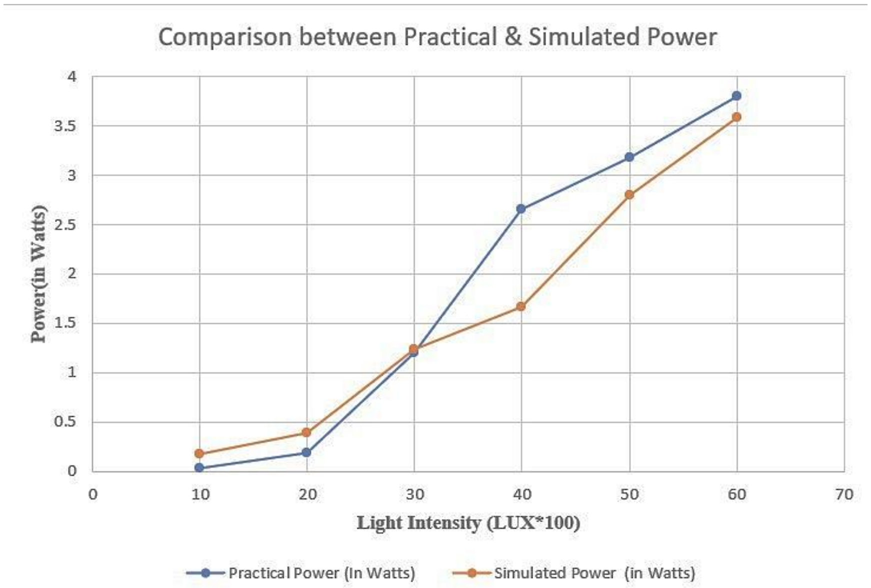


Fig 6.18 Comparision of Practical and Simulated Power

The graph is the comparison of the of practical and simulation graph. It helps to test and validate the data. It is evident from the graph that simulation values are in close proximity of practical values.

CHAPTER 7

Advantages & Application

Chapter 7: Advantages & Contribution

7.1. Advantages

1. This system allows us to acquire real-time data related to the solar panel module and compare it with the simulated results.
2. It enables us to determine the various factors that contribute to a more effective and efficient solar power generation system.
3. The cost associated with operation and maintenance of solar panels accounts for about 15-20% of the overall energy generation cost which will be addressed.
4. Condition monitoring allows the implementation of predictive operation and maintenance strategies helping to reduce costs.
5. Data acquisition and visualization will help in using the data collected from sensors for productive application.
6. This project helps in generating high quality experimental data is crucial for understanding and improving existing system efficiency.
7. It will also potentially help to adjust the consumption habits to align with solar production.

7.2. Applications:

1. It helps to decide the feasibility of a solar power project. The analytical data generated can be used for well-grounded statistics.
2. By measuring average parameters of particular location, it can determine whether the location is suitable for setting up a solar plant.
3. Online monitoring systems of solar panel can be utilized to guarantee 24/7 data collection and safety.
4. The microcontroller collects various real time data which can be used for different applications.
5. It is useful for on ground workers to study the various parameters related to solar panel systems.
6. It can be used in commercial as well as household applications to collect data and analyze it.
7. condition monitoring allows the implementation of predictive operation and
8. maintenance strategies helping to reduce costs.

CHAPTER 8

Conclusion

Chapter 8: Expected Conclusion

8.1 Conclusion

The most promising renewable energy source, particularly for residential uses, is photovoltaic (PV) solar energy. Solar powered devices are becoming more commercially purchasable as the price of PV generating system gradually drops. Additionally, rising consumer knowledge is correlated with a higher willingness to pay for clean energy produced from renewable sources. Consequently, a mechanism to gauge a location's capacity for solar energy production is required. The technology meets these demands and will aid in spreading awareness of solar power among the general public.

8.2 Future Scope

1. Upgrading the system to wireless for seamless transfer without loss during transfer of data through cable.
2. Developing an application to access the data from remote location.
3. Measuring further parameters such as temperature, panel temperature, humidity, orientation and displaying them.
4. Adding more variable parameters to the simulation to increase the accuracy of output.
5. Generalizing the simulation so that PV panels of different brands can be considered.

REFERENCES

[1] V. Voicu, D. Petreus and R. Etz, "Data Acquisition System for Solar Panels," 2019 42nd International Spring Seminar on Electronics Technology (ISSE), 2019, pp. 1-6, doi: 10.1109/ISSE.2019.8810289.

[2] M. Galád and P. Špánik, "Design of photovoltaic solar cell model for stand-alone renewable system", IEEE 10th International ELEKTRO Conference, pp. 285-288, 19 – 20 May 2014.

[3] S. Lineykin, M. Averbukh and A. Kuperman, "Five-parameter model of photo voltaic cell based on STC data and dimensionless", 2012 IEEE 27th Convention of Electrical and Electronics Engineers in Israel, pp. 1-5, 2012.

[4] D. Sera, R. Teodorescu and P. Rodriguez, "PV panel model based on datasheet values", Proc. IEEE Int. Symp. Ind. Electron., pp. 2392-2396, 2007.

[5] V. Boscaino, G. Cipriani, V. Di Dio, R. Miceli and G. Capponi, "A simple and accurate model of photovoltaic modules for power system design," 2014 Ninth International Conference on Ecological Vehicles and Renewable Energies (EVER), 2014, pp. 1-6, doi: 10.1109/EVER.2014.6844088.

Solar Grp C-08 Report (Phase-2)

by Vaishali Nilesh Patil

General metrics

49,860	7,193	743	28 min 46 sec	55 min 19 sec
characters	words	sentences	reading time	speaking time

Score

83

This text scores better than 83% of all texts checked by Grammarly

Writing Issues

315	32	283
Issues left	Critical	Advanced

Plagiarism

2 %

9 sources

2% of your text matches 9 sources on the web or in archives of academic publications

Writing Issues

178	**Clarity**	
50	Wordy sentences	
89	Passive voice misuse	
33	Unclear sentences	
1	Hard-to-read text	
5	Intricate text	
65	**Correctness**	
13	Text inconsistencies	
1	Wrong or missing prepositions	
3	Faulty subject-verb agreement	
10	Determiner use (a/an/the/this, etc.)	
5	Confused words	
5	Comma misuse within clauses	
7	Closing punctuation	
1	Misspelled words	
1	Faulty tense sequence	
1	Misuse of modifiers	
2	Misplaced words or phrases	
3	Pronoun use	
2	Conjunction use	
1	Incomplete sentences	
9	Improper formatting	
1	Punctuation in compound/complex sentences	
58	**Engagement**	

58	Word choice	
14	**Delivery**	
5	Tone suggestions	
8	Incomplete sentences	
1	Inappropriate colloquialisms	

Unique Words

Measures vocabulary diversity by calculating the percentage of words used only once in your document

20%

unique words

Rare Words

Measures depth of vocabulary by identifying words that are not among the 5,000 most common English words.

42%

rare words

Word Length

Measures average word length

5.1

characters per word

Sentence Length

Measures average sentence length

9.7

words per sentence

APPENDIX A : PROGRAMME CODE

```
// Define the analog pin to read potential

int analogInput = A1;

// Declare and initialize variables

float vout = 0.0;
float vin = 0.0;
float R1 = 30000.0;                         // Resistance of R1 in Ohms
float R2 = 7500.0;                           // Resistance of R2 in Ohms
int adcValue = 0;

void setup() {
  // Set the analog input pin as input
  pinMode(analogInput, INPUT);

  // Start the serial communication with a baud rate of 9600

  Serial.begin(9600);

  // Print a message on the serial monitor to indicate that the device is ready

  Serial.println("Device is ready");
  delay(2000);

}

void loop() {
  // Read the analog input from A0
  adcValue = analogRead(A0);

  // Convert the ADC value to voltage

  float voltage = adcValue * 5 / 1023.0;

  // Calculate the current based on the voltage (assuming a 0.1 Ohm load resistor)

  float current = (voltage - 2.5) / 0.185;
  current = current*10;

  // Print a message on the serial monitor to indicate the start of data acquisition

  Serial.println("\n\n\tData Acquisition of Solar Panel");

  //GUI: print column headers
  Serial.println("\n\n\tPARAMETERS\tVALUES");

  // Print the current on the serial monitor

  Serial.print("\n\tCurrent :\t");
  Serial.print(current);
  Serial.println(" A");

  // Read the voltage from the analog input pin

  adcValue = analogRead(analogInput);
```

```
  // Convert the ADC value to voltage

  vout = (adcValue * 5.0) / 1024.0;

  // Calculate the input voltage based on the voltage divider formula

  vin = vout / (R2 / (R1 + R2));

  // Calculate the power based on the voltage and current values

  float power = current * vin;

  // Print the input voltage and power on the serial monitor

  Serial.print("\n\tVoltage :\t");
  Serial.print(vin, 2);
  Serial.println(" V");

  Serial.print("\n\tPower   :\t");
  Serial.print(power, 2);
  Serial.println(" W");

  // Wait for 3 seconds
  delay(1500);

  // Clear the serial monitor
  Serial.write(27);                    // ESC command
  Serial.print("[2J");                 // clear screen command
  Serial.write(27);
  Serial.print("[H");                  // cursor to home command

}
```

APPENDIX B : DATASHEETS

Smart Energy Solutions

Save Energy

Save Money

Save Earth

GREENTEK

INDIA PVT. LTD.

we make sun work for you

Who we are !

Greentek India Pvt. Ltd. is Incorporated in the year 2007 and expertise in all renewable energy systems. Joint ventured with many reputed companies throughout the India and having the best technical partners and supplier in their class throughout India.

GIPL is an ISO 9001:2015 & 14001:2015 certified Company based in Hyderabad as one of the leading manufacturers of Solar Photo Voltaic Modules (SPV) in the Country. We are manufacturing modules in the range of 40Wp to 330Wp. Thus, our Module production line is geared to produce panels of any custom size or wattage having Certifications/ Approvals from MNRE, IEC 61215, IEC 61701, IEC 61730.

Scope of Activities

Greentek India Pvt. Ltd. is rapidly expanding and successful Indian-owned company, with show piece manufacturing facility at Hyderabad , Hitech City of Telangana & Pune, Maharashtra. Subsidiary Unit M/s Greentek Northern India Pvt. Ltd. is formed to catter the North Indian market. Greentek is preferred supplier to the Solar industry for Solar water Heaters , Solar Modules , Solar Inverter having major installations across the country for varied applications duly serviced by well-trained Dealers.

The quality of these units is reflected in their extensive use by the various Government Agencies and reputed Organizations.

Greentek also supplies larger Solar Water Heating Systems for specialist project needs.

Greentek is clearly among leaders in providing Solar Heating for medium to high usage hot water heating. Greentek Solar hot water system applications have been made for uses such as hospitals, restaurants, carwashes, nursing homes, commercial laundries, hospital laundries, defence force bases, dormitories, hostels, clubs and private residences.
Greentek is specialist in manufacture of Solar modules at Hyderabad facility and also provides solutions in Solar Photovoltaic systems for off grid applications and Solar Power Plants Grid Interactive.

Greentek retains complete flexibility in manufacture/supply and installation to allow for a unique range of design options in both Solar Thermal and Solar Photovoltaic Systems. Greentek takes utmost care in understanding the end client's needs and builds its units to provide optimum performance and comfort.

Greentek is committed to quality systems and ongoing performance improvement. The company is recognized with quality accreditation from BIS and MNRE

Products Manufacture :

- Solar Water Heaters – Domestic
- Solar Water Heaters – Industrial
- Solar Thermal Collectors
- Solar Air Heating Systems – Dryers
- Solar PV Modules
- Solar Lanterns - Various Models
- Solar Home Lighting Systems
- Solar Power Pack
- Solar Street Lighting Systems
- Solar Water Pumping Systems
- Solar Power Fencing
- Solar Swimming pool Heating

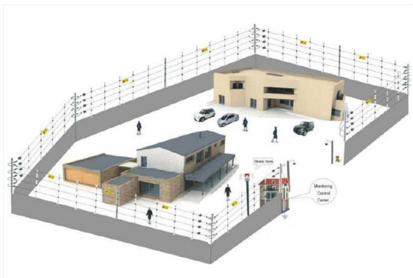
Services Provided :

- SPV Systems design, installation and services
- SWHS design, installation and services

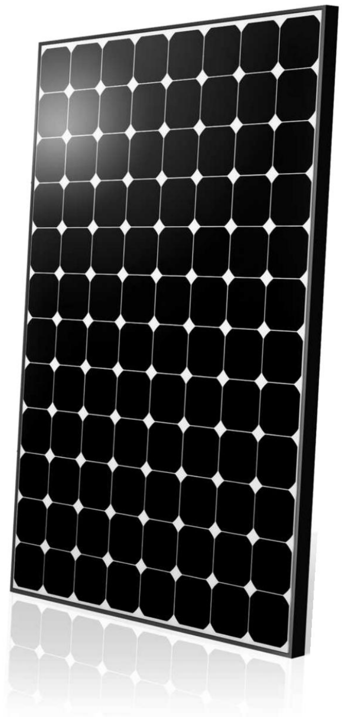






Solar Photovoltic Panels



Monocrystalline Silicon Solar Panels

Efficiency

Maximum Efficiency
17.60% conversion efficiency

Tolerance

Positive Power Tolerance
0~±5%

Application

Application
Applied for IEC DC 1000V solar PV system

2400Pa
5400Pa

Severe environment resistance
Wind load 2400 Pascal
Snow load 5400 Pascal

Certification

Certification
IEC 61215
IEC 61730 - 1 & 2
IEC 61701

- Product Guarantee : 10 year
- Limited Power Warranty : 90% @ 12 years
  80% @ 30 years

WARRANTY WARRANTY WARRANTY

PV Module Greentek GTK40-330Wp

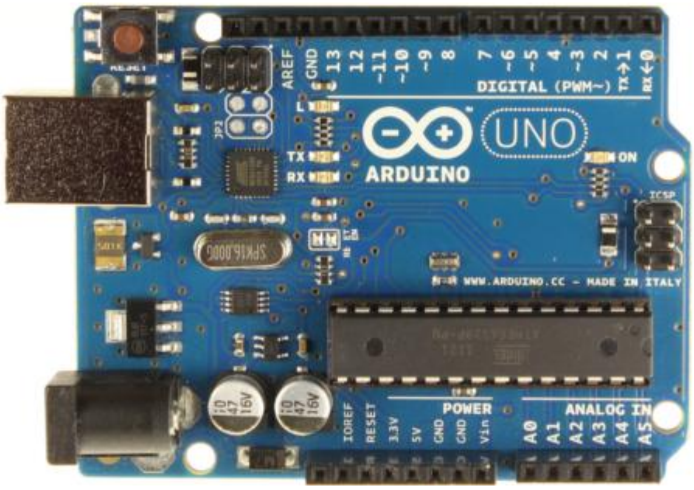
Note : The data presented may change due to further improvements in the products

Polycrystalline Silicon Solar Panels
We are also manufacturing polycrystalline

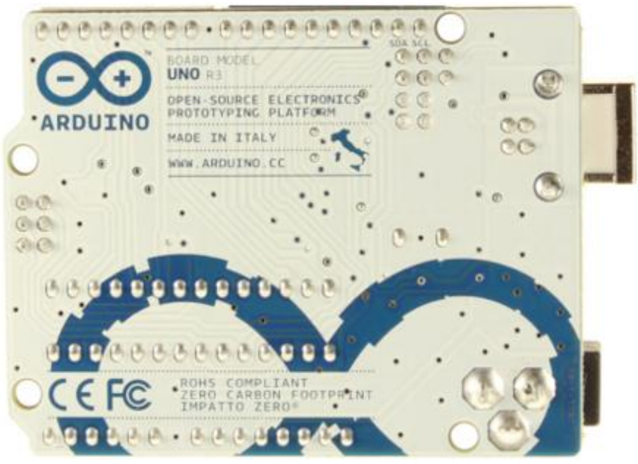
PV Module Rating Sheets

Provide Model name which will come in black label	Maximum Voltage System (V dc)	Open Circuit Voltage	Maximum power voltage @	Short circuit current @	Maximum power current @	Rated Maximum power @	Maximum series fuse, (A)	Cell type (Mono/Multi)	Cut cell full cell	Total No. of cell	Total No. of Diodes
GTK-40W-36P	600V	21.5	17.5	3	2.4	40	5A	Multi	Cut cell	36	2
GTK-45W-36P	600V	21.5	17.5	3.5	2.6	45	5A	Multi	Cut cell	36	2
GTK-50W-36P	600V	21.5	17.5	4.1	3.1	50	5A	Multi	Cut cell	36	2
GTK-60W-36P	600V	21.5	17.5	4.6	3.7	60	10A	Multi	Cut cell	36	2
GTK-75W-36P	600V	21.5	17.5	4.74	4.3	75	10A	Multi	Cut cell	36	2
GTK-80W-36P	600V	21.5	17.5	5.7	4.6	80	10A	Multi	Cut cell	36	2
GTK-100W-36P	600V	21.5	17.5	7.6	6.1	100	10A	Multi	Cut cell	36	2
GTK-120W-36P	600V	21.5	17.5	7.8	7.1	120	15A	Multi	Cut cell	36	2
GTK-145W-36P	600V	21.5	17.5	8.87	8.29	145	15A	Multi	Full cell	36	2
GTK-150W-36P	600V	21.5	17.5	8.7	8.75	150	15A	Multi	Full cell	36	3
GTK-180W-36P	1000V	21.5	17.5	11.01	10.29	180	15A	Multi	Full cell	36	3
GTK-200W-54P	1000V	33.8	27.5	8.11	7.7	200	15A	Multi	Full cell	54	3
GTK-205W-54P	1000V	33.8	27.5	8.26	7.86	205	15A	Multi	Full cell	54	3
GTK-210W-54P	1000V	33.8	27.5	8.42	8.02	210	15A	Multi	Full cell	54	3
GTK-215W-54P	1000V	33.8	27.5	8.58	8.18	215	15A	Multi	Full cell	54	3
GTK-220W-54P	1000V	33.8	27.5	8.56	8.04	220	15A	Multi	Full cell	54	3
GTK-225W-54P	1000V	33.8	27.5	8.71	8.19	225	15A	Multi	Full cell	54	3
GTK-200W-60P	1000V	37.6	30.6	7.42	6.81	200	15A	Multi	Full cell	60	3
GTK-220W-60P	1000V	37.6	30.6	8.07	7.54	220	15A	Multi	Full cell	60	3
GTK-225W-60P	1000V	37.6	30.6	8.25	7.71	225	15A	Multi	Full cell	60	3
GTK-240W-60P	1000V	37.6	30.6	8.4	8.1	240	15A	Multi	Full cell	60	3
GTK-250W-72P	1000V	44.7	36.6	7.48	6.98	250	15A	Multi	Full cell	60	3
GTK-255W-72P	1000V	44.7	36.6	7.68	7.12	255	15A	Multi	Full cell	72	3
GTK-260W-72P	1000V	44.7	36.6	7.8	7.25	260	15A	Multi	Full cell	72	3
GTK-265W-72P	1000V	44.7	36.6	8.12	7.35	265	15A	Multi	Full cell	72	3
GTK-270W-72P	1000V	44.7	36.6	8.22	7.5	270	15A	Multi	Full cell	72	3
GTK-275W-72P	1000V	44.7	36.6	8.31	7.6	275	15A	Multi	Full cell	72	3
GTK-280W-72P	1000V	44.7	36.6	8.42	7.84	280	15A	Multi	Full cell	72	3
GTK-285W-72P	1000V	44.7	36.6	8.51	7.97	285	15A	Multi	Full cell	72	3
GTK-290W-72P	1000V	44.7	36.6	8.62	8.08	290	15A	Multi	Full cell	72	3
GTK-295W-72P	1000V	44.7	36.6	8.74	8.2	295	15A	Multi	Full cell	72	3
GTK300W-72P	1000V	44.7	36.6	8.85	8.31	300	15A	Multi	Full cell	72	3
GTK-305W-72P	1000V	44.7	36.6	8.96	8.42	305	15A	Multi	Full cell	72	3
GTK-310W-72P	1000V	44.7	36.6	9.05	8.53	310	15A	Multi	Full cell	72	3
GTK-315W-72P	1000V	44.7	36.6	9.14	8.68	315	15A	Multi	Full cell	72	3
GTK-320W-72P	1000V	44.7	36.6	9.25	8.76	320	15A	Multi	Full cell	72	3
GTK-325W-72P	1000V	44.7	36.6	9.34	8.89	325	15A	Multi	Full cell	72	3
GTK-330W-72P	1000V	44.7	36.6	9.43	9.12	330	15A	Multi	Full cell	72	3

Arduino Uno

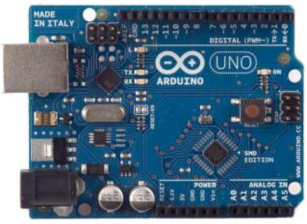


Arduino Uno R3 Front



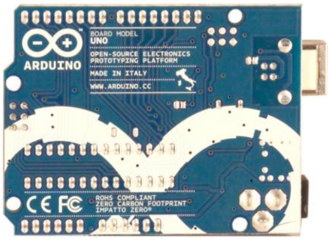
Arduino Uno R3 Back

Arduino Uno R2 Front



Arduino Uno SMD

Arduino Uno Front



Arduino Uno Back

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, 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 Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V

Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Schematic & Reference Design

EAGLE files: arduino-uno-Rev3-reference-design.zip (NOTE: works with Eagle 6.0 and newer)
Schematic: arduino-uno-Rev3-schematic.pdf
Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

Power

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

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.**This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

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

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

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

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.
The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI 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.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

onsemi

DATA SHEET
www.onsemi.com

3.0 A, Step-Down Switching Regulator

LM2596

The LM2596 regulator is monolithic integrated circuit ideally suited for easy and convenient design of a step−down switching regulator (buck converter). It is capable of driving a 3.0 A load with excellent line and load regulation. This device is available in adjustable output version and it is internally compensated to minimize the number of external components to simplify the power supply design.

Since LM2596 converter is a switch−mode power supply, its efficiency is significantly higher in comparison with popular three−terminal linear regulators, especially with higher input voltages.

The LM2596 operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5−lead TO−220 package with several different lead bend options, and D^2PAK surface mount package.

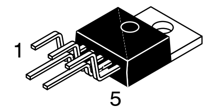
The other features include a guaranteed $\pm 4\%$ tolerance on output voltage within specified input voltages and output load conditions, and $\pm 15\%$ on the oscillator frequency. External shutdown is included, featuring 80 μA (typical) standby current. Self protection features include switch cycle−by−cycle current limit for the output switch, as well as thermal shutdown for complete protection under fault conditions.

Features

- Adjustable Output Voltage Range 1.23 V – 37 V
- Guaranteed 3.0 A Output Load Current
- Wide Input Voltage Range up to 40 V
- 150 kHz Fixed Frequency Internal Oscillator
- TTL Shutdown Capability
- Low Power Standby Mode, typ 80 μA
- Thermal Shutdown and Current Limit Protection
- Internal Loop Compensation
- Moisture Sensitivity Level (MSL) Equals 1
- These Devices are Pb−Free

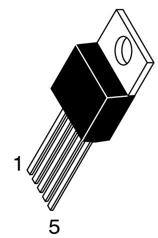
Applications

- Simple High−Efficiency Step−Down (Buck) Regulator
- Efficient Pre−Regulator for Linear Regulators
- On−Card Switching Regulators
- Positive to Negative Converter (Buck−Boost)
- Negative Step−Up Converters
- Power Supply for Battery Chargers



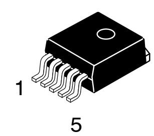
TO−220
TV SUFFIX
CASE 314B

Heatsink surface connected to Pin 3



TO−220
T SUFFIX
CASE 314D

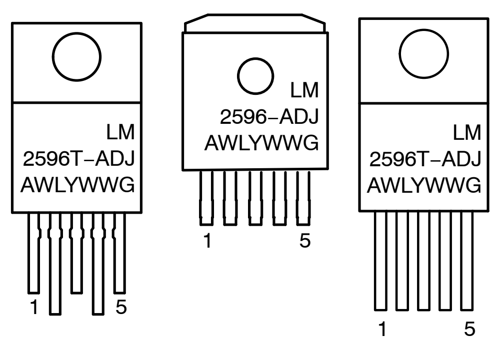
Pin
1. V_{in}
2. Output
3. Ground
4. Feedback
5. $\overline{\text{ON}}$/OFF



D^2PAK
D2T SUFFIX
CASE 936A

Heatsink surface (shown as terminal 6 in case outline drawing) is connected to Pin 3

MARKING DIAGRAMS

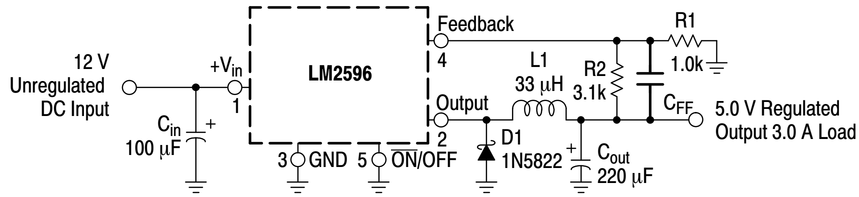


A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 23 of this data sheet.

Typical Application (Adjustable Output Voltage Version)



Block Diagram

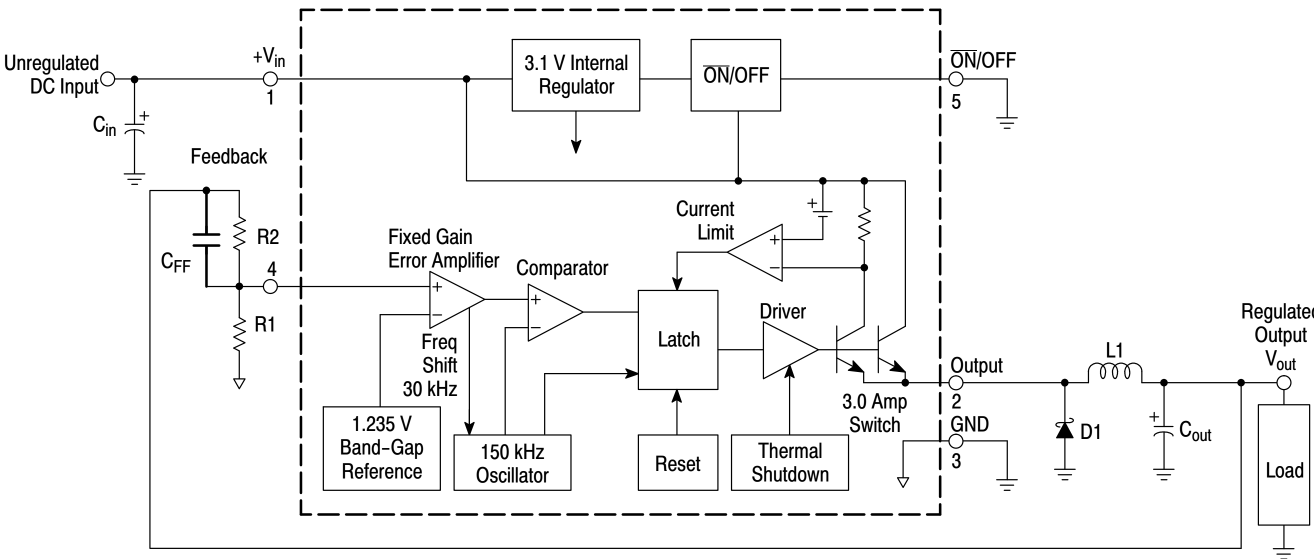


Figure 1. Typical Application and Internal Block Diagram

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Maximum Supply Voltage	V_{in}	45	V
$\overline{ON}$/OFF Pin Input Voltage	–	$-0.3\ V \le V \le +V_{in}$	V
Output Voltage to Ground (Steady–State)	–	−1.0	V
Power Dissipation			
Case 314B and 314D (TO–220, 5–Lead)	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	65	°C/W
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	5.0	°C/W
Case 936A (D^2PAK)	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	70	°C/W
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	5.0	°C/W
Storage Temperature Range	T_{stg}	−65 to +150	°C
Minimum ESD Rating (Human Body Model: C = 100 pF, R = 1.5 kΩ)	–	2.0	kV
Lead Temperature (Soldering, 10 seconds)	–	260	°C
Maximum Junction Temperature	T_J	150	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 15)

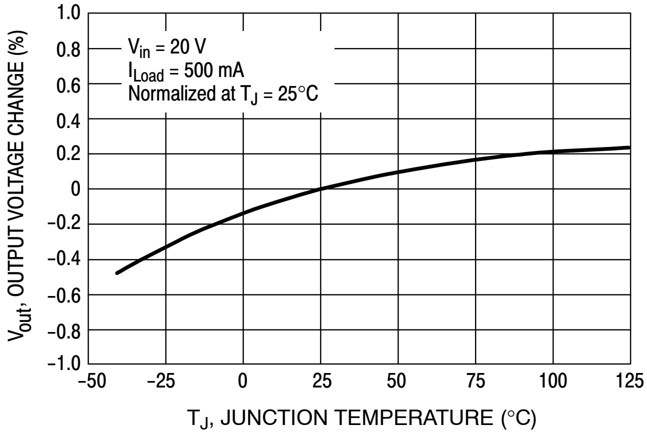


Figure 2. Normalized Output Voltage

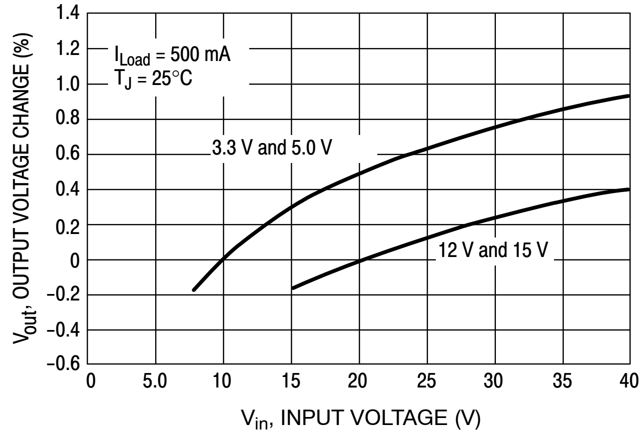


Figure 3. Line Regulation

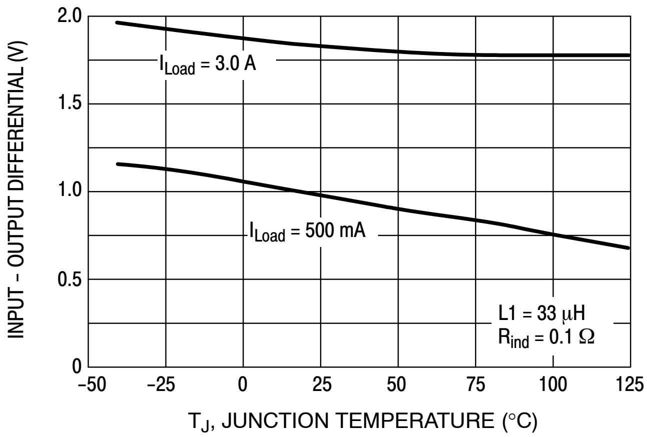


Figure 4. Dropout Voltage

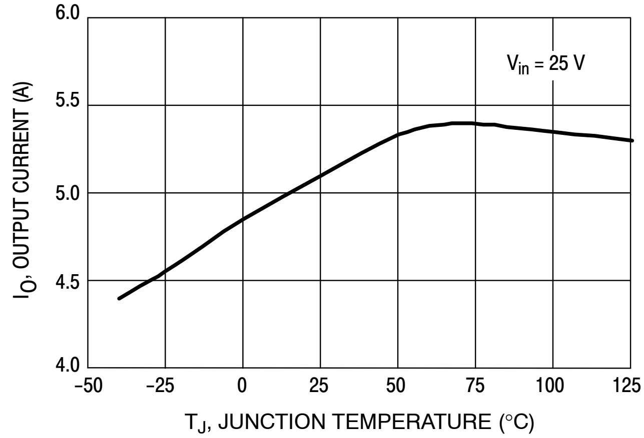


Figure 5. Current Limit

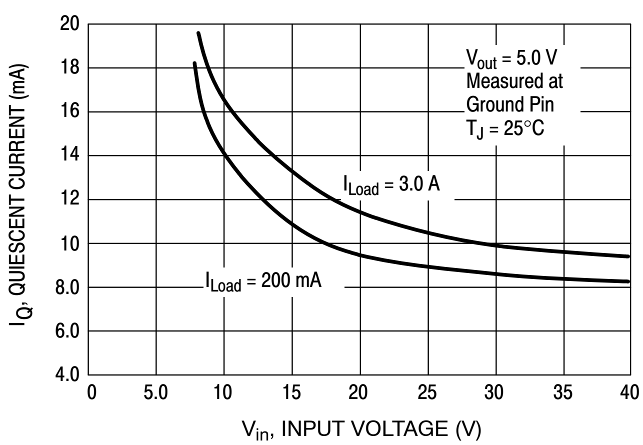


Figure 6. Quiescent Current

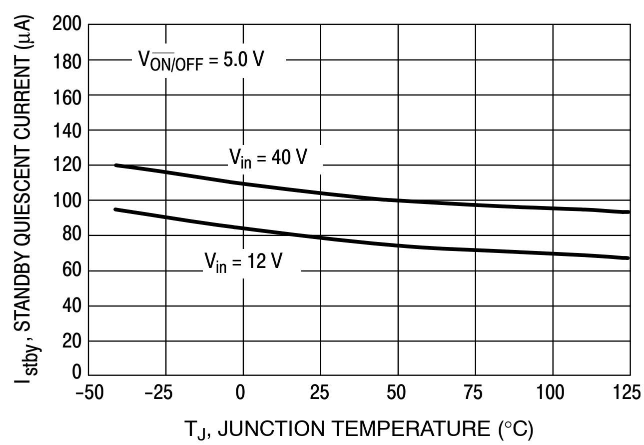
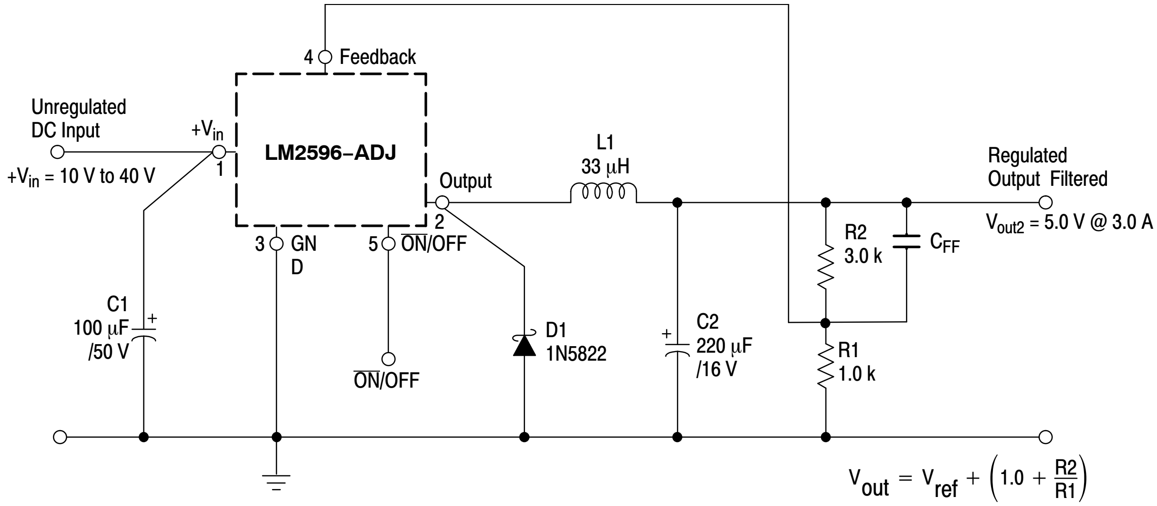


Figure 7. Standby Quiescent Current

THE LM2596 STEP−DOWN VOLTAGE REGULATOR WITH 5.0 V @ 3.0 A OUTPUT POWER CAPABILITY. TYPICAL APPLICATION WITH THROUGH−HOLE PC BOARD LAYOUT



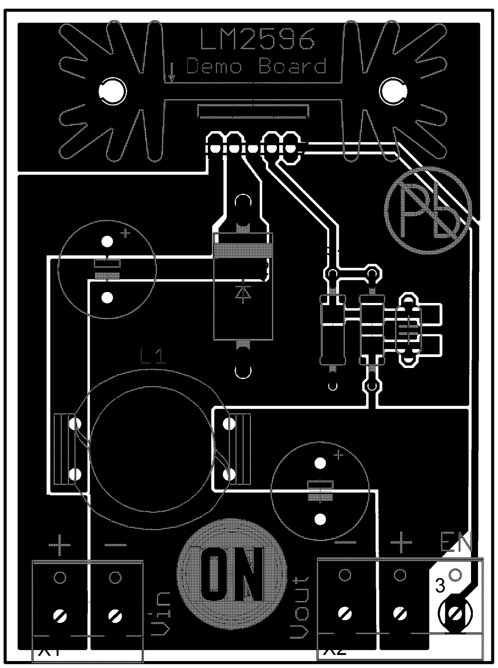
C1	–	100 µF, 50 V, Aluminium Electrolytic
C2	–	220 µF, 25 V, Aluminium Electrolytic
D1	–	3.0 A, 40 V, Schottky Rectifier, 1N5822
L1	–	33 µH, DO5040H, Coilcraft
R1	–	1.0 kΩ, 0.25 W
R2	–	3.0 kΩ, 0.25 W

$$V_{out} = V_{ref} + \left(1.0 + \frac{R2}{R1}\right)$$

$V_{ref} = 1.23$ V

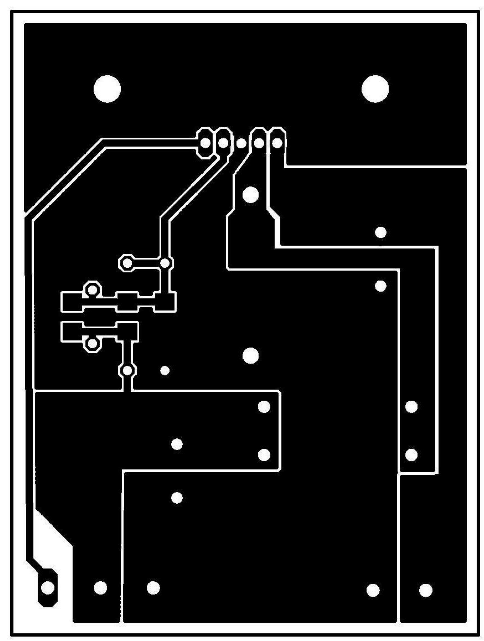
R1 is between 1.0 k and 5.0 k

Figure 31. Schematic Diagram of the 5.0 V @ 3.0 A Step−Down Converter Using the LM2596−ADJ



NOTE: Not to scale.

Figure 32. Printed Circuit Board Layout Component Side

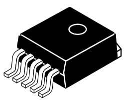


NOTE: Not to scale.

Figure 33. Printed Circuit Board Layout Copper Side

References

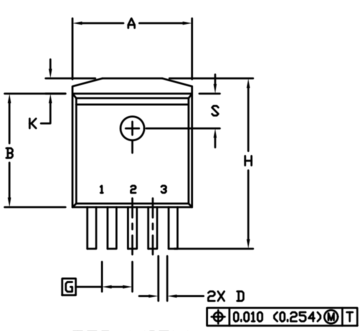
- National Semiconductor LM2596 Data Sheet and Application Note
- National Semiconductor LM2595 Data Sheet and Application Note
- Marty Brown “Practical Switching Power Supply Design”, Academic Press, Inc., San Diego 1990
- Ray Ridley “High Frequency Magnetics Design”, Ridley Engineering, Inc. 1995



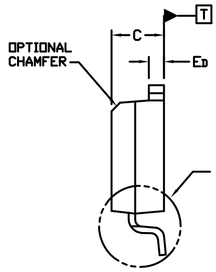
SCALE 1:1

D²PAK 5−LEAD
CASE 936A−02
ISSUE E

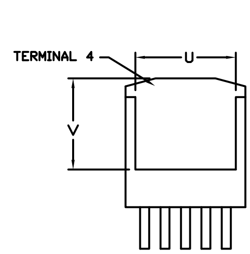
DATE 28 JUL 2021



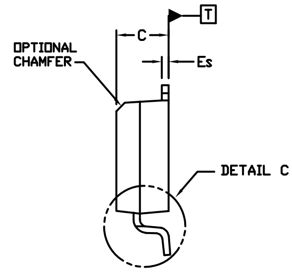
TOP VIEW



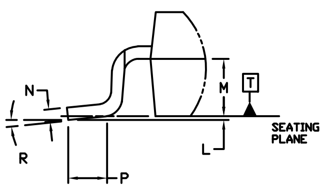
SIDE VIEW
DUAL GUAGE CONSTRUCTION



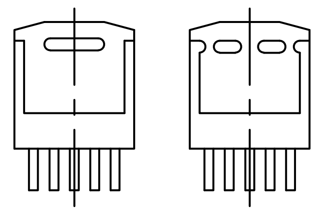
BOTTOM VIEW



SIDE VIEW
SINGLE GUAGE CONSTRUCTION



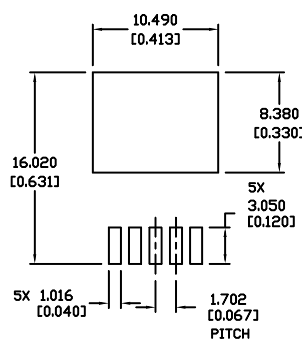
DETAIL C
TIP LEADFORM
ROTATED 90° CW



BOTTOM VIEW
OPTIONAL CONSTRUCTIONS

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCHES
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

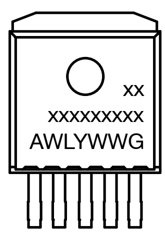
DIM	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.
A	0.396	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
ED	0.045	0.055	1.143	1.397
ES	0.018	0.026	0.457	0.660
G	0.067 BSC		1.702 BSC	
H	0.539	0.579	13.691	14.707
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	0°	8°	0°	8°
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	



RECOMMENDED
MOUNTING FOOTPRINT *

* For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC
MARKING DIAGRAM*



xxxxxx	= Device Code
A	= Assembly Location
WL	= Wafer Lot
Y	= Year
WW	= Work Week
G	= Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.

DOCUMENT NUMBER:	**98ASH01006A**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.
DESCRIPTION:	**D2PAK 5−LEAD**	**PAGE 1 OF 1**

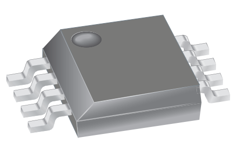
Fully Integrated, Hall-Effect-Based Linear Current Sensor IC with 2.1 kV_{RMS} Isolation and a Low-Resistance Current Conductor

FEATURES AND BENEFITS

- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5 µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at T_A = 25°C
- Small footprint, low-profile SOIC-8 package
- 1.2 mΩ internal conductor resistance
- 2.1 kV_{RMS} minimum isolation voltage from pins 1-4 to pins 5-8
- 5.0 V, single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis
- Ratiometric output from supply voltage

TÜV America
Certificate Number:
U8V 15 05 54214 038
CB 13 06 54214 026

PACKAGE: 8-Lead SOIC (suffix LC)



Not to scale

DESCRIPTION

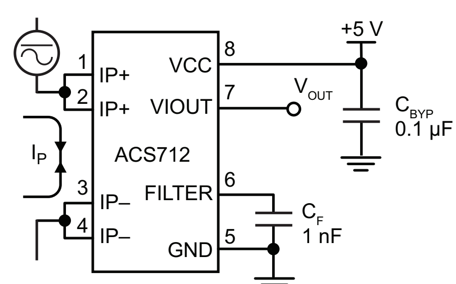
The Allegro™ ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch-mode power supplies, and overcurrent fault protection. The device is not intended for automotive applications.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.

The output of the device has a positive slope (>$V_{IOUT(Q)}$) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of

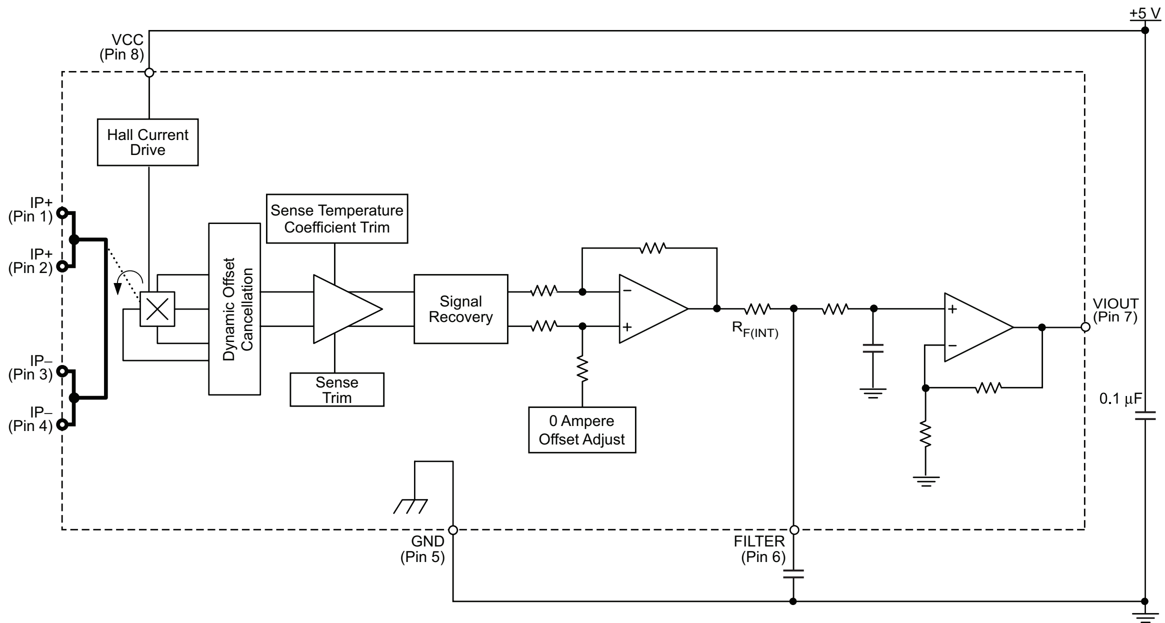
Continued on the next page…

Typical Application

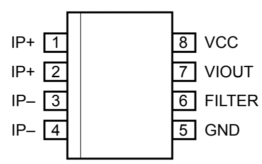


Application 1. The ACS712 outputs an analog signal, V_{OUT}. that varies linearly with the uni- or bi-directional AC or DC primary sampled current, I_P, within the range specified. C_F is recommended for noise management, with values that depend on the application.

FUNCTIONAL BLOCK DIAGRAM



Pinout Diagram



Terminal List

Number	Name	Description
1 and 2	IP+	Terminals for current being sampled; fused internally
3 and 4	IP–	Terminals for current being sampled; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

COMMON OPERATING CHARACTERISTICS [1]: Over full range of T_A, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	$I_P = I_P$(max), T_A = 25°C, C_{OUT} = open	–	3.5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling [2]			–	12	–	G/A
Internal Filter Resistance [3]	$R_{F(INT)}$			1.7		kΩ

[1] Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2] 1G = 0.1 mT.

[3] $R_{F(INT)}$ forms an RC circuit via the FILTER pin.

COMMON THERMAL CHARACTERISTICS [1]

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Operating Internal Leadframe Temperature	T_A	E range	–40	–	85	°C
Characteristic	**Symbol**	**Test Conditions**			**Value**	**Units**
Junction-to-Lead Thermal Resistance [2]	$R_{\theta JL}$	Mounted on the Allegro ASEK 712 evaluation board			5	°C/W
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	Mounted on the Allegro 85-0322 evaluation board, includes the power consumed by the board			23	°C/W

[1] Additional thermal information is available on the Allegro website.

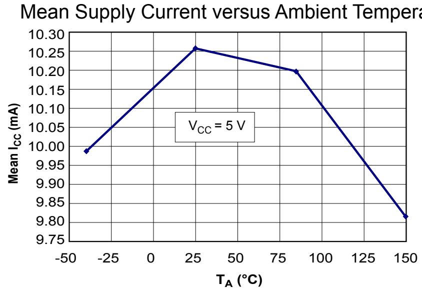
[2] The Allegro evaluation board has 1500 mm^2 of 2 oz. copper on each side, connected to pins 1 and 2, and to pins 3 and 4, with thermal vias connecting the layers. Performance values include the power consumed by the PCB. Further details on the board are available from the Frequently Asked Questions document on our website. Further information about board design and thermal performance also can be found in the Applications Information section of this datasheet.

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

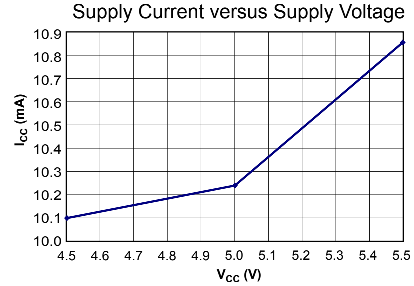
CHARACTERISTIC PERFORMANCE

I_P = 5 A, unless otherwise specified

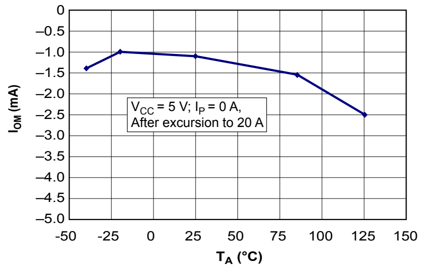
Mean Supply Current versus Ambient Temperature



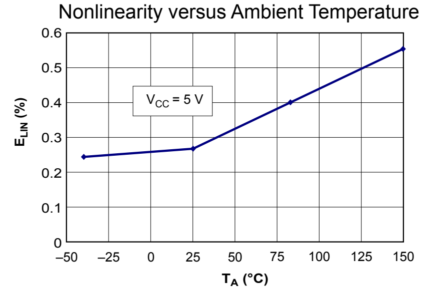
Supply Current versus Supply Voltage



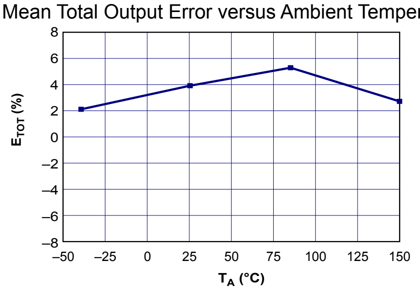
Magnetic Offset versus Ambient Temperature



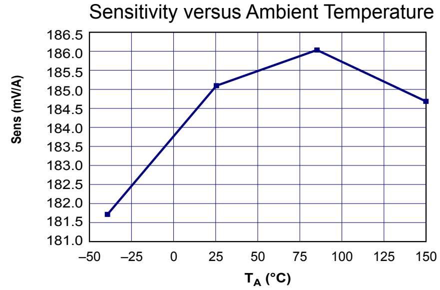
Nonlinearity versus Ambient Temperature



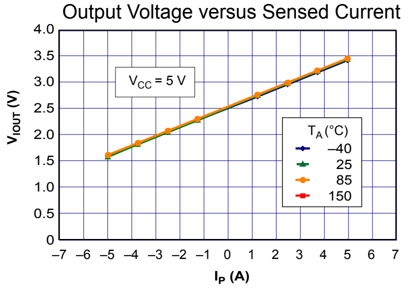
Mean Total Output Error versus Ambient Temperature



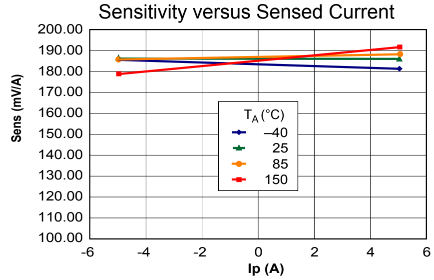
Sensitivity versus Ambient Temperature



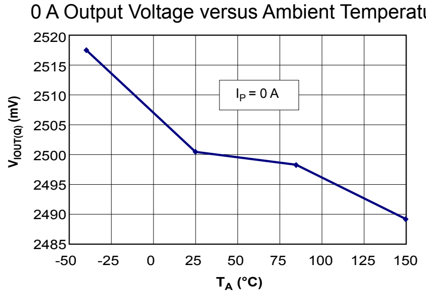
Output Voltage versus Sensed Current



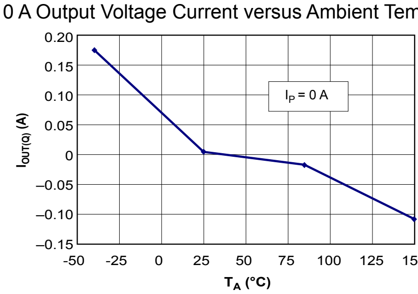
Sensitivity versus Sensed Current



0 A Output Voltage versus Ambient Temperature



0 A Output Voltage Current versus Ambient Temperature



Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

REVISION HISTORY

Number	Date	Description
15	November 16, 2012	Update rise time and isolation, I_{OUT} reference data, patents
16	June 5, 2017	Updated product status
17	December 10, 2018	Updated certificate numbers
18	May 17, 2019	Updated TUV certificate mark, and minor editorial updates
19	January 30, 2020	Updated product status and minor editorial updates
20	February 7, 2022	Updated package drawing (page 14)

The products described herein are protected by U.S. patents: 5,621,319; 7,598,601; and 7,709,754.

For the latest version of this document, visit our website:

www.allegromicro.com

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Arduino 25V Voltage Sensor Module

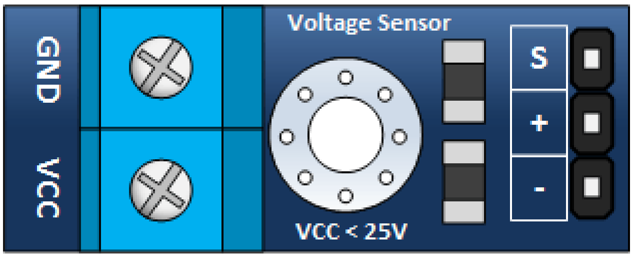
The Basics

The Arduino analog input is limited to a 5 VDC input. If you wish to measure higher voltages, you will need to resort to another means. One way is to use a voltage divider. The one discussed here is found all over Amazon and eBay.

It is fundamentally a 5:1 voltage divider using a 30K and a 7.5K Ohm resistor.

Keep in mind, you are restricted to voltages that are less than 25 volts. More than that and you will exceed the voltage limit of your Arduino input.

Basic Connection



Inputs

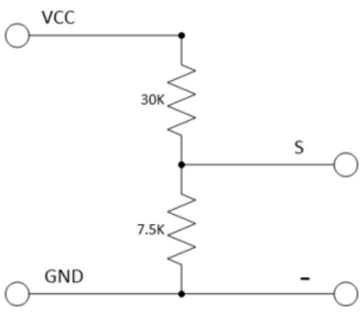
- **GND –** This is where you connect the low side of the voltage you are measuring. Caution! : This is the same electrical point as your Arduino ground.
- **VCC:** The is where you connect the high side of the voltage you are measuring

Outputs

- **S:** This connects to your Arduino analog input.
- **– (or minus):** This connects to your Arduino ground.
- **+:** This is not connected. It does absolutely nothing… zilch… nada… jack diddly doo doo.

Schematic

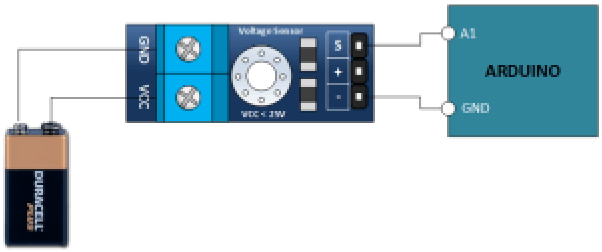
The schematic for this is pretty straight forward. As previously mentioned, its just a couple of resistors. In fact, you could build your own in a pinch.



Tutorial

The Connections

Find yourself a 9 volt battery and connect it, your voltage sensor module and Arduino as shown below.



The Sketch

Enter the following sketch, upload it and go to town. If you open your Arduino serial monitor you will be able to see the voltage.

```
/*
DC Voltmeter Using a Voltage Divider
Based on Code Created By
T.K.Hareendran
*/

int analogInput = A1;
float vout = 0.0;
float vin = 0.0;
float R1 = 30000.0; //
float R2 = 7500.0; //
int value = 0;
void setup(){
   pinMode(analogInput, INPUT);
   Serial.begin(9600);
   Serial.print("DC VOLTMETER");
}
void loop(){
   // read the value at analog input
   value = analogRead(analogInput);
   vout = (value * 5.0) / 1024.0; // see text
   vin = vout / (R2/(R1+R2));

Serial.print("INPUT V= ");
Serial.println(vin,2);
delay(500);
}
```

APPENDIX C : PROJECT OUTCOME

ABHIYANTRIX'23

CONFERENCE FOR THE STUDENTS BY THE STUDENTS

Technically Sponsored By

IEEE Signal Processing Society, Pune Chapter

Organized By

Department of Electronics & Telecommunication, PCCOE, Pune

CERTIFICATE OF PARTICIPATION

This is to certify that Vipulkumar Patil, Aditya Karale, Saadain Shaikh

has presented a paper at Abhiyantrix'23 a department level conference organized by Department of Electronics & Telecommunication, Pimpri Chinchwad College of Engineering, Nigdi, Pune on 10th - 11th April, 2023

Vaishnavi Gadhave	Pushkar Mahajan	Guruprasad Deshpande	Dr. M. T. Kolte
General Co-Chair	General Co-Chair	General Chair	HOD, E&TC