PIMPRI CHINCHWAD EDUCATION TRUST'S

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE- 411044.

MINI PROJECT REPORT

SOLAR TRACKING SYSTEM

Project ID:- C-02

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DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION

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Acknowledgment

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Abstract

Our project will include the design and construction of a microcontroller-based solar panel tracking system. The system compares the light intensity and places the panels perpendicular to light source. This increases the span of peak output generation and hence results in higher efficiency. The solar energy sources and storage units in this model are decentralized and appropriate control algorithm can redirect the available energy when the designated storage devices in a traditional system are fully charged. the solar energy is stored in rechargeable cell and another cell is used to run the servo motor used for rotating the solar panel. Two LDRs are fixed on the two edges of solar panel for capturing intensity of light.

Programming of this device is done in the manner that the LDR sensor, in accordance with the detection of the sun rays, will provide direction to the Servo Motor that in which way the solar panel is going to revolve. Through this, the solar panel is positioned in such a manner that the maximum amount of sun rays could be received. Tracking helps in the wider projection of the panel to the Sun with increased power output.

This project is discussed all about the design and construction mechanism of the prototype for the solar tracking system having a single axis of freedom

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1. INTRODUCTION

1.1 Background:

Solar tracker, a system that positions an object at an angle relative to the Sun. The most-common applications for solar trackers are positioning photovoltaic (PV) panels (solar panels) so that they remain perpendicular to the Sun's rays and positioning space telescopes so that they can determine the Sun's direction.

1.2 Problem staement :-

Tracking the position of sun and getting maximum output energy.

1.3 Objective: -

1. Position the Solar Panels so that they will acquire maximum energy light source.
2.To fabricate a Servo motor control interfaced with driver circuit.
3.To construct a model prototype solar cell movement system with a mechanical assemble to move the panel from 180° E to W.
4 To design an electronic circuit to sense the intensity of light and to control the panel movement.

1.4 Brief Application areas:

1. **Solar-powered desalination unit technology:**

   Solar tracking desalination unit is a device that transforms salt water into drinking water by converting the Sun’s energy to heat, directly or indirectly, to drive the desalination process.

2. **Solar Pond: -**

   Solar pond, any large human-made body of salt water that collects and stores solar energy, thereby providing a sustainable source of heat and power.

2. Literature Survey

Table No. 1

Sr. No.	Title of Paper	Authors & Publication details	Methodology	Limitation
1.	**Development of Microcontroller based solar tracking system.**	Kamil.R. Kehinde, Seriki.B. Salaudeen, Aliyu.Y. Sharif and Kamil.I. Jemilat, International Journal of Scientific & Engineering Research, Volume 12, Issue 5, May- 2021 ISSN 2229-5518	This paper gives idea about developing a solar tracker using microcontroller.	
2.	**A novel UV sensor based dual axis solar tracking system**	Chaowanan Jamroen, Chanon Fongkerd, Wipa Krongpha, Preecha Komkum, Alongkorn Pirayawaraporn, Nachaya Chindakham, Division of Instrumentation and Automation Engineering Technology, Faculty of Engineering and Technology, King Mongkut's University of Technology North Bangkok, Thailand 2021.	This paper propose a novel UV sensor-based dual-axis solar tracking system to improve tracking movements and PVenergy generation by utilizing the advantages of UV radiation enhancement and UV sensor capability.	
3.	**Implementation of an Automatic Solar Tracking System**	Akhil Raj K R, Sreejith Suresh, Amal Razic K A, Vidhu Narayan K B, Sanju B, GRD Journals | Global Research and Development Journal for Engineering |National Conference on Emerging Research Trend in Electrical and Electronics Engineering (ERTE'19) | May 2019	This paper concerns the successful implementation of solar tracker and also by making some modifications in basic model.	

4.	**Technologies of solar tracking systems**	A.R. Amelia, Y.M. Irwan, I. Safwati, W.Z. Leow, M.H. Mat and Mohd Shukor Abdul Rahim, S. Md. Esa, International Symposium on Engineering and Technology (ISETech) 2020	This paper aims to review on various technologies of solar tracking to determine the best PV panel orientation.	
5.	**Solar tracking systems: Technologies and trackers drive types**	A.Z. Hafez, A.M. Yousef, N.M. Harag, Renewable and Sustainable Energy Reviews 91 (2018) 754–782	The paper overviews the design parameters, construction, types and drive system techniques covering different usage application.	

2.1Summary of Literature Survey

It demonstrates a working software solution for maximizing solar cell output by positioning a solar panel at appoint of maximum light intensity during the daytime. The system proved sufficiently stable and a relatively low cost of implementation, which makes it very feasible for use in solar to electricity conversion in both large and small scale. The simplicity of the design makes the system reliable for operation over a long period of time. [1]

This paper mainly presents the design and implementation of a novel UV sensor-based solar tracking system. It utilizes the advantages of UV radiation enhancement and UV sensor capability to increase the performance in terms of tracking movement and energy gain. The solar tracking system was implemented on a pseudo-azimuthal mounting structure, which was capable of following the sun's trajectory through daily and elevation angles. The proposed tracking system considered the comparisons of UV sensor signals obtained by UV sensors mounted on the axes of rotation to track the sun's position. [2]

The paper has presented a means of tracking the sun's position with the help of microcontroller. Specially, it demonstrates a working software solution for maximizing solar cell output by positioning a solar panel at the point of maximum light intensity. The prototype represents a method for tracking the sun both in normal and bad weather condition. Moreover, the tracker can initialize the starting position itself which reduce the need of any more photo resistors. [3]

The power generated and efficiency of the PV panel could be improved with the existing of the solar tracker systems. This work present and categorize different types of solar tracking systems based on their technologies and degree movement of rotation. Active solar tracking systems use sensors and motors to track the position of the sun and control PV panel's position. Meanwhile, the passive tracking systems use a low-boiling-point compressed gas fluid that originates from solar heat. [4]

The main objective of this study is to investigate the feasibility of the solar tracking systems using different systems of axes and various regions of the world. The solar tracker drive systems encompassed five categories based on the tracking technologies, namely, active tracking, passive tracking, semi-passive tracking, manual tracking, and chronological tracking. Furthermore, the present work introduces a review of the major applications and systems design for solar tracking systems, which developed over the past 50 years. [5]

3. Specification

3.1 Specifications for power supply: -

9V battery

3.2 Specifications for sensor: -

2 x LDR

3.3 Specification for final circuit: -

Input Voltage : 9 – 12 V

Input Current : 0.5 – 2 A

Output Voltage : 4 – 6 V

Output Current : 100 – 200 mA

Solar output voltage : 3 – 3.5 V

3.4 Operating Frequency: -

Servo Motor Input : 50 Hz

Arduino Uno : 16 MHz

3.5 Sensor Range: -

LDR Resistance : 100 – 1M Ohm

4. Proposed Methodology

4.1 Introduction to the project

As the non-renewable energy resources are decreasing, use of renewable resources for producing electricity is increasing. Solar panels are becoming more popular day by day. Solar panel absorbs the energy from the Sun, converts it into electrical energy and stores the Energy in battery. A solar tracker is a device that orients a payload toward the sun. Presently solar Panels are of fixed type which lower the efficiency. Maintaining vertical direction between light and panel maximizes efficiency. The position of the Sun with respect to the solar panel is not fixed due to the rotation of the earth. For an efficient usage of the solar energy, the Solar panels should absorb energy to a maximum extent. Tracking systems are found in all concentrator applications because such systems do not produce energy unless pointed at the sun. The panels are continuously placed towards the direction of the Sun So, solar panel should continuously rotate in the direction of Sun. Solar tracking system has 35% higher generating power than fixed. This system based on microcontroller that can automatically adjust the orientation of panel. Such a system utilizes Light Dependent Resistors (LDR). Arduino , whose input is fed to motor controlling IC which in turn governs the rotation of motors. The motors rotate and place the panel in position with highest light intensity. This increases the span of peak output generation and hence results in higher efficiency.

4.2 Explanation of block diagram :

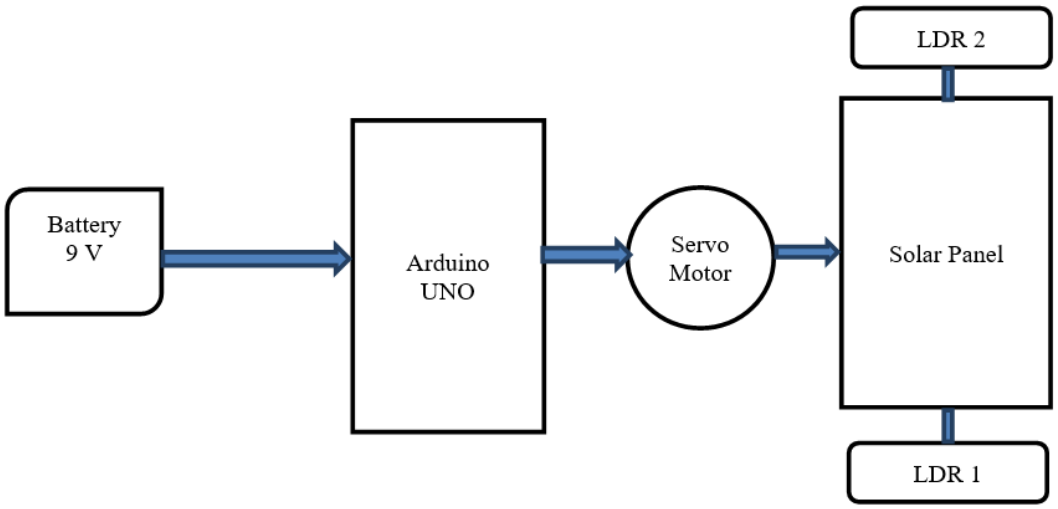


Fig. 1 : Block Diagram

Arduino Uno : - It gets analog input from LDRs. It processes it into digital and then computes the motion of servo motor

Battery: - 9 V battery is required for working of development board. It also provides adequate current to motor .

Servo Motor : - It gets digital input from arduino and rotates the solar panel . It has 180 degree of motion .

LDRs : - These are fixed on the edges of the solar panels and measures the intensity of light falling on the solar panel and accordingly provide analog input to the arduino .

Solar panel : - It generates energy from sunlight which furthur gets stored in rechargable battery .

The Sun tracking solar panel consists of LDR's, solar panel and a servo motor and Arduino UNO. Two LDR's are used as shown in the fig , The LDR's are placed on the top and bottom edges of the solar panel. When the sunlight falls on the solar panel the LDR's detects the light intensity if the intensity on both the LDR is same the solar panel stays horizontal.
If the intensity of light on the top LDR the solar panel turns upwards with help of servo motor to gain maximum energy from the sun .

4.3 Hardware Specifications :

Arduino UNO

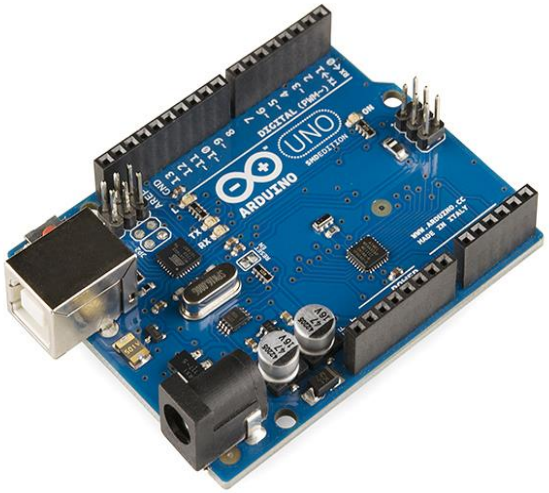


Fig. 2: Arduino UNO

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

The power pins are as follows:

Vin. The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power sources). 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. The maximum current draw is 50 mA.

LDR Sensors x2

Fig. 3: LDR

Light dependent resistors, LDRs or photoresistors are electronic components that are often used in electronic circuit designs where it is necessary to detect the presence or the level of light.

LDRs are very different to other forms of resistor like the carbon film resistor, metal oxide film resistor, metal film resistor and the like that are widely used in other electronic designs. They are specifically designed for their light sensitivity and the change in resistance this causes.

These electronic components can be described by a variety of names from light dependent resistor, LDR, photoresistor, or even photo cell, photocell or photoconductor.

Although other electronic components such as photodiodes or photo-transistor can also be used, LDRs or photo-resistors are a particularly convenient to use in many electronic circuit designs. They provide large change in resistance for changes in light level.

In view of their low cost, ease of manufacture, and their ease of use, LDRs have been used in a variety of different applications. At one time LDRs were used in photographic light meters, and even now they are still used in a variety of applications where it is necessary to detect light levels.

Light dependent resistors are widely available:- they are normally stocked by electronic component distributors, and in view of the way the electronics industry supply chain operates these days, this is the normal way to obtain them. Electronic component distributors large and small will typically have a good selection

Mini Servo Motor SG90

Fig. 4: Servo Motor

Servo motors (or servos) are self-contained electric devices that rotate or push parts of a machine with great precision. Servos are found in many places: from toys to home electronics to cars and airplanes. If you have a radio-controlled model car, airplane, or helicopter, you are using at least a few servos. In a model car or aircraft, servos move levers back and forth to control steering or adjust wing surfaces. By rotating a shaft connected to the engine throttle, a servo regulates the speed of a fuel-powered car or aircraft. Servos also appear behind the scenes in devices we use every day. Electronic devices such as DVD and Blu-ray DiscTM players use servos to extend or retract the disc trays

The simplicity of a servo is among the features that make them so reliable. The heart of a servo is a small direct current (DC) motor, similar to what you might find in an inexpensive toy. These motors run on electricity from a battery and spin at high RPM (rotations per minute) but put out very low torque . An arrangement of gears takes the high speed of the motor and slows it down while at the same time increasing the torque. T he gear design inside the servo case converts the output to a much slower rotation speed but with more torque (big force, little distance). The amount of actual work is the same, just more useful. Gears in an inexpensive servo motor are generally made of plastic to keep it lighter and less costly.

TP4056 Charging module

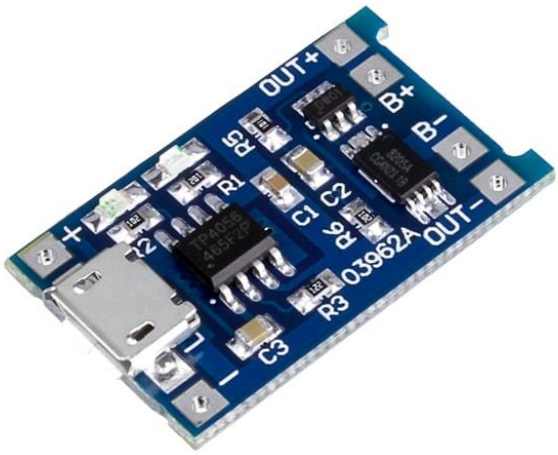


Fig. 5: TP4056 Charging module

This module uses the TP4056 / TC4056 Li-Ion charge controller IC and a separate protection IC. There are other types of modules on the market that use the TP4056 / TC4056 but lack any protection circuits or ICs to provide the necessary protection needed with lithium batteries. This module uses both the TP4056 / TC4056 and the DW01A Li-Ion battery protection IC, which together in combination provide the following protection features:

Manage the constant current to constant voltage charging of a connected lithium battery
Over-discharge protection - keeps your battery from being discharged below 2.4V, a healthy minimum voltage level for your battery
If a connected battery has been discharged below 2.4V the module will cut output power from the battery until the battery voltage has been re-charged above 3.0V (the over-discharge release voltage), which at that time the module will again allow discharge of power from the battery to a connected load. Although the module cuts output power from the battery during an over-discharge situation, it still allows charging of the battery to occur through the parasitic diode of the discharge control MOSFET (FS8205A Dual MOSFET).
Overcharge protection - the module will safely charge your battery to 4.2V
Overcurrent and short-circuit protection - the module will cut the output from the battery if the discharge rate exceeds 3A or if a short-circuit condition occurs
Soft-start protection limits inrush current
Trickle charge (battery reconditioning) - if the voltage level of the connected battery is less than 2.9V, the module will use a trickle charge current of 130mA until the battery voltage reaches 2.9V, at which point the charge current will be linearly increased to the configured charge current.

Can be powered, for charging, from a USB cable (USB Micro or USB C) or the + and - connections, see Power Supply Options Diagram below.

Solar Panel 3W

Fig. 6 : Solar Panel

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. Most modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can be either the top layer or the back layer. Cells must be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells are usually connected electrically in series, one to another to the desired voltage, and then in parallel to increase current. The power (in watts) of the module is the mathematical product of the voltage (in volts) and the current (in amperes) of the module. The manufacturing specifications on solar panels are obtained under standard condition, which is not the real operating condition the solar panels are exposed to on the installation site.[9]

A PV junction box is attached to the back of the solar panel and functions as its output interface. External connections for most photovoltaic modules use MC4 connectors to facilitate easy weatherproof connections to the rest of the system. A USB power interface can also be used.[10]

Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

1 k resistor x 2

Fig. 7: Resistor

These are carbon film axial leaded through hole type and can handle up to 1/4W of power at voltages up to 350V. 1/4W resistors are the most commonly used size for breadboarding.

We offer this particular line of resistors specifically for breadboarding because they have easy to read color-coding on a tan (5%) background so you don't have to keep dragging out the multimeter to figure out values.

In addition the leads are very stout with a 0.55 mm diameter constructed of tin and copper plated over steel wire, so they hold up well with repeated insertions into solderless breadboards. No more trying to use needle nose pliers to get the resistor leads to insert into the breadboard. The larger leads also grip better in the contacts.

Because the leads are strong, these resistors can also be useful when sky-wiring a project.

1K is a common value used for stiff pull-up and pull-down resistors.

Battery 9 V

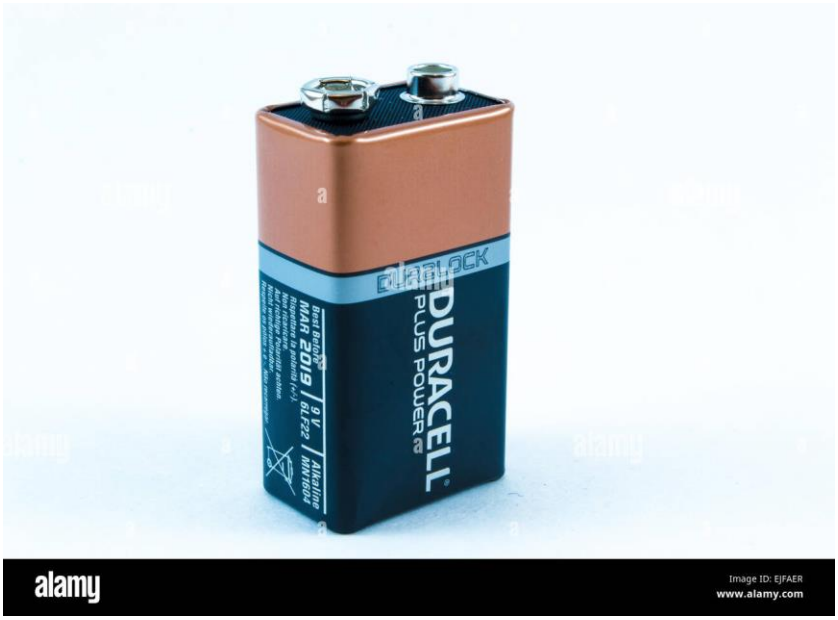


Fig. 8: Battery

The 9V battery is an extremely common battery that was first used in transistor radios. It features a rectangular prism shape that utilizes a pair of snap connectors which are located at the top of the battery. A wide array of both large and small battery manufacturers produce versions of the 9V battery. Possible chemistries of primary (non-rechargeable) 9V batteries include Alkaline, Carbon-Zinc (Heavy Duty), Lithium. Possible chemistries of secondary (rechargeable) 9V batteries include nickel-cadmium (NiCd), nickel-metal hydride (NiMH), and lithium ion. The performance and application of the battery can vary greatly between different chemistries, meaning that some chemistiries are better suited for some applications over others.

Battery Clip

Fig. 9: Battery Clip

A battery holder is most commonly sold as an integral or removable compartment or cavity, designed to be inserted into - or attached onto - a suitable item of cell-powered equipment.

The primary function of a battery holder is to keep cells fixed in place safely and securely while conveying power from the batteries to the device in question. External connections on battery holders are most often made by contacts either with pins, surface mount feet, soldered lugs or via a set of wire leads.

Battery holders are often designed to be incorporated within the body of an electrical item, but they're also frequently sold as external compartments or attachments. Either way, some of the most important factors to consider when choosing an appropriate battery holder for a given application will be:

Battery size
Compatible cell types
Contact/terminal style
Battery mounting and insertion method
Unit size and shape
Battery holder cover and housing design
Build quality and manufacturer reputation
Over the following sections of this guide, we'll examine each of these aspects in turn

4.4 Software Specifications :

Arduino IDE

Fig. 10: Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

Writing Sketches

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

Proteus 8

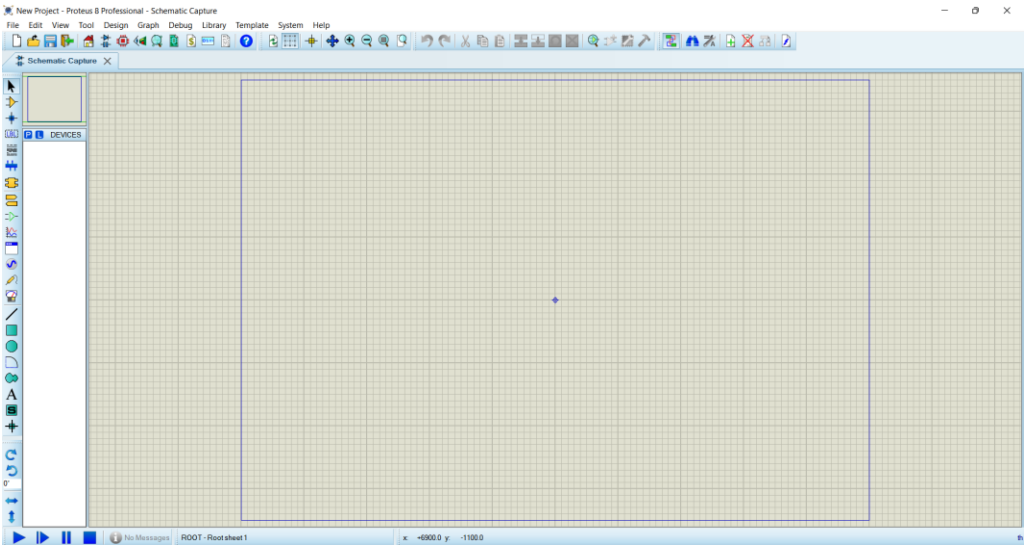


Fig. 11: Proteus 8

Simulation:

Circuit ready for testing? You can test it using Proteus's simulation feature. Many of the components in Proteus can be simulated. There are two options for simulating: Run simulator and advance frame by frame. The "Run simulator" option simulates the circuit in a normal speed (If the circuit is not heavy). "Advance frame by frame" option advances to next frame and waits till you click this button for the next time. This can be useful for debugging digital circuits. You can also simulate microcontrollers. The microcontrollers which can be simulated include PIC24, dsPIC33, 8051, Arduino, ARM7 based microcontrollers. You can download the compilers for Proteus or use different compiler and dump the hex files in the microcontroller in Proteus. You can even interact in real-time with the simulation using switches, resistors, LDRs, etc. There are even virtual voltmeter, ammeter, oscilloscope, logic analyzer,etc.

Designing: PCB:

Designing PCBs are easy using Proteus. You can make your own design or let Proteus do that for you. Making your own design is simple, you just have to place the components used in the schematic and draw traces over them. Don't worry about violating any design rules because it automatically detects design rule (DRC) errors. You can also let Proteus do the work for you. You can place the components on their respective places and select the "auto route" option. This will automatically draw multiple variations of traces and selects the best one.

EasyEDA PCB Design

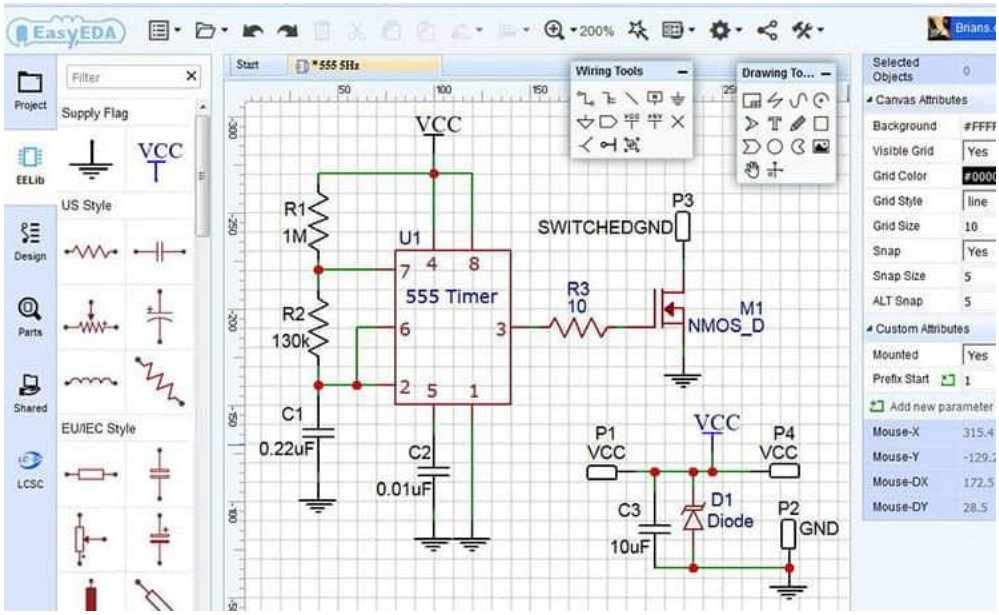


Fig. 12: EasyEDA PCB Design

EasyEDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share - publicly and privately - and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats.

EasyEDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription.

Registered users can download Gerber files from the tool free of charge; but for a fee, EasyEDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

5. Design and Implementation

5.1 EDA Simulation result: -

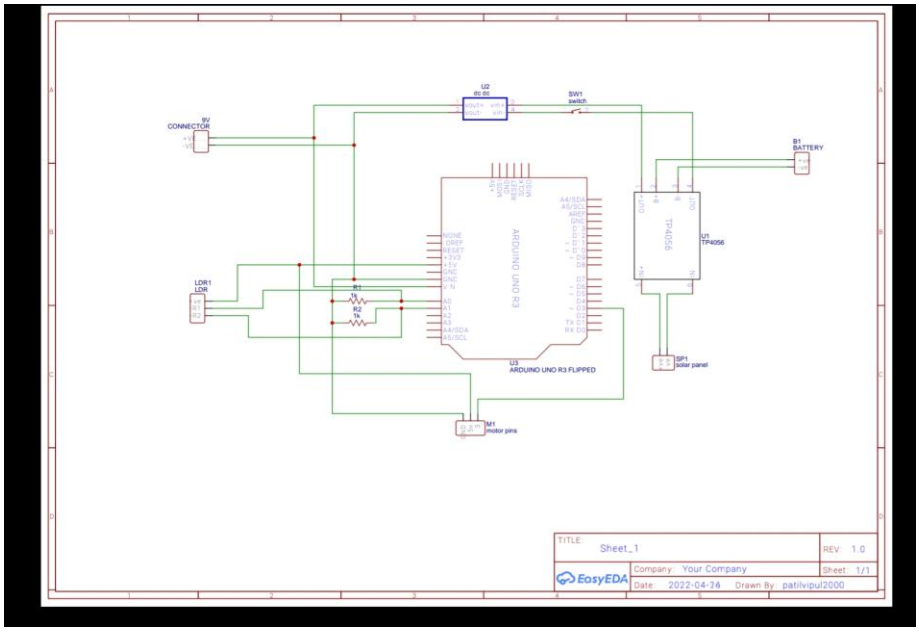


Fig. 13: EDA Simulation result

EasyEDA PCB designing tool was used to design schematics and for connecting components.

Component connections

1) Servo motor: -
   +Ve – Gnd (Arduino)
   -Ve – 5V (Arduino)
   PWM pin- D3 (Arduino)

2) Resistors: -
   R1 connected to A0 and Gnd (Arduino)
   R2 connected to A1 and Gnd (Arduino)

3) LDRs: -
   LDR1 +Ve - 5V(Arduino)
   -Ve - A0(Arduino)

   LDR2 +Ve - 5V(Arduino)
   -Ve - A1(Arduino)

4) 9V(BATTERY): -

+Ve - Vin (Arduino)
-Vin – Gnd (Arduino)

5) DC-DC boost converter [TP4056]: -

+Ve Vout – Vin (Arduino)
-Ve Vout – Gnd (Arduino)
+Ve Vin - +Ve OUT[TP4056]
-Ve Vin - -Ve OUT[TP4056]

6) Switch: –
Connected between Vin(-ve) of MT3608 and Vout(-ve) of TP4056

7) TP4056: -

B+ - +Ve of Rechargeable battery
B- - -Ve of Rechargeable battery

8) Solar Panel: -

+Ve - In+Ve [TP4056]
-Ve - In-Ve [TP4056]

5.2 Layout of PCB : -

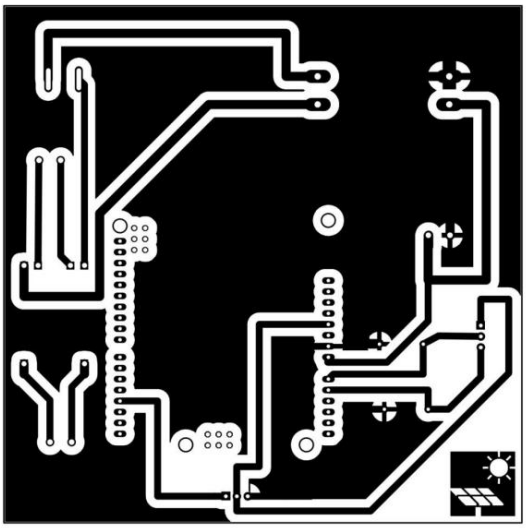


Fig. 14: Layout of PCB

Bottom side PCB routing was done with grounded copper layer.

5.3 Testing and verification of circuit: -

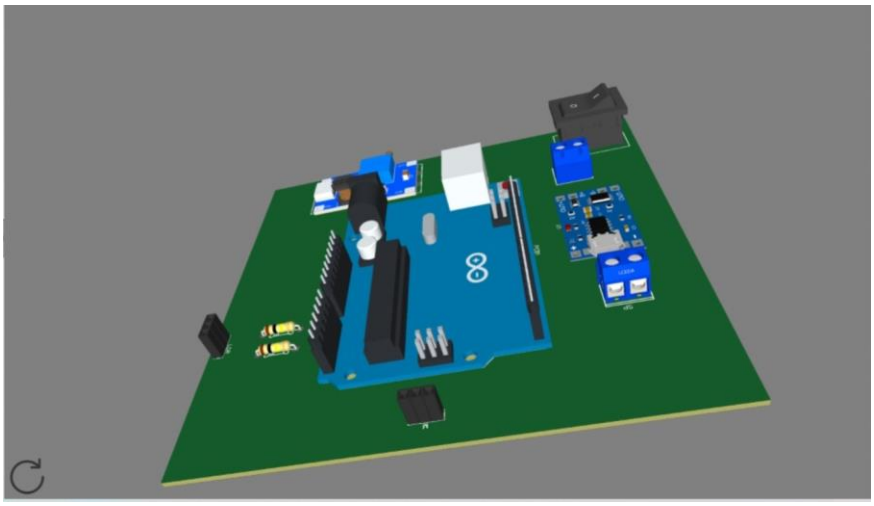


Fig. 15: Testing and verification of circuit

3D Implementation of PCB was verified on EasyEDA software tool.

5.4 Snaps shots of implementation: -

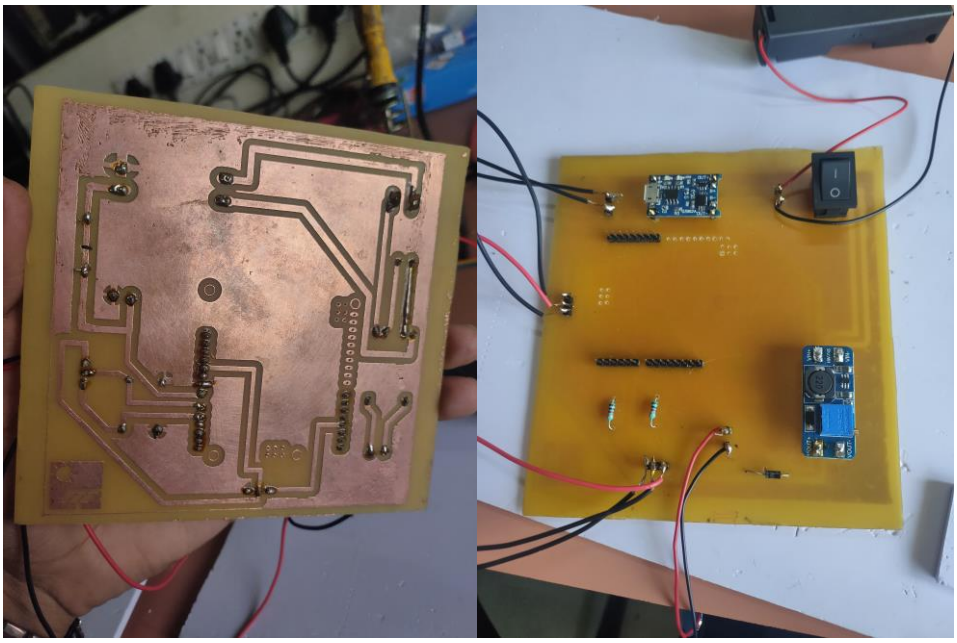


Fig. 16: Snaps shots of implementation

Components were placed on top side and soldered at bottom side. The continuity of copper traces was tested using DMM

6. Results

6.1 Simulation Software tool Introduction:

Proteus Software was used for simulation purpose.

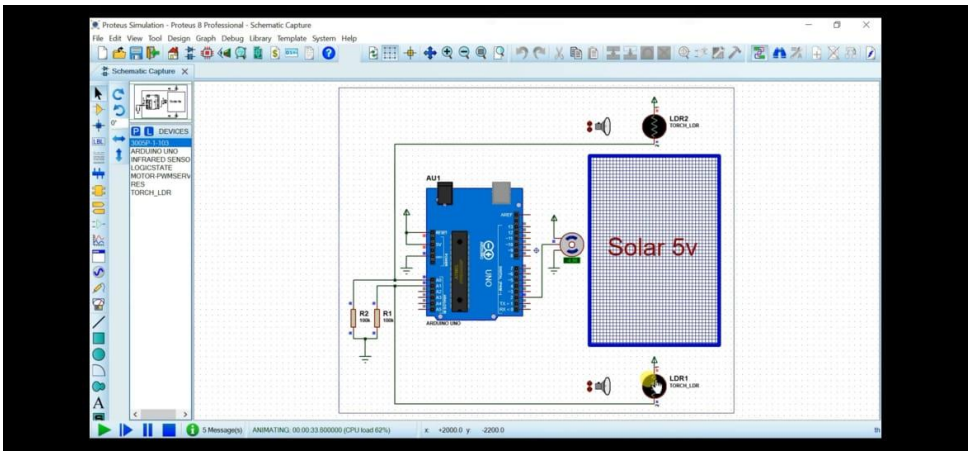


Fig. 17: Simulation

In the simulation we checked and verified the code of our project.

6.2 Hardware Implementation:

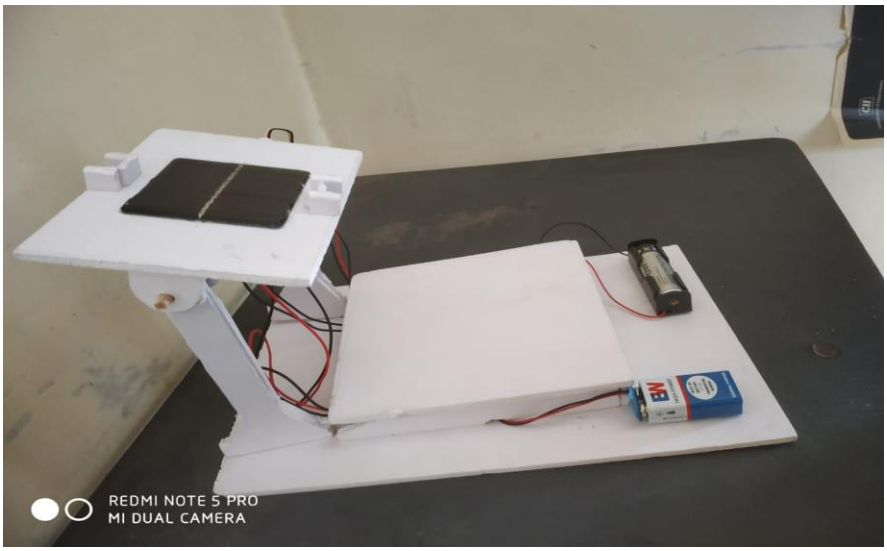


Fig. 18: Hardware Implementation

This is the final working prototype of our project.

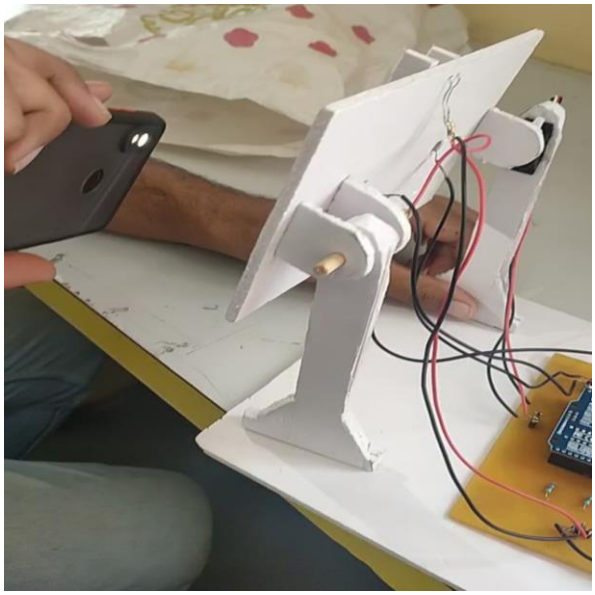


Fig. 19

LDR 2 detects more intensity so the solar panel bends upwards .

Fig. 20

LDR 1 detects more intensity so the solar panel bends downwards .

7. Conclusion

- **Conclusion**

The use of Solar Tracking system will help us to improve the performance of PV solar system. It will increase the utilization rate of solar energy and efficiency of photovoltaic power generation system.

- **Future Scope**

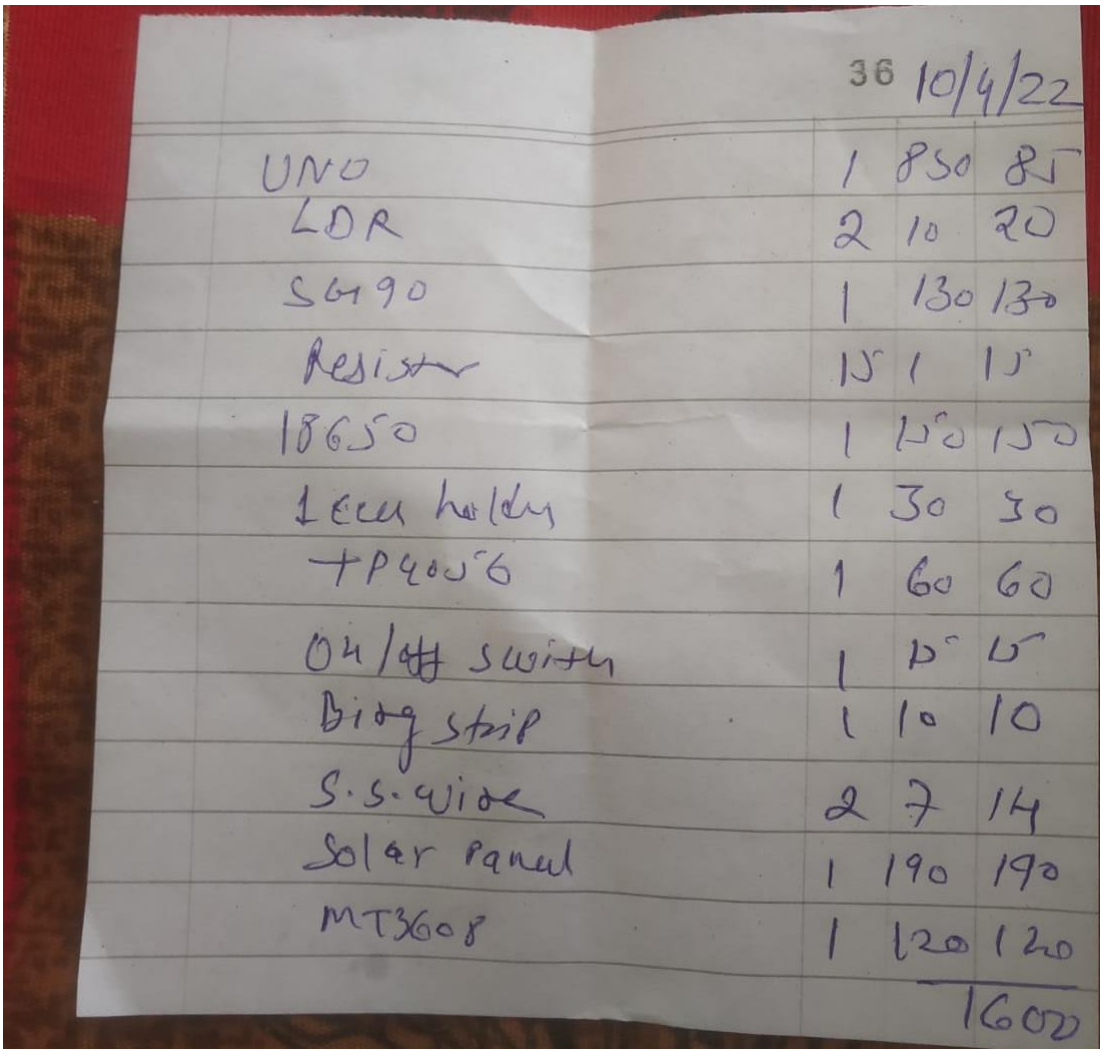
The goals of this project were a purposely kept within what was believed to be attainable within the allotted timeline. As such, many advance improvements can be made up of initial design of solar tracker. It is felt this design represents a functioning scale model which could be replicated for a much larger scale. following recommendation are provided as ideas for future expansion for this project.

- **Applications**

The Solar Tracking System has the following applications: -

- The Solar Tracking system can be utilized for tracking the sun and thus pointing the solar panel at the point of maximum solar intensity.
- Off-grid areas can be effectively electrified.
- Most efficient for pumping water and other agricultural applications.
- Governmental schools, hospitals etc. can effectively use and thus help in improving their carbon image.

8. Bill of Material



	36 10/4/22		
UNO	1	850	85
LDR	2	10	20
SG90	1	130	130
Resistor	15	1	15
18650	1	150	150
1 Cell holder	1	30	30
TP4056	1	60	60
On/off switch	1	05	05
Berg strip	1	10	10
S.S. wire	2	7	14
Solar Panel	1	190	190
MT3608	1	120	120
			1602

Fig. 21

9. References: -

1) Kamil.R. Kehinde, Seriki.B. Salaudeen, Aliyu.Y. Sharif and Kamil.I. Jemilat, "Development of A Microcontroller Based Solar Tracking System," International Journal of Scientific & Engineering Research, Volume 12, Issue 5, May- 2021 ISSN 2229-5518

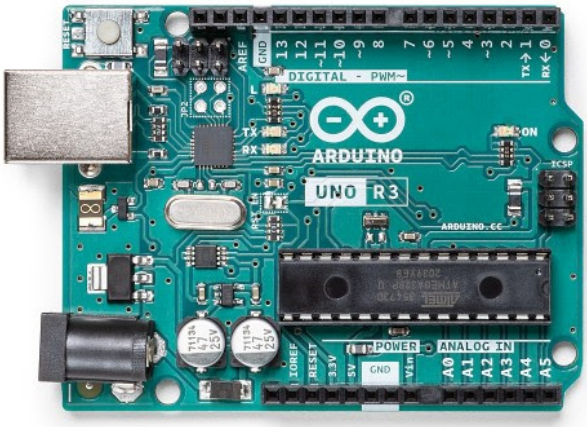
2) Chaowanan Jamroen, Chanon Fongkerd, Wipa Krongpha, Preecha Komkum, Alongkorn Pirayawaraporn, Nachaya Chindakham, "A novel UV sensor-based dual-axis solar tracking system: Implementation and performance analysis," Division of Instrumentation and Automation Engineering Technology, Faculty of Engineering and Technology, King Mongkut's University of Technology North Bangkok, Thailand 2021.

3) Akhil Raj K R, Sreejith Suresh, Amal Razic K A, Vidhu Narayan K B, Sanju B, "Implementation of an Automatic Solar Tracking System," GRD Journals | Global Research and Development Journal for Engineering |National Conference on Emerging Research Trend in Electrical and Electronics Engineering (ERTE'19) | May 2019

4) A.R. Amelia, Y.M. Irwan, I. Safwati, W.Z. Leow, M.H. Mat and Mohd Shukor Abdul Rahim, S. Md. Esa, "Technologies of solar tracking systems: A review," International Symposium on Engineering and Technology (ISETech) 2020

5) A.Z. Hafez, A.M. Yousef, N.M. Harag, "Solar tracking systems: Technologies and trackers drive types – A review," Renewable and Sustainable Energy Reviews 91 (2018) 754–782

Product Reference Manual
SKU: A000066



Description

The Arduino UNO R3 is the perfect board to get familiar with electronics and coding. This versatile microcontroller is equipped with the well-known ATmega328P and the ATMega 16U2 Processor.
This board will give you a great first experience within the world of Arduino.

Target areas:

Maker, introduction, industries

Features

- **ATMega328P** Processor
  - **Memory**
    - AVR CPU at up to 16 MHz
    - 32KB Flash
    - 2KB SRAM
    - 1KB EEPROM
  - **Security**
    - Power On Reset (POR)
    - Brown Out Detection (BOD)
  - **Peripherals**
    - 2x 8-bit Timer/Counter with a dedicated period register and compare channels
    - 1x 16-bit Timer/Counter with a dedicated period register, input capture and compare channels
    - 1x USART with fractional baud rate generator and start-of-frame detection
    - 1x controller/peripheral Serial Peripheral Interface (SPI)
    - 1x Dual mode controller/peripheral I2C
    - 1x Analog Comparator (AC) with a scalable reference input
    - Watchdog Timer with separate on-chip oscillator
    - Six PWM channels
    - Interrupt and wake-up on pin change
  - **ATMega16U2 Processor**
    - 8-bit AVR® RISC-based microcontroller
  - **Memory**
    - 16 KB ISP Flash
    - 512B EEPROM
    - 512B SRAM
    - debugWIRE interface for on-chip debugging and programming
  - **Power**
    - 2.7-5.5 volts

CONTENTS

1 The Board

1.1 Application Examples

The UNO board is the flagship product of Arduino. Regardless if you are new to the world of electronics or will use the UNO as a tool for education purposes or industry-related tasks.

First entry to electronics: If this is your first project within coding and electronics, get started with our most used and documented board; Arduino UNO. It is equipped with the well-known ATmega328P processor, 14 digital input/output pins, 6 analog inputs, USB connections, ICSP header and reset button. This board includes everything you will need for a great first experience with Arduino.

Industry-standard development board: Using the Arduino UNO board in industries, there are a range of companies using the UNO board as the brain for their PLC's.

Education purposes: Although the UNO board has been with us for about ten years, it is still widely used for various education purposes and scientific projects. The board's high standard and top quality performance makes it a great resource to capture real time from sensors and to trigger complex laboratory equipment to mention a few examples.

1.2 Related Products

- Starter Kit
- Tinkerkit Braccio Robot
- Example

2 Ratings

2.1 Recommended Operating Conditions

Symbol	Description	Min	Max
	Conservative thermal limits for the whole board:	-40 °C (-40°F)	85 °C (185°F)

NOTE: In extreme temperatures, EEPROM, voltage regulator, and the crystal oscillator, might not work as expected due to the extreme temperature conditions

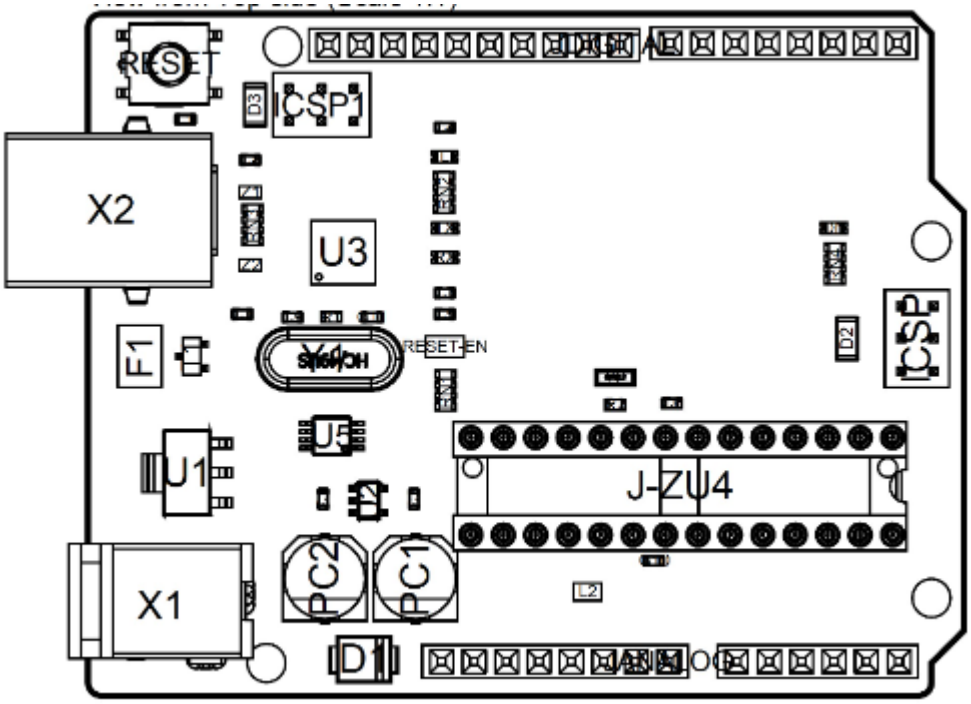
2.2 Power Consumption

Symbol	Description	Min	Typ	Max	Unit
VINMax	Maximum input voltage from VIN pad	6	-	20	V
VUSBMax	Maximum input voltage from USB connector		-	5.5	V
PMax	Maximum Power Consumption	-	-	xx	mA

3 Functional Overview

3.1 Board Topology

Top view



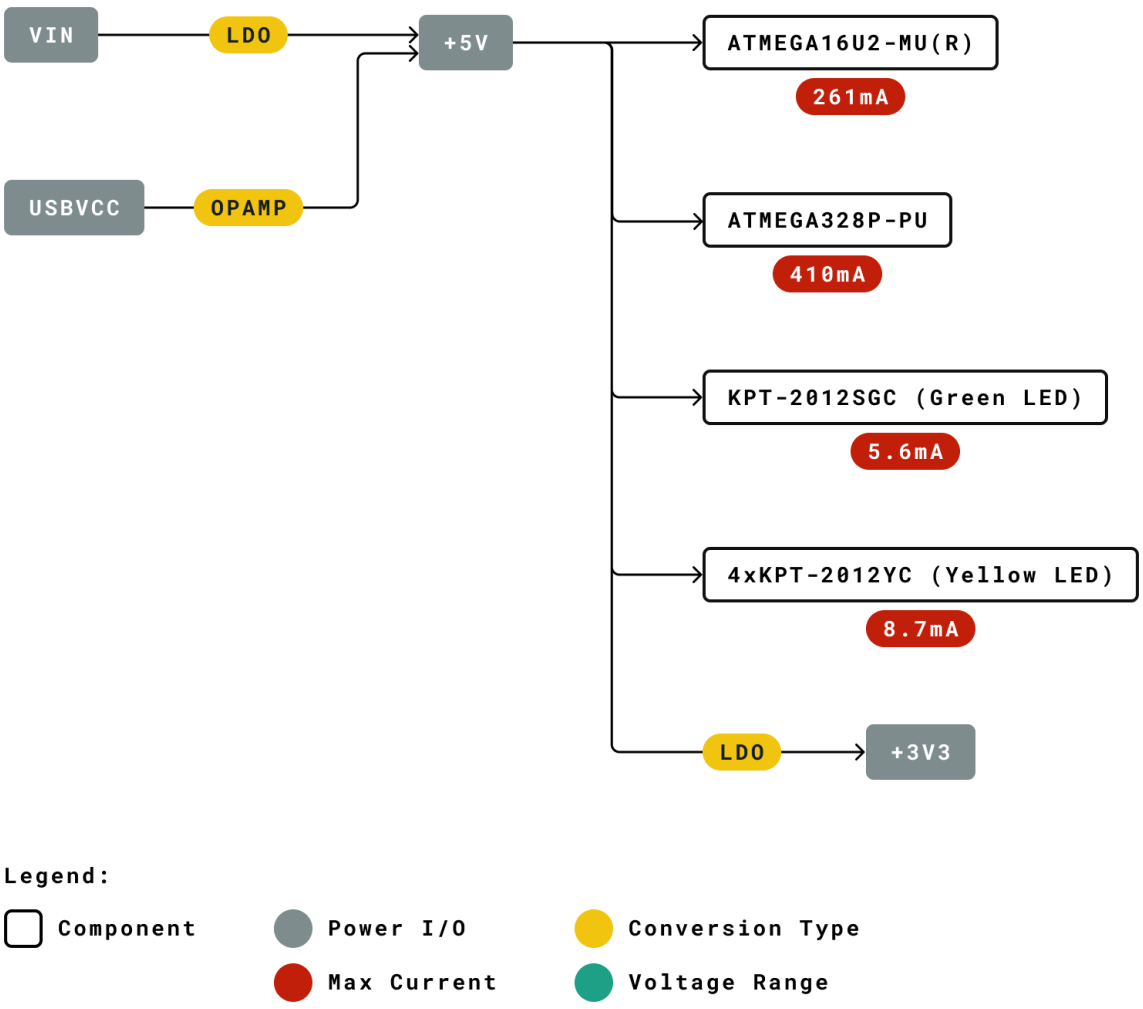
Board topology

Ref.	Description	Ref.	Description
X1	Power jack 2.1x5.5mm	U1	SPX1117M3-L-5 Regulator
X2	USB B Connector	U3	ATMEGA16U2 Module
PC1	EEE-1EA470WP 25V SMD Capacitor	U5	LMV358LIST-A.9 IC
PC2	EEE-1EA470WP 25V SMD Capacitor	F1	Chip Capacitor, High Density
D1	CGRA4007-G Rectifier	ICSP	Pin header connector (through hole 6)
J-ZU4	ATMEGA328P Module	ICSP1	Pin header connector (through hole 6)
Y1	ECS-160-20-4X-DU Oscillator		

3.2 Processor

The Main Processor is a ATmega328P running at up tp 20 MHz. Most of its pins are connected to the external headers, however some are reserved for internal communication with the USB Bridge coprocessor.

3.3 Power Tree



Power tree

4 Board Operation

4.1 Getting Started - IDE

If you want to program your Arduino UNO while offline you need to install the Arduino Desktop IDE [1] To connect the Arduino UNO to your computer, you'll need a Micro-B USB cable. This also provides power to the board, as indicated by the LED.

4.2 Getting Started - Arduino Web Editor

All Arduino boards, including this one, work out-of-the-box on the Arduino Web Editor [2], by just installing a simple plugin.

The Arduino Web Editor is hosted online, therefore it will always be up-to-date with the latest features and support for all boards. Follow **[3]** to start coding on the browser and upload your sketches onto your board.

4.3 Getting Started - Arduino IoT Cloud

All Arduino IoT enabled products are supported on Arduino IoT Cloud which allows you to Log, graph and analyze sensor data, trigger events, and automate your home or business.

4.4 Sample Sketches

Sample sketches for the Arduino XXX can be found either in the "Examples" menu in the Arduino IDE or in the "Documentation" section of the Arduino Pro website [4]

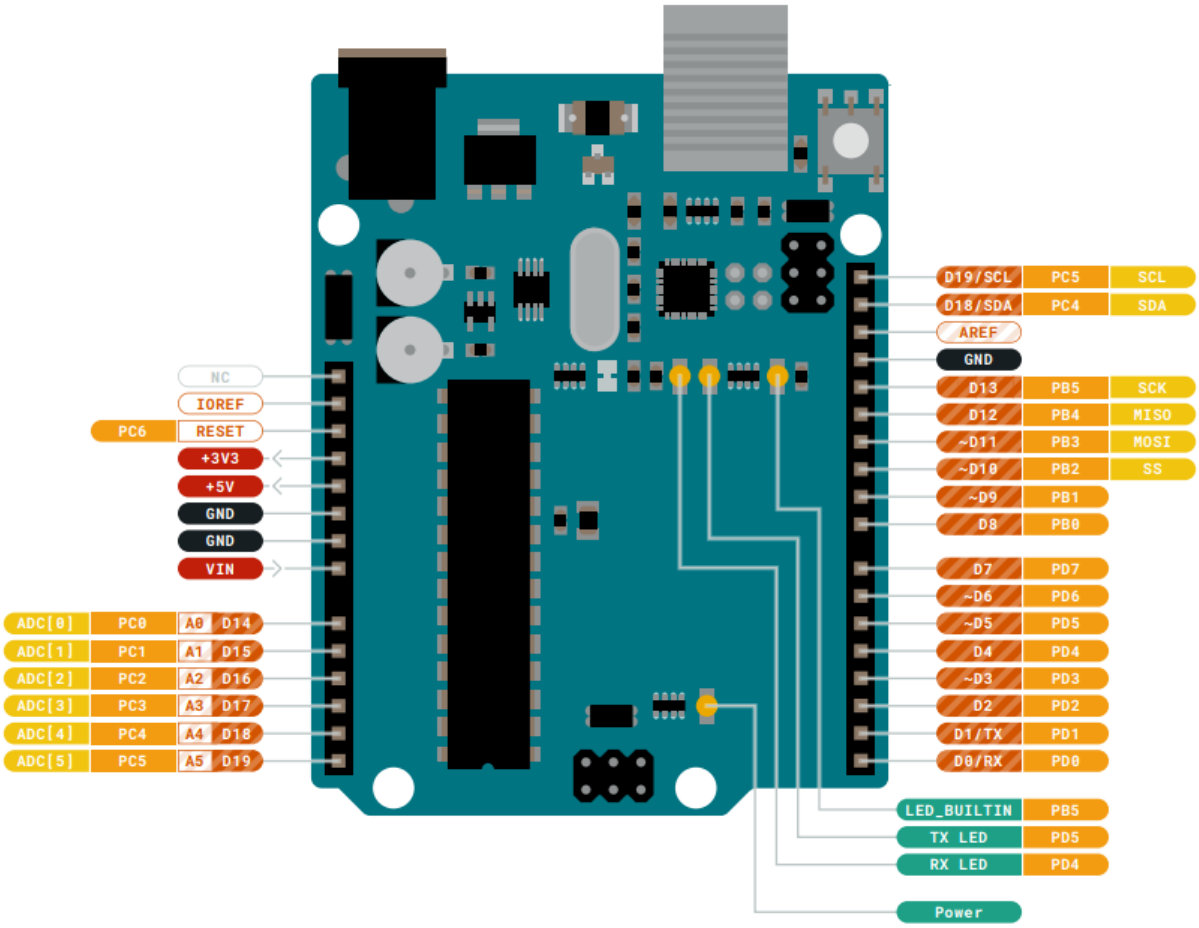
4.5 Online Resources

Now that you have gone through the basics of what you can do with the board you can explore the endless possibilities it provides by checking exciting projects on ProjectHub **[5]**, the Arduino Library Reference **[6]** and the online store **[7]** where you will be able to complement your board with sensors, actuators and more

4.6 Board Recovery

All Arduino boards have a built-in bootloader which allows flashing the board via USB. In case a sketch locks up the processor and the board is not reachable anymore via USB it is possible to enter bootloader mode by double-tapping the reset button right after power up.

5 Connector Pinouts



Pinout

5.1 JANALOG

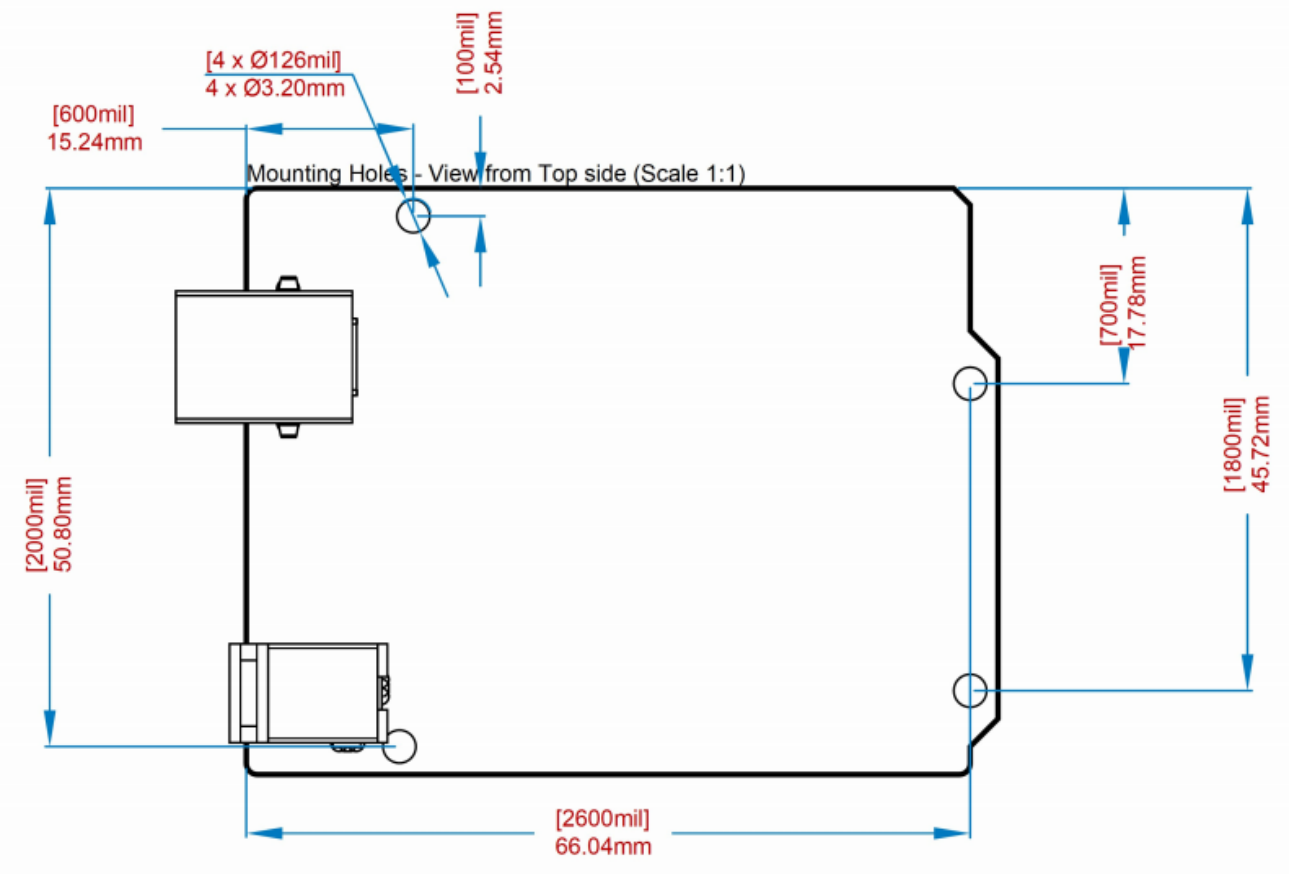
Pin	Function	Type	Description
1	NC	NC	Not connected
2	IOREF	IOREF	Reference for digital logic V - connected to 5V
3	Reset	Reset	Reset
4	+3V3	Power	+3V3 Power Rail
5	+5V	Power	+5V Power Rail
6	GND	Power	Ground
7	GND	Power	Ground
8	VIN	Power	Voltage Input
9	A0	Analog/GPIO	Analog input 0 /GPIO
10	A1	Analog/GPIO	Analog input 1 /GPIO
11	A2	Analog/GPIO	Analog input 2 /GPIO
12	A3	Analog/GPIO	Analog input 3 /GPIO
13	A4/SDA	Analog input/I2C	Analog input 4/I2C Data line
14	A5/SCL	Analog input/I2C	Analog input 5/I2C Clock line

5.2 JDIGITAL

Pin	Function	Type	Description
1	D0	Digital/GPIO	Digital pin 0/GPIO
2	D1	Digital/GPIO	Digital pin 1/GPIO
3	D2	Digital/GPIO	Digital pin 2/GPIO
4	D3	Digital/GPIO	Digital pin 3/GPIO
5	D4	Digital/GPIO	Digital pin 4/GPIO
6	D5	Digital/GPIO	Digital pin 5/GPIO
7	D6	Digital/GPIO	Digital pin 6/GPIO
8	D7	Digital/GPIO	Digital pin 7/GPIO
9	D8	Digital/GPIO	Digital pin 8/GPIO
10	D9	Digital/GPIO	Digital pin 9/GPIO
11	SS	Digital	SPI Chip Select
12	MOSI	Digital	SPI1 Main Out Secondary In
13	MISO	Digital	SPI Main In Secondary Out
14	SCK	Digital	SPI serial clock output
15	GND	Power	Ground
16	AREF	Digital	Analog reference voltage
17	A4/SD4	Digital	Analog input 4/I2C Data line (duplicated)
18	A5/SD5	Digital	Analog input 5/I2C Clock line (duplicated)

5.3 Mechanical Information

5.4 Board Outline & Mounting Holes



Board outline

6 Certifications

6.1 Declaration of Conformity CE DoC (EU)

We declare under our sole responsibility that the products above are in conformity with the essential requirements of the following EU Directives and therefore qualify for free movement within markets comprising the European Union (EU) and European Economic Area (EEA).

ROHS 2 Directive 2011/65/EU	
Conforms to:	EN50581:2012
Directive 2014/35/EU. (LVD)	
Conforms to:	EN 60950-1:2006/A11:2009/A1:2010/A12:2011/AC:2011
Directive 2004/40/EC & 2008/46/EC & 2013/35/EU, EMF	
Conforms to:	EN 62311:2008

6.2 Declaration of Conformity to EU RoHS & REACH 211 01/19/2021

Arduino boards are in compliance with RoHS 2 Directive 2011/65/EU of the European Parliament and RoHS 3 Directive 2015/863/EU of the Council of 4 June 2015 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Substance	Maximum limit (ppm)
Lead (Pb)	1000
Cadmium (Cd)	100
Mercury (Hg)	1000
Hexavalent Chromium (Cr6+)	1000
Poly Brominated Biphenyls (PBB)	1000
Poly Brominated Diphenyl ethers (PBDE)	1000
Bis(2-Ethylhexyl} phthalate (DEHP)	1000
Benzyl butyl phthalate (BBP)	1000
Dibutyl phthalate (DBP)	1000
Diisobutyl phthalate (DIBP)	1000

Exemptions: No exemptions are claimed.

Arduino Boards are fully compliant with the related requirements of European Union Regulation (EC) 1907 /2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH). We declare none of the SVHCs (https://echa.europa.eu/web/guest/candidate-list-table), the Candidate List of Substances of Very High Concern for authorization currently released by ECHA, is present in all products (and also package) in quantities totaling in a concentration equal or above 0.1%. To the best of our knowledge, we also declare that our products do not contain any of the substances listed on the "Authorization List" (Annex XIV of the REACH regulations) and Substances of Very High Concern (SVHC) in any significant amounts as specified by the Annex XVII of Candidate list published by ECHA (European Chemical Agency) 1907 /2006/EC.

6.3 Conflict Minerals Declaration

As a global supplier of electronic and electrical components, Arduino is aware of our obligations with regards to laws and regulations regarding Conflict Minerals, specifically the Dodd-Frank Wall Street Reform and Consumer Protection Act, Section 1502. Arduino does not directly source or process conflict minerals such as Tin, Tantalum, Tungsten, or Gold. Conflict minerals are contained in our products in the form of solder, or as a component in metal alloys. As part of our reasonable due diligence Arduino has contacted component suppliers within our supply chain to verify their continued compliance with the regulations. Based on the information received thus far we declare that our products contain Conflict Minerals sourced from conflict-free areas.

7 FCC Caution

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference

(2) this device must accept any interference received, including interference that may cause undesired operation.

FCC RF Radiation Exposure Statement:

1. This Transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
2. This equipment complies with RF radiation exposure limits set forth for an uncontrolled environment.
3. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

English: User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both. This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

French: Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l' appareil nedoit pas produire de brouillage

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

IC SAR Warning:

English This equipment should be installed and operated with minimum distance 20 cm between the radiator and your body.

French: Lors de l' installation et de l' exploitation de ce dispositif, la distance entre le radiateur et le corps est d 'au moins 20 cm.

Important: The operating temperature of the EUT can't exceed 85℃ and shouldn't be lower than -40℃.

Hereby, Arduino S.r.l. declares that this product is in compliance with essential requirements and other relevant provisions of Directive 2014/53/EU. This product is allowed to be used in all EU member states.

8 Company Information

Company name	Arduino S.r.l
Company Address	Via Andrea Appiani 25 20900 MONZA Italy

9 Reference Documentation

Reference	Link
Arduino IDE (Desktop)	https://www.arduino.cc/en/Main/Software
Arduino IDE (Cloud)	https://create.arduino.cc/editor
Cloud IDE Getting Started	https://create.arduino.cc/projecthub/Arduino_Genuino/getting-started-with-arduino-web-editor-4b3e4a
Arduino Pro Website	https://www.arduino.cc/pro
Project Hub	https://create.arduino.cc/projecthub?by=part&part_id=11332&sort=trending
Library Reference	https://www.arduino.cc/reference/en/
Online Store	https://store.arduino.cc/

10 Revision History

Date	Revision	Changes
xx/06/2021	1	Datasheet release

Data Sheet

Light dependent resistors

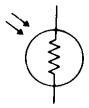
NORP12 RS stock number 651-507
NSL19-M51 RS stock number 596-141

Two cadmium sulphide (cdS) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

Guide to source illuminations

Light source	Illumination (Lux)
Moonlight	0.1
60W bulb at 1m	50
1W MES bulb at 0.1m	100
Fluorescent lighting	500
Bright sunlight	30,000

Circuit symbol



Light memory characteristics

Light dependent resistors have a particular property in that they remember the lighting conditions in which they have been stored. This memory effect can be minimised by storing the LDRs in light prior to use. Light storage reduces equilibrium time to reach steady resistance values.

NORP12 (**RS** stock no. 651-507)

Absolute maximum ratings

Voltage, ac or dc peak	320V
Current	75mA
Power dissipation at 30°C	250mW
Operating temperature range	-60°C to +75°C

Electrical characteristics

T_A = 25°C. 2854°K tungsten light source

Parameter	Conditions	Min.	Typ.	Max.	Units
Cell resistance	1000 lux	-	400	-	Ω
	10 lux	-	9	-	kΩ
Dark resistance	-	1.0	-	-	MΩ
Dark capacitance	-	-	3.5	-	pF
Rise time 1	1000 lux	-	2.8	-	ms
	10 lux	-	18	-	ms
Fall time 2	1000 lux	-	48	-	ms
	10 lux	-	120	-	ms

1. Dark to 110% R_L
2. To 10 × R_L

R_L = photocell resistance under given illumination.

Features

- Wide spectral response
- Low cost
- Wide ambient temperature range.

Dimensions

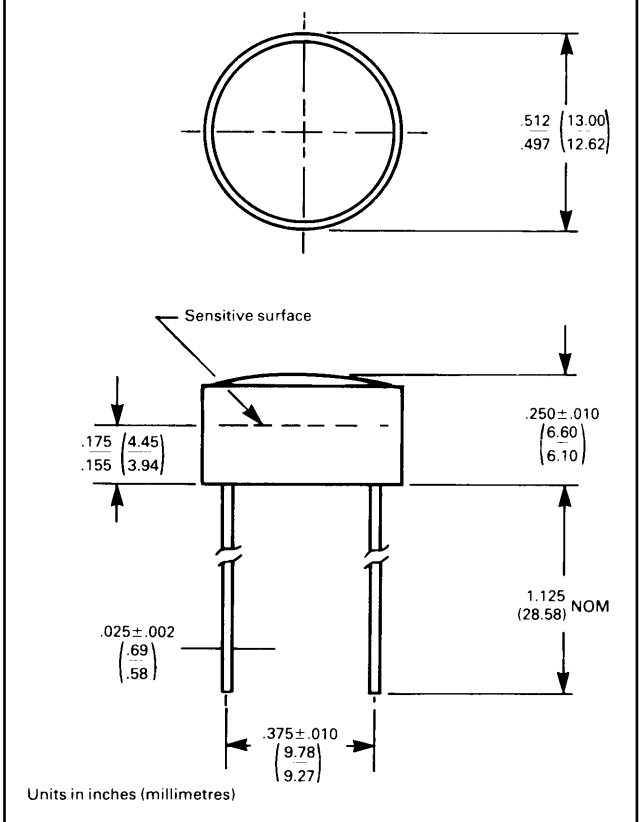


Figure 1 Power dissipation derating

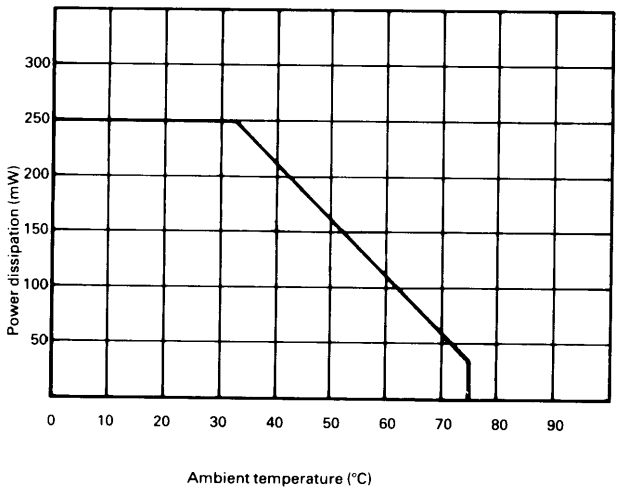


Figure 2 Spectral response

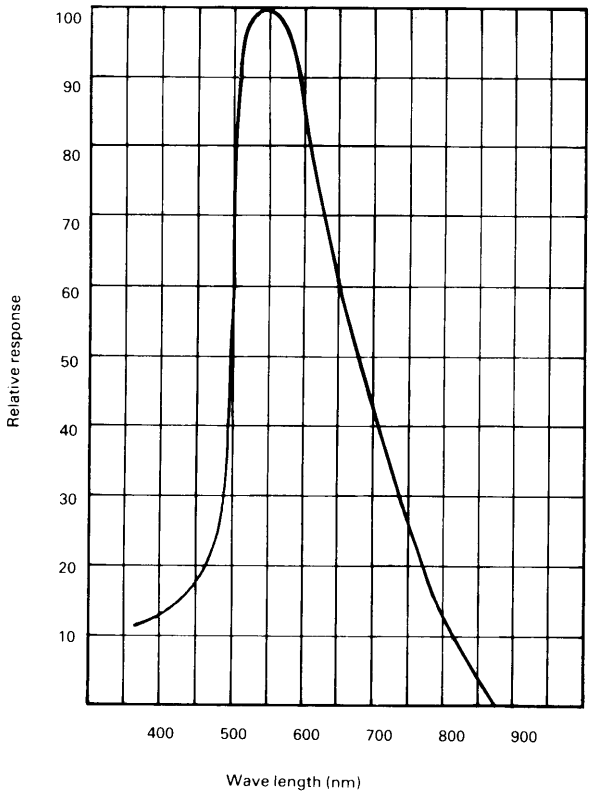
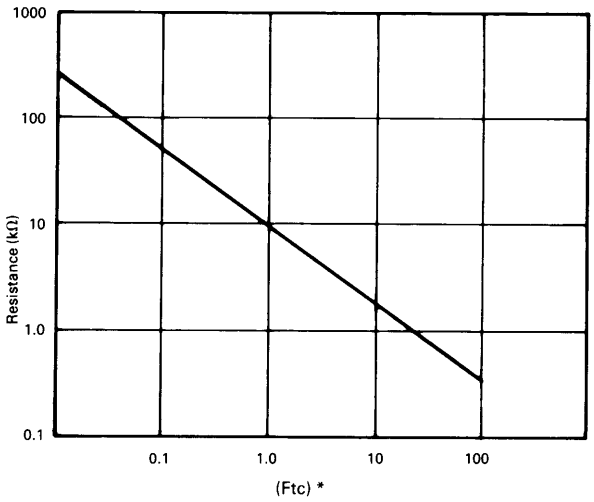


Figure 3 Resistance as a function of illumination



*1Ftc=10.764 lumens

Absolute maximum ratings

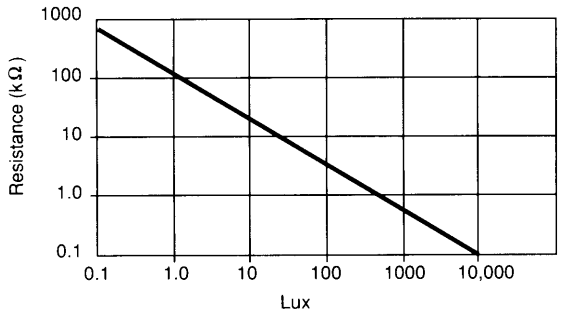
Voltage, ac or dc peak _____ 100V
Current _____ 5mA
Power dissipation at 25°C _____ 50mW*
Operating temperature range _____ -25°C +75°C

*Derate linearly from 50mW at 25°C to 0W at 75°C.

Electrical characteristics

Parameter	Conditions	Min.	Typ.	Max.	Units
Cell resistance	10 lux 100 lux	20 -	- 5	100 -	kΩ kΩ
Dark resistance	10 lux after 10 sec	20	-	-	MΩ
Spectral response	-	-	550	-	nm
Rise time	10ftc	-	45	-	ms
Fall time	10ftc	-	55	-	ms

Figure 4 Resistance as a function illumination



Dimensions

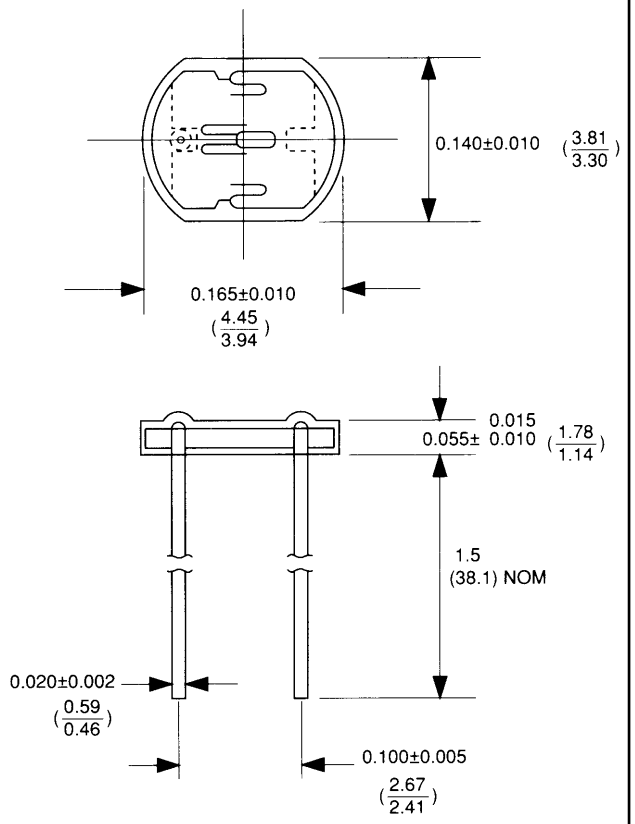
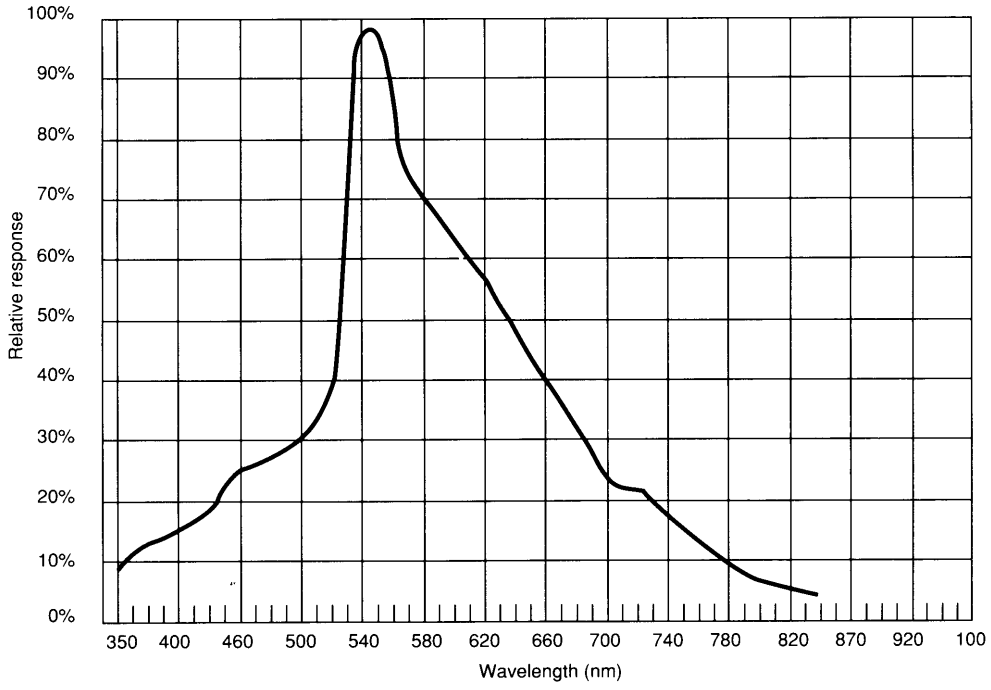
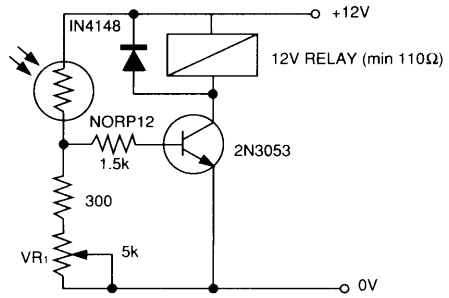


Figure 5 Spectral response



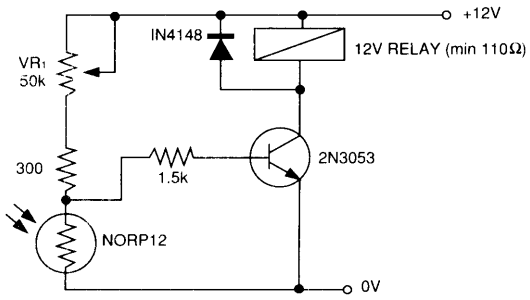
Typical application circuits

Figure 6 Sensitive light operated relay



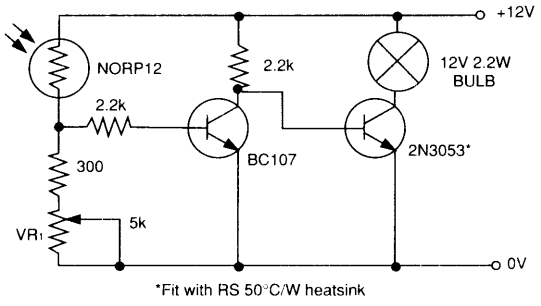
Relay energised when light level increases above the level set by VR_1

Figure 7 Light interruption detector



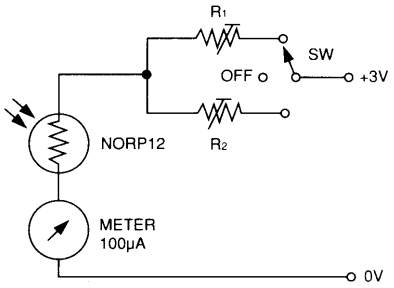
As Figure 6 relay energised when light level drops below the level set by VR_1

Figure 8 Automatic light circuit



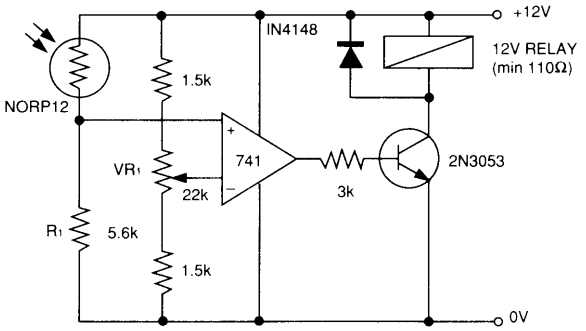
Adjust turn-on point with VR_1

Figure 9 Logarithmic law photographic light meter



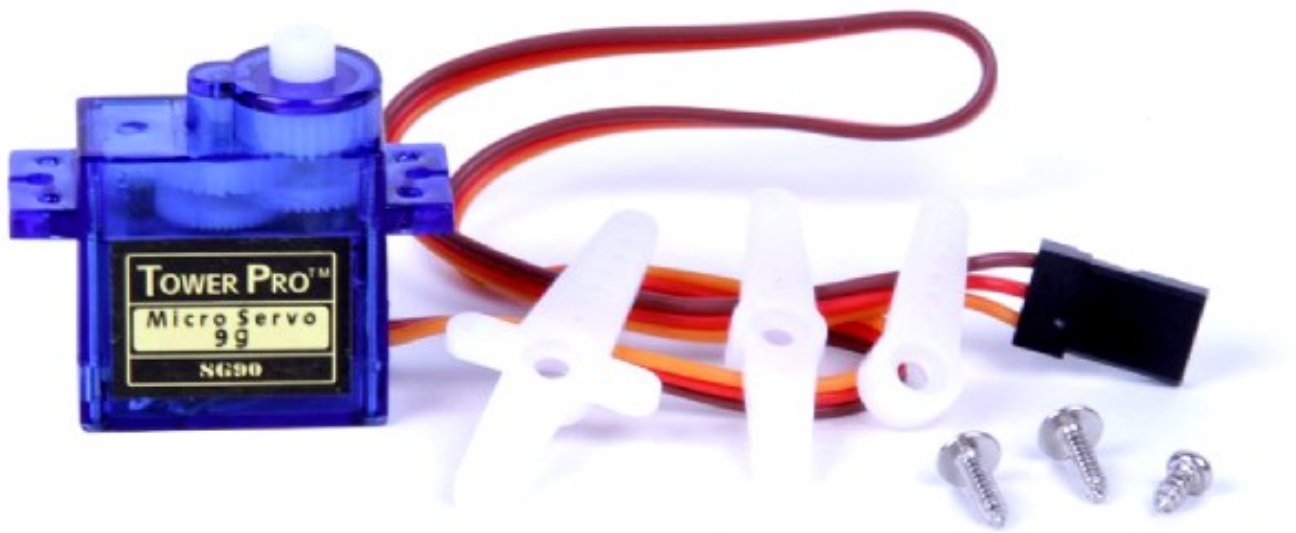
Typical value $R^1 = 100k\Omega$
$R^2 = 200k\Omega$ preset to give two overlapping ranges.
(Calibration should be made against an accurate meter.)

Figure 10 Extremely sensitive light operated relay

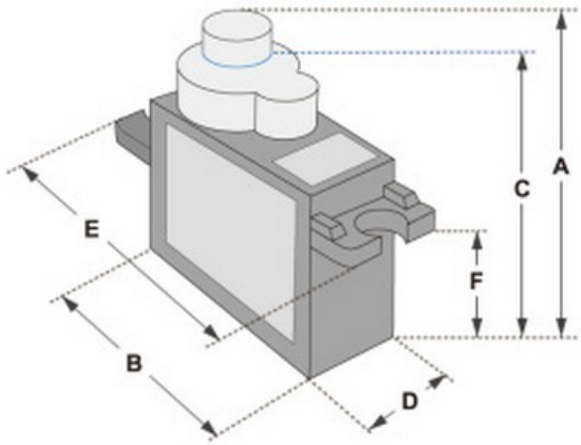


(Relay energised when light exceeds preset level.)
Incorporates a balancing bridge and op-amp. R_1 and NORP12 may be interchanged for the reverse function.

SERVO MOTOR SG90 DATA SHEET

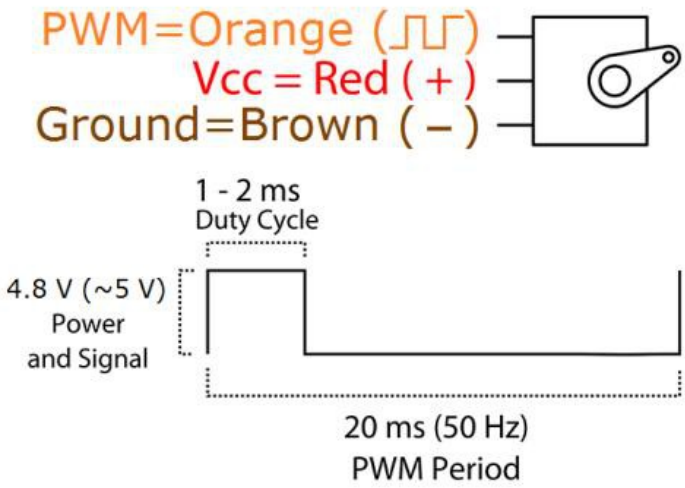


Tiny and lightweight with high output power. Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller. You can use any servo code, hardware or library to control these servos. Good for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. It comes with a 3 horns (arms) and hardware.



Dimensions & Specifications
A (mm) : 32
B (mm) : 23
C (mm) : 28.5
D (mm) : 12
E (mm) : 32
F (mm) : 19.5
Speed (sec) : 0.1
Torque (kg-cm) : 2.5
Weight (g) : 14.7
Voltage : 4.8 - 6

Position "0" (1.5 ms pulse) is middle, "90" (~2ms pulse) is middle, is all the way to the right, "-90" (~1ms pulse) is all the way to the left.



TP4056 1A Standalone Linear Li-Ion Battery Charger with Thermal Regulation in SOP-8

DESCRIPTION

The TP4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its SOP package and low external component count make the TP4056 ideally suited for portable applications. Furthermore, the TP4056 can work within USB and wall adapter.

No blocking diode is required due to the internal PMOSFET architecture and have prevent to negative Charge Current Circuit. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4056 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

TP4056 Other features include current monitor, under voltage lockout, automatic recharge and two status pin to indicate charge termination and the presence of an input voltage.

FEATURES

- Programmable Charge Current Up to 1000mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in SOP-8 Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.2V Charge Voltage with 1.5% Accuracy
- Automatic Recharge
- two Charge Status Output Pins
- C/10 Charge Termination
- 2.9V Trickle Charge Threshold (TP4056)
- Soft-Start Limits Inrush Current
- Available Radiator in 8-Lead SOP Package, the Radiator need connect GND or impending

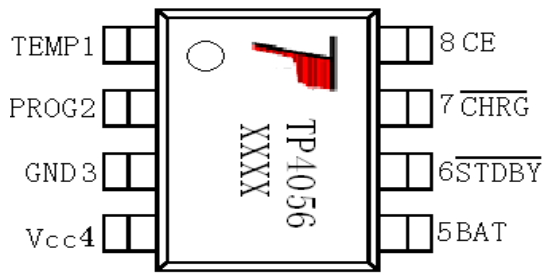
ABSOLUTE MAXIMUM RATINGS

- Input Supply Voltage(V_{CC})：-0.3V～8V
- TEMP：**-0.3V**～10V
- CE：**-0.3V**～10V
- BAT Short-Circuit Duration：Continuous
- BAT Pin Current：1200mA
- PROG Pin Current：1200uA
- Maximum Junction Temperature：145℃
- Operating Ambient Temperature Range：-40℃～85℃
- Lead Temp.(Soldering, 10sec)：260℃

APPLICATIONS

- Cellular Telephones, PDAs, GPS
- Charging Docks and Cradles
- Digital Still Cameras, Portable Devices
- USB Bus-Powered Chargers,Chargers

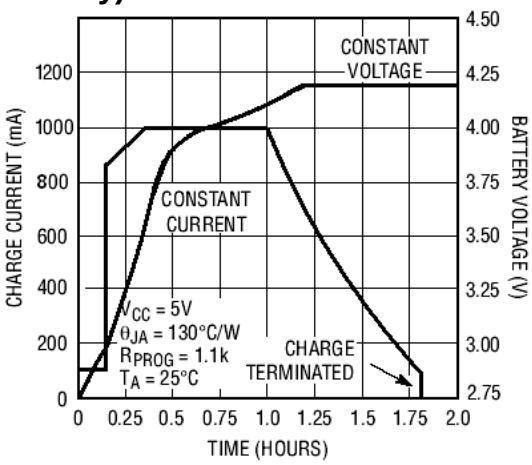
PACKAGE/ORDER INFORMATION



SOP－8

photo	ORDER PART NUMBER
	TP4056-42-SOP8-PP
	PART MARKING TP4056

Complete Charge Cycle (1000mAh Battery)



TEMP(Pin 1) :Temperature Sense Input Connecting TEMP pin to NTC thermistor's output in Lithium ion battery pack. If TEMP pin's voltage is below 45% or above 80% of supply voltage V_{IN} for more than 0.15S, this means that battery's temperature is too high or too low, charging is suspended. The temperature sense function can be disabled by grounding the TEMP pin.

PROG(Pin 2): Constant Charge Current Setting and Charge Current Monitor Pin charge current is set by connecting a resistor R_{ISET} from this pin to GND. When in precharge mode, the ISET pin's voltage is regulated to 0.2V. When in constant charge current mode, the ISET pin's voltage is regulated to 2V.In all modes during charging, the voltage on ISET pin can be used to measure the charge current as follows:

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1200 \quad (V_{PROG}=1V)$$

GND(Pin3): Ground Terminal

Vcc(Pin 4): Positive Input Supply Voltage V_{IN} is the power supply to the internal circuit. When V_{IN} drops to within 30mv of the BAT pin voltage, TP4056 enters low power sleep mode, dropping BAT pin's current to less than 2uA.

BAT(Pin5): Battery Connection Pin. Connect the positive terminal of the battery to BAT pin. BAT pin draws less than 2uA current in chip disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.

$\overline{\text{STDBY}}$(Pin6): Open Drain Charge Status Output When the battery Charge Termination, the $\overline{\text{STDBY}}$ pin is pulled low by an internal switch, otherwise $\overline{\text{STDBY}}$ pin is in high impedance state.

$\overline{\text{CHRG}}$ (Pin7): Open Drain Charge Status Output When the battery is being charged, the $\overline{\text{CHRG}}$ pin is pulled low by an internal switch, otherwise $\overline{\text{CHRG}}$ pin is in high impedance state.

CE(Pin8): Chip Enable Input. A high input will put the device in the normal operating mode. Pulling the CE pin to low level will put the YP4056 into disable mode. The CE pin can be driven by TTL or CMOS logic level.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at **T_A=25℃， V_{CC}=5V**， unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage		●	4.0	5	8.0	V
I_{CC}	Input Supply Current	Charge Mode, R_{PROG} = 1.2k	●		150	500	μA
		StandbyMode(Charge	●		55	100	μA
		Terminated)	●		55	100	μA
		Shutdown Mode (R_{PROG} Not Connected,V_{CC} < V_{BAT}, or V_{CC} < V_{UV})					
V_{FLOAL}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃， I_{BAT}=40mA		4.137	4.2	4.263	V
I_{BAT}	BAT Pin Current	R_{PROG} = 2.4k, Current Mode	●	450	500	550	mA
	Text condition:VBAT=4.0V	R_{PROG} = 1.2k, Current Mode	●	950	1000	1050	mA
		Standby Mode, V_{BAT} = 4.2V	●	0	−2.5	−6	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{PROG}=1.2K	●	120	130	140	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG}=1.2K, V_{BAT} Rising		2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{PROG}=1.2K		60	80	100	mV
T_{LIM}	Junction Temperature in Constant Temperature Mode				145		℃

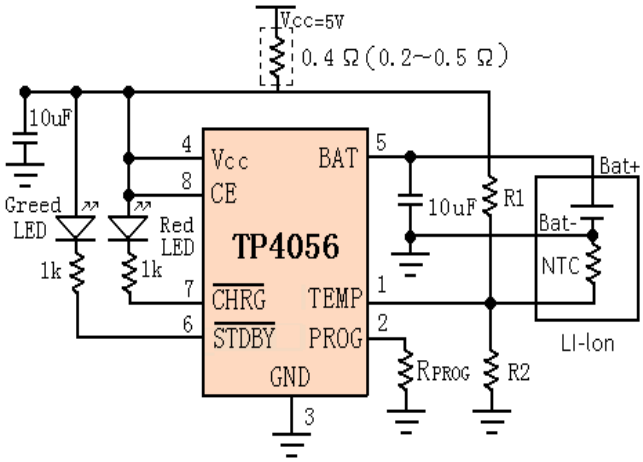
indicator light state

Charge state	Red LED $\overline{CHRG}$	Greed LED $\overline{STDBY}$
charging	bright	extinguish
Charge Termination	extinguish	bright
Vin too low; Temperature of battery too low or too high; no battery	extinguish	extinguish
BAT PIN Connect 10u Capacitance; No battery	Greed LED bright，Red LED Coruscate T=1-4 S	

Rprog Current Setting

R_{PROG} (k)	I_{BAT} (mA)
10	130
5	250
4	300
3	400
2	580
1.66	690
1.5	780
1.33	900
1.2	1000

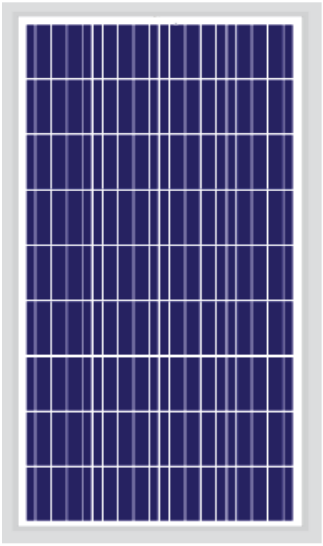
TYPICAL APPLICATIONS



TECHNICAL DATA

Electrical Data : All Data refers to STC (1000W/m2, AM1.5G, 25°C)

Model Name	LGV12V40	LGV12V50	LGV12V75	LGV12V100	LGV12V160
Peak Power Pmax (Wp)	40	50	75	100	160
Maximum Voltage Vmp (V)	17.50	18.00	18.00	18.00	18.20
Maximum Current Imp (A)	2.46	2.78	4.17	5.66	8.79
Open Circuit Voltage Voc (V)	21.00	22.00	22.00	22.00	22.20
Short Circuit Current Isc (A)	2.54	3.28	4.67	6.06	9.34
Maximum System Voltage	600 VDC	600 VDC	600 VDC	600 VDC	1000 VDC
Max Rated Current Series (Fuse Rating)	6A	6A	6A	10A	15A
Solar Cell Size (in mm)	39x156.75	52x156.75	78x156.75	99x156.75	156.75x156.75
No. of Solar Cells per module	36	36	36	36	36

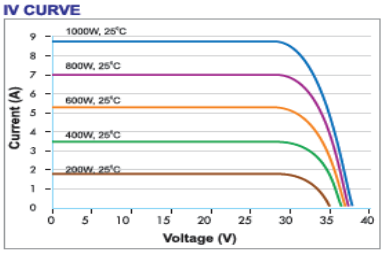


STC :1000W/m2 Irradiance, 25°C Cell Temperature, AM1.5G Spectrum according to EN 60904-3
Average relative effciency reduction of < 5% at 200W/m2 according to EN 60904-1

PERMIISSBLE OPERATING CONDITIONS

Tc of Open Circuit Voltage (ß)	-0.31%/°C ± 0.02
Tc of Short Circuit Voltage (α)	0.057%/°C ± 0.01
Tc of Power (Y)	-0.41%/°C ± 0.02
NOCT	45 ± 2°C
Temperature Range	-40°C to +85 °C
Limiting Reverse Current (Ir)	15 A

IV CURVE



MECHANICAL DATA

Junction Box	IP 65 rated with bypass diodes
Application Class	Class A (Safety Class II)
Substrate (Glass)	High transmission low iron tempered glass
Cells Encapsulant	EVA (Ethyelene Vinyl Acetate) - FC/UFC
Back Sheet	Composite film - White
Frame	Silver Anodized aluminum frame with twin wall profile
Mechanical Load Test	Sustain Heavey wind & snow loads (2400 Pa & 5400 Pa or 550 Kg/m^2
	Maximum diameter of 24 mm with hail impact of 83 Km/h

WARRANTY AND CERTIFICATION

Performance Warranty**	Linear Power Warranty for 25 years, 90% for 10 years and 80% for 25 years
Approvals and certificates	Products : IEC 61215:2005 - Ed 2 , IEC 61730 - Ed1 & Ed2, IEC 61701, IEC 62804, MNRE, UL,CE, IS:14286, IS-61215, IS-61730

** Refer warranty documents for terms and conditions.

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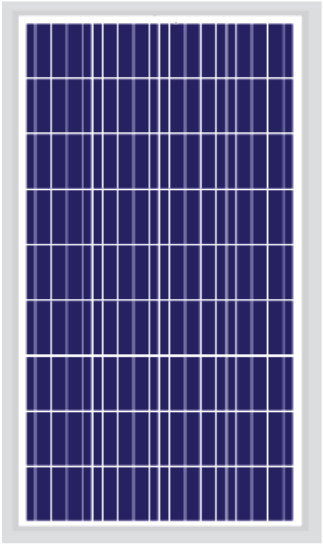
TECHNICAL DATA

Electrical Data : All Data refers to STC (1000W/m2, AM1.5G, 25°C)

Model Name	LGV24V325
Peak Power Pmax (Wp)	325
Maximum Voltage Vmp (V)	37.80
Maximum Current Imp (A)	8.60
Open Circuit Voltage Voc (V)	46.20
Short Circuit Current Isc (A)	9.13
Module Efffciency (%)	16.81
No. of Solar Cells per Module	72



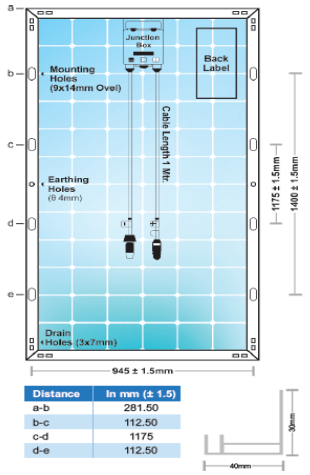
STC :1000W/m2 Irradiance, 25°C Cell Temperature, AM1.5G Spectrum according to EN 60904-3

Average relative effciency reduction of < 5% at 200W/m2 according to EN 60904-1

ELECTRICAL PARAMETERS AT NOCT

Maximum Power Pmax (Wp)	238.30
Maximum Power voltage V@Pmax (V)	34.60
Maximum Power Current I@Pmax (A)	6.88
Open Circuit Voltage Voc (V)	42.70
Short Circuit current Isc(A)	7.38

NOCT Irradiance 800W/m2, Ambient Temperature 20°C, Wind Speed 1 m/s



Distance	In mm (± 1.5)
a-b	281.50
b-c	112.50
c-d	1175
d-e	112.50

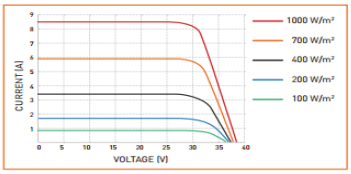
PERMISSIBLE OPERATING CONDITIONS

Tc of Open Circuit Voltage (ß)	-0.31%/°C ± 0.02
Tc of Short Circuit Voltage (α)	0.052%/°C ± 0.01
Tc of Power (Y)	-0.40%/°C ± 0.02
NOCT	45 ± 2°C
Maximum Series Fuse Ratings	20 A
Temperature Range	-40°C to +85 °C
Maximum System Voltage	1000 VDC

MECHANICAL DATA

Length x Width x Height (in mm)	1963mm x 985mm x 40mm (± 1.5 mm)
Weight	21.50Kg
Junction Box	IP 67/IP 68 rated with 3 bypass diodes
Cable & Connectors	4 sqm (12AWG) solar cable 1000 mm x 2 nos. black MC4/ MC4 compatible connectors
Application Class	Class A (Safety Class II)
Substrate (Glass)	High transmission low iron tempered glass AR coated
Solar Cells & Orientation	72 Nos. (12 x 6) polycrystalline solar cells
Cells Encapsulant	EVA (Ethyelene Vinyl Acetate) - FC/UFC
Back Sheet	Composite film - White
Frame	Silver Anodized aluminum frame with twin wall profile
Mechanical Load Test	Sustain Heavey wind & snow loads (2400 Pa & 5400 Pa or 550 Kg/m^2
	Maximum diameter of 24 mm with hail impact of 83 Km/h

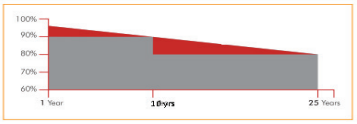
IV Curves



WARRANTY AND CERTIFICATION

Performance Warranty**	Linear Power Warranty for 25 years, 90% for 10 years and 80% for 25 years
Approvals and Certificates	Products : IEC 61215:2005 - Ed 2 , IEC 61730 - Ed1 & Ed2, IEC 61701, IEC 62804, MNRE, UL,CE, IS:14286, IS-61215, IS-61730

Performance Warranty



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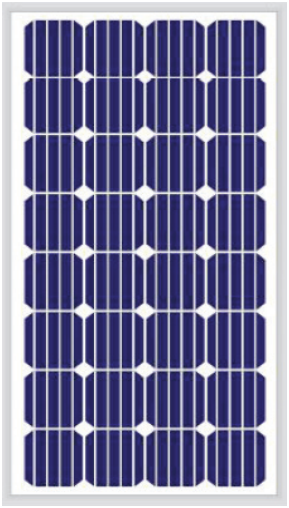
TECHNICAL DATA

Electrical Data : All Data refers to STC (1000W/m^2, AM1.5G, 25°C)

Model Name	LGV12V165M
Peak Power Pmax (Wp)	165
Maximum Voltage Vmp (V)	17.65
Maximum Current Imp (A)	9.42
Open Circuit Voltage Voc (V)	21.82
Short Circuit Current Isc (A)	9.80
Max Rated Current Series (Fuse Rating)	15 A
Module Efffciency (%)	18.55
No. of Solar Cells per Module	32



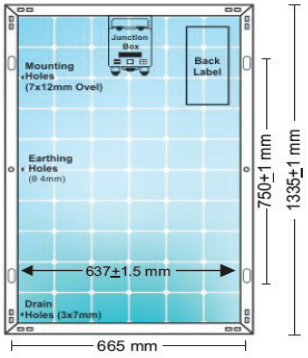
STC :1000W/m2 Irradiance, 25°C Cell Temperature, AM1.5G Spectrum according to EN 60904-3

Average relative effciency reduction of < 5% at 200W/m2 according to EN 60904-1

ELECTRICAL PARAMETERS AT NOCT

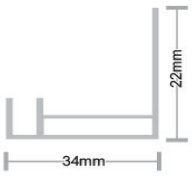
Maximum Power Pmax (Wp)	123.00
Maximum Power voltage V@Pmax (V)	16.05
Maximum Power Current I@Pmax (A)	7.84
Open Circuit Voltage Voc (V)	20.12
Short Circuit current Isc(A)	8.05

NOCT Irradiance 800W/m2, Ambient Temperature 20°C, Wind Speed 1 m/s



PERMISSIBLE OPERATING CONDITIONS

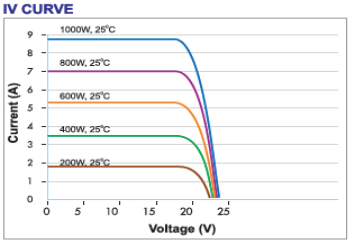
Tc of Open Circuit Voltage (ß)	-0.28%/°C ± 0.02
Tc of Short Circuit Voltage (α)	0.048%/°C ± 0.01
Tc of Power (Y)	-0.38%/°C ± 0.02
NOCT	45 ± 2°C
Temperature Range	-40°C to +85 °C
Maximum System Voltage	1000 VDC
Max Reverse Current	15 A



MECHANICAL DATA

Length x Width x Height (in mm)	1335mm x 665mm x 35mm
Junction Box	IP 65 rated with bypass diodes
Application Class	Class A (Safety Class II)
Substrate (Glass)	High transmission low iron tempered glass
Solar Cells & Orientation	(8x4 matrix) Mono Perc Solar Cells
Cells Encapsulant	EVA (Ethyelene Vinyl Acetate) - FC/UFC
Back Sheet	Composite film - White
Frame	Silver Anodized aluminum frame with twin wall profile
Mechanical Load Test	Sustain Heavey wind & snow loads (2400 Pa & 5400 Pa or 550 Kg/m^2
	Maximum diameter of 24 mm with hail impact of 83 Km/h

IV CURVE



WARRANTY AND CERTIFICATION

Performance Warranty**	Linear Power Warranty for 25 years, 90% for 10 years and 80% for 25 years
Approvals and Certificates	Products : IEC 61215:2005 - Ed 2 , IEC 61730 - Ed1 & Ed2, IEC 61701, IEC 62804, MNRE, UL,CE, IS:14286, IS-61215, IS-61730

** Refer warranty documents for terms and conditions.

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TECHNICAL DATA

Electrical Data : All Data refers to STC (1000W/m^2, AM1.5G, 25°C)

Model Name	LGV24V375M
Peak Power Pmax (Wp)	375
Maximum Voltage Vmpp(V)	40.30
MaximumCurrent Impp(A)	9.26
Open Circuit Voltage Voc (V)	49.10
Short Circuit Current Isc (A)	9.70
Module Efffciency (%)	19.40
Nos. of Solar cell per module	72

STC :1000W/m2 Irradiance, 25°C Cell Temperature, AM1.5G Spectrum according to EN 60904-3

Average relative effciency reduction of < 5% at 200W/m2 according to EN 60904-1

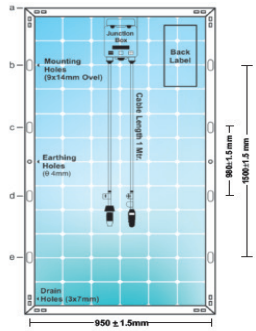
ELECTRICAL PARAMETERS AT NOCT

Maximum Power Pmax (Wp)	278.50
Maximum Power voltage V@Pmax(V)	37.50
Maximum Powercurrent I@Pmax(A)	7.42
Open circuit Voltage Voc (V)	45.90
Short circuit current Isc (A)	7.84

NOCT Irradiance 800W/m2, Ambient Temperature 20°C, Wind speed 1 m/sec

PERMISSIBLE OPERATING CONDITIONS

Tc of Open Circuit Voltage (ß)	-0.286%/°C ± 0.02
Tc of Short Circuit Voltage (α)	0.057%/°C ± 0.01
Tc of Power (Y)	-0.37%/°C ± 0.02
NOCT	45±2°C
Temerature Range	-40°C to +85 °C
Maximum System Voltage	1500 VDC
Max Reverse Current	20 A

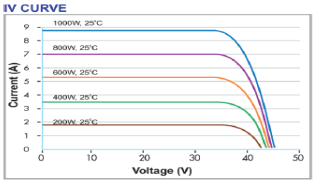


Distance	In mm (± 1.5)
a-b	235
b-c	260
c-d	960
d-e	260
b-e	1500

MECHANICAL DATA

Length x Width x Height (in mm)	1970mmx990mmx40mm
Weight	22 Kg
Junction Box	IP 67/68 rated with 3 Bypass diodes
Application Class	Class A (Safety class II)
Cable and Connectors	4 sqm (12AWG) solar cable 1000mm x 2nos black MC4/MC4 compatible connectors
Substrate (Glass)	High transmission low iron tempered glass AR coated
Solar cells & Orientation	(12x6 matrix) Mono Perc Solar Cells
Cells Encapsulant	EVA (Ethyelene Vinyl Acetate) - FC/UFC
Back Sheet	Composite film - White
Frame	Silver Anodized aluminum frame with twin wall profile
Mechanical Load Test	Sustain Heavey wind & snow loads (2400 Pa & 5400 Pa or 550 Kg/m2)
	Maximum diameter of 24 mm with Hail impact of 83 Km/h

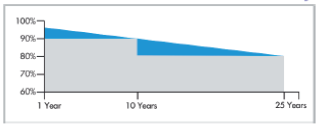
IV CURVE



WARRANTY AND CERTIFICATION

Performance Warranty**	Linear Power Warranty for 25 years, 90% for 10 years and 80% for 25 years
Approvals and Certificates	Products : IEC 61215:2005 - Ed 2 , IEC 61730 - Ed1 & Ed2, IEC 61701, IEC 62804, MNRE, UL,CE, IS:14286, IS-61215, IS-61730

Performance Warranty



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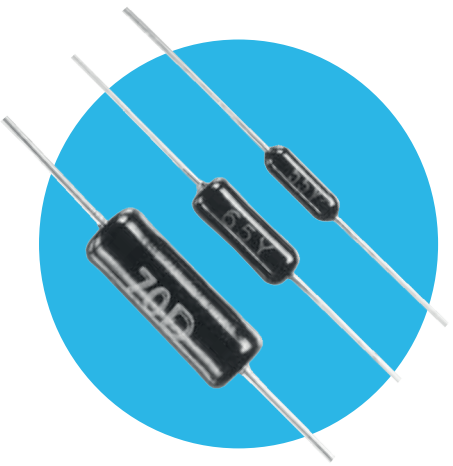
Resistors

Precision Metal Film Resistors



RC series

- CECC released products with low TCRs over a wide resistance range
- Resistance tolerance down to 0.05%
- Express delivery available
- Low noise and negligible voltage coefficient
- Screened parts available for critical applications
- Temperature Coefficient of Resistance down to 5 ppm/°C
- Options for RoHS compliant and Lead bearing wire finishes

All Pb-free parts comply with EU Directive 2011/65/EU amended by (EU) 2015/863 (RoHS3)

Electrical Data

		RC55	RC65	RC70	Notes
Commercial					
Power rating at 70°C	watts	0.25	0.5	1.0	
Resistance range	ohm	1R to 4M	1R to 4M	1R to 10M	
Limiting element voltage	volts	350	350	500	
Isolation voltage	volts	500	500	700	
TCR (20 to +70°C)	ppm/°C	5, 10, 15, 25, 50, 100			See resistance
Resistance tolerance	%	0.05, 0.1, 0.25, 0.5 & 1			restrictions

CECC 40101-004 Requirements		H	J	K	K	L	
Power rating at 70°C	watts	0.063	0.125	0.25	0.25	0.5	
Resistance range	ohms	1R to 1M	1R to 1M	1R to 1M	10R to 1M	10R to 1M	
Limiting element voltage	volts	200	200	250	250	350	
Isolation voltage	volts	280	280	350	350	500	
TCR	ppm/°C	15, 25, 50, 100					See resistance
Resistance tolerance	%	0.05, 0.1, 0.25., 0.5 & 1					restrictions

CECC 40101-804 Requirements		A	B	B	C	
Power rating at 70°C	watts	0.125	0.25	0.25	0.5	
Resistance range	ohms	1R to 1M	1R to 1M	10R to 1M	10R to 1M	
Limiting element voltage	volts	200	250	250	350	
Isolation voltage	volts	280	350	350	500	
TCR	ppm/°C	15, 25, 50, 100				See resistance
Resistance tolerance	%	0.05, 0.1, 0.25, 0.5 & 1				restrictions

These tables indicate the CECC specification requirements, and these are met or exceeded by the corresponding RC series products.

Standard values		E24, E96 preferred			Any value
Thermal impedance	°C/watt	110	70	60	to order
Ambient temperature range	°C	-55 to +155			

General Note

TT Electronics reserves the right to make changes in product specification without notice or liability.
All information is subject to TT Electronics' own data and is considered accurate at time of going to print.

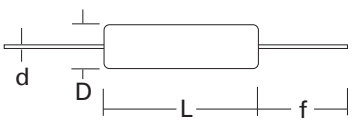
BI Technologies IRC Welwyn

www.ttelectronics.com/resistors

Physical Data

Dimensions (mm) & Weight (g)

Type	L max	D max	f min [1]	d nom	PCB mounting centres	Min. Bend Radius	Wt. nom
RC55	7.2	2.5	30	0.6	10.2	0.6	0.24
RC65	10.0	3.7	30	0.6	12.7	0.6	0.40
RC70	15.5	5.5	30	0.8	18.4	1.2	1.15



Note 1 - dimension relates only to bulk packed product.

Construction

A metal film is deposited onto a high quality ceramic former. Nickel-plated steel caps are force fitted to the former and termination wires are welded to the caps.

The resistor is adjusted to value by a helical cut in the film and the body is protected with a specially formulated epoxy coating.

Terminations

Material Solder coated copper wire

Strength The terminations meet the requirements of IEC 68.2.21.

Solderability The terminations meet the requirements of IEC 115-1, Clause 4.17.3.2.

Marking

Type reference, TCR code, resistance value and tolerance code.

The resistance values conform to IEC 62.

Solvent Resistance

The body protection and marking are resistant to all normal industrial cleaning solvents suitable for printed circuits.

Performance Data

		CECC 40101-004	CECC 40101-804	*Actual Performance	
		Requirements	Requirements	Maximum	Typical
Load at commercial rating: 1000 hours at 70°C	ΔR%			0.3	0.1
Load at CECC rating: 1000 hours at 70°C	ΔR%	0.5	0.5	0.3	0.05
Dry heat: 1000 hours at 155°C	ΔR%	0.5	0.5	**1.0	0.15
Shelf life: 12 months at room temperature	ΔR%	Not specified	Not specified	0.1	0.03
Derating from rated power at 70°C		Zero at 155°C	50% at 125°C	50% at 125°C & Zero at 155°C	
Short term overload	ΔR%	0.1	0.1	0.1	0.02
Climatic	ΔR%	0.5	0.5	0.3	0.1
Climatic category		55/155/56	55/125/56	55/155/56	
Long term damp heat	ΔR%	0.5	0.5	0.5	0.1
Temperature rapid change	ΔR%	0.1	0.1	**0.2	0.05
Resistance to solder heat	ΔR%	0.1	0.1	0.06	0.03
Vibration and bump	ΔR%	0.1	0.1	0.06	0.02
Noise (in a decade of frequency)	μV/V	Not specified	Not specified	1.0	0.1
Voltage coefficient of resistance	ppm/V	Not specified	Not specified		<1

Note: *An 0.01 ohm addition to be added to the performance claims of all resistors <10R.
** All products within the specified approved range meet CECC requirements.

Table of Resistance Restrictions

TCR ppm/°C	Tolerance								
	RC55			RC65			RC70		
	0.05%	0.1 - 0.25%	0.5%[3] - 1%[3]	0.05%	0.1 - 0.25%	0.5%[3] - 1%[3]	0.05%	0.1 - 0.25%	0.5%[3] - 1%[3]
5[1]	10R to 500K	10R to 500K	1R to 500K	10R to 500K	10R to 500K	1R to 500K	10R to 750K	10R to 750K	10R to 750K
10	10R to 1M	10R to 1M	1R to 1M	10R to 1M	10R to 1M	1R to 1M	10R to 1M	10R to 1M	1R to 1M
15	10R to 1M	2R49 to 1M	1R to 1M	10R to 1M	5R to 1M	1R to 1M	10R to 1M	10R to 2M	1R to 2M
25	10R to 1M	2R49 to 2M	1R to 2M	10R to 1M	5R to 2M	1R to 2M	10R to 1M	10R to 5M	1R to 5M
50[2]	10R to 1M	2R49 to 2M	1R to 4M	10R to 1M	5R to 2M	1R to 4M	10R to 1M	5R to 10M	1R to 10M
100[2]	10R to 1M	1R to 2M	1R to 4M	10R to 1M	1R to 2M	1R to 4M	10R to 1M	1R to 10M	1R to 10M

Note1:

1. Based on sampling. 100% screened product is available.
2. For maximum availability, where the ohmic value permits, 25ppm/°C is preferred to 50 or 100ppm/°C.
3. For maximum availability, where the ohmic value permits, 0.25% is preferred to 0.5% or 1%

Application Notes

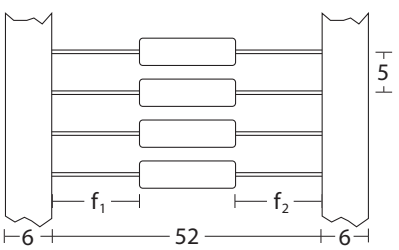
Matched Sets

TT Electronics has many years' experience in the supply of matched sets of precision resistors.

Resistors can be supplied matched for tolerance and TCR down to ±0.02% and ±2ppm/°C.

Packaging

RC55 and RC65 standard packing is in tape, as shown below, whilst RC70 is bulk packed. Taped resistors on reel or loose packed components can also be supplied by special request.



Body location $f_1 - f_2 \leq 1.4$ mm

Ordering Procedure

This product has two valid part numbers:

European (Welwyn) Part Number: RC55V-31K6BI (RC55 with TCR ±5ppm/°C at 31.6 kilohms ±0.1%, Pb-free)

R	C	5	5	V	-	3	1	K	6	B	I	
1				2		3				4	5	

1 Type	2 TCR (ppm/°C)	3 Value	4 Tolerance	5 Finish, Screening & Packing		
RC55	V = ±5	E24 = 3/4 characters E96 = 4/5 characters R = ohms K = kilohms M = megohms	W = ±0.05%	I	Pb-free (RoHS)	
RC65	T = ±10		B = ±0.1%	SC	Pb-free with screened TCR (5ppm only)	
RC70	Y = ±15		C = ±0.25%	PB	Sn(95)Pb(5) finish	
	D = ±25		D = ±0.5%	HL	Sn(60)Pb(40) high lead finish	
	C = ±50		F = ±1%	All above in Standard Packing		
	Z = ±100			RC55	Ammo	Up to 5000/box
				RC65		Up to 2500/box
				RC70	Bulk	250/box

For CECC released product state on order the CECC number and style. Example: RC55Y-31K6BI CECC40101-004 JY
For CECC 40101-804 the TCR codes T and E relate to 15 and 25ppm/°C and are coded in the MPN as Y and D respectively. Also an additional suffix-804 is added after the Finish, Screening & Packing code, and, in the case of Pb-free, this code (I) is omitted. Example: RC65Y-31K6B-804 CECC 40101-804BT

USA (IRC) Part Number: RC55LFV3162BA (RC55 with TCR ±5ppm/°C at 31.6 kilohms ±0.1%, Pb-free)

R	C	5	5	L	F	V	3	1	6	2	B	A
1				2		3			4		5	6

1 Type	2 Termination	3 TCR (ppm/°C)	4 Value	5 Tolerance	6 Packing		
RC55	Omit for Sn(95)Pb(5)	V = ±5	3 digits + multiplier	A = ±0.05%	A	RC55	Ammo, up to 5000/box
RC65		T = ±10	R = ohms for values <100 ohms	B = ±0.1%		RC65	Ammo, up to 2500/box
RC70	LF = Pb-free	Y = ±15		C = ±0.25%	B	RC70	Bulk, 250/box
		D = ±25		D = ±0.5%			
		C = ±50		F = ±1%			
		Z = ±100					

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

TT Electronics:

RC55-D-48K7-B-B RC55-D-49K9-B-B RC55-D-3K24-B-B RC55-D-9K76-B-B RC55-D-64R9-B-B RC55-D-191K-B-B RC55-D-8K06-B-B RC55-D-33K2-B-B RC55-D-357K-B-B RC55-D-25R5-B-B RC55-D-196K-B-B RC55-D-56K2-B-B RC55-D-3K48-B-B RC55-D-6K65-B-B RC55-D-681K-B-B RC55-D-19K6-B-B RC55-D-21K5-B-B RC55-D-29R4-B-B RC55-D-392K-B-B RC55-D-866K-B-B RC55-D-1K47-B-B RC55-D-130K-B-B RC55-D-15R4-B-B RC55-D-15R8-B-B RC55-D-1K43-B-B RC55-D-127K-B-B RC55-D-681R-B-B RC55-D-3K4-B-B RC55-D-649R-B-B RC55-D-40K2-B-B RC55-D-665R-B-B RC55-D-2K87-B-B RC55-D-10K7-B-B RC55-D-10K5-B-B RC55-D-1K58-B-B RC55-D-100K-B-B RC55-D-102K-B-B RC55-D-76K8-B-B RC55-D-1K24-B-B RC55-D-18K2-B-B RC55-D-18K7-B-B RC55-D-21R5-B-B RC55-D-316K-B-B RC55-D-150K-B-B RC55-D-274K-B-B RC55-D-1K27-B-B RC55-D-1K21-B-B RC55-D-17R4-B-B RC55-D-17R8-B-B RC55-D-154K-B-B RC55-D-8K45-B-B RC55-D-158K-B-B RC55-D-500R-B-B RC55-D-523R-B-B RC55-D-562R-B-B RC55-D-25K5-B-B RC55-D-549R-B-B RC55-D-536R-B-B RC55-D-732R-B-B RC55-D-750R-B-B RC55-D-2K94-B-B RC55-D-715R-B-B RC55-D-787R-B-B RC55-D-768R-B-B RC55-D-392R-B-B RC55-D-240R-B-B RC55-D-261R-B-B RC55-D-316R-B-B RC55-D-232R-B-B RC55-D-210R-B-B RC55-D-267R-B-B RC55-D-200R-B-B RC55-D-243R-B-B RC55-D-255R-B-B RC55-D-215R-B-B RC55-D-237R-B-B RC55-D-287R-B-B RC55-D-294R-B-B RC55-D-205R-B-B RC55-D-249R-B-B RC55-D-357R-B-B RC55-D-274R-B-B RC55-D-280R-B-B RC55-D-51R1-B-B RC55-D-35R7-B-B RC55LF-D-14K-B-B RC55-D-453K-B-B RC55-D-38R3-B-B RC55-D-44R2-B-B RC55-D-32R4-B-B RC55-D-422K-B-B RC55-D-549K-B-B RC55-D-11K3-B-B RC55-D-205K-B-B RC55-D-11K8-B-B RC55-D-200K-B-B RC55-D-38K3-B-B RC55-D-249K-B-B RC55-D-243K-B-B RC55-D-2K1-B-B

DURACELL®

DURALOCK POWER PRESERVE™

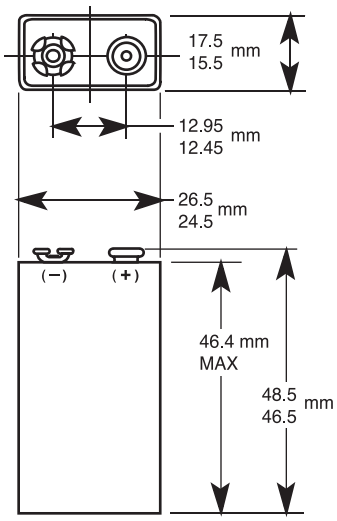
ULTRA POWER

MX1604
Size: 9V (6LR61)

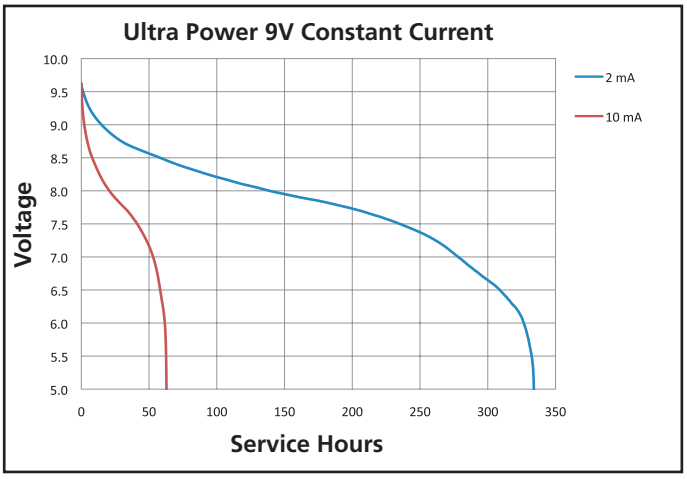
Alkaline-Manganese Dioxide Battery

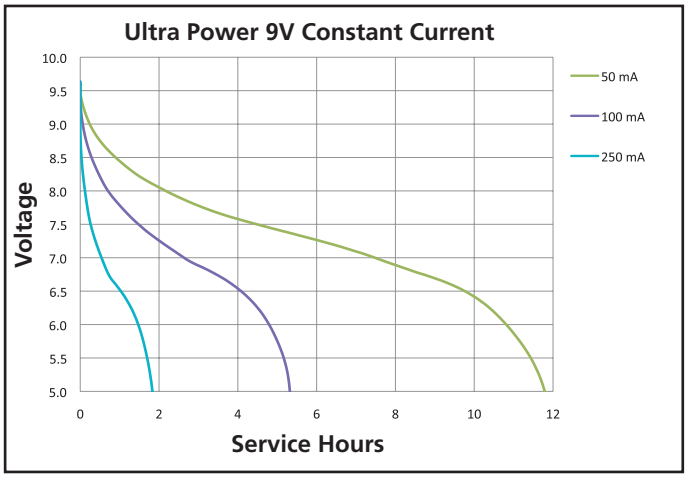
Zn/MnO_2

Nominal voltage	9 V
Impedance	1,700 m-ohm @ 1 kHz
Typical weight	45 g (1.6 oz)
Typical volume	22.8 cm^3 (1.4 in^3)
Terminals	Miniature snap
Storage temperature range	5°C to 30°C (41°F to 86°F)
Operating temperature range	-20°C to 54°C (-4°F to 130°F)
Designation	**IEC:** 6LR61



Dimensions shown are IEC standards





DURACELL® BATTERIES

Berkshire Corporate Park
Bethel, CT. 06801 U.S.A.
Telephone: Toll-free 1-800-544-5454
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Delivered capacity is dependent on the applied load, operating temperature and cut-off voltage. Please refer to the charts and discharge data shown for examples of the energy/service life that the battery will provide for various load conditions.

DURACELL®

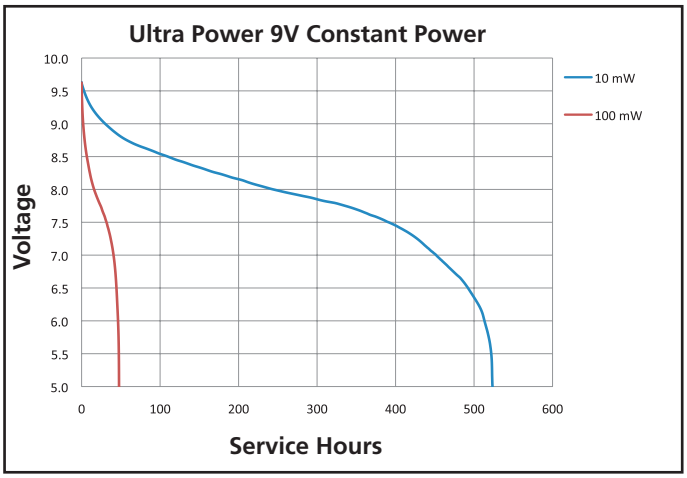
DURALOCK POWER PRESERVE™

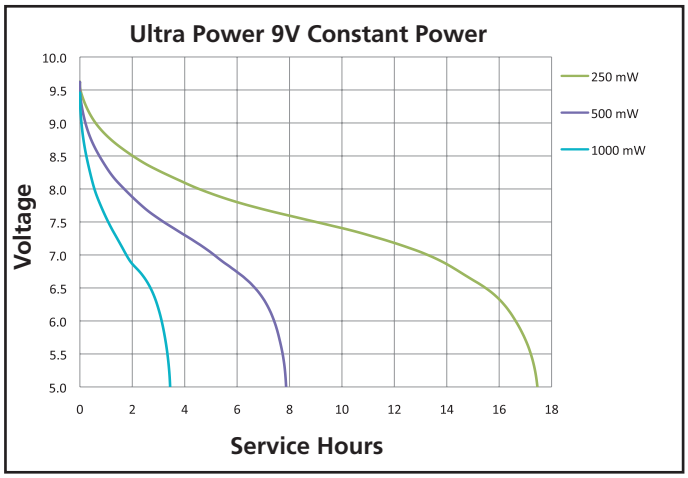
ULTRA POWER

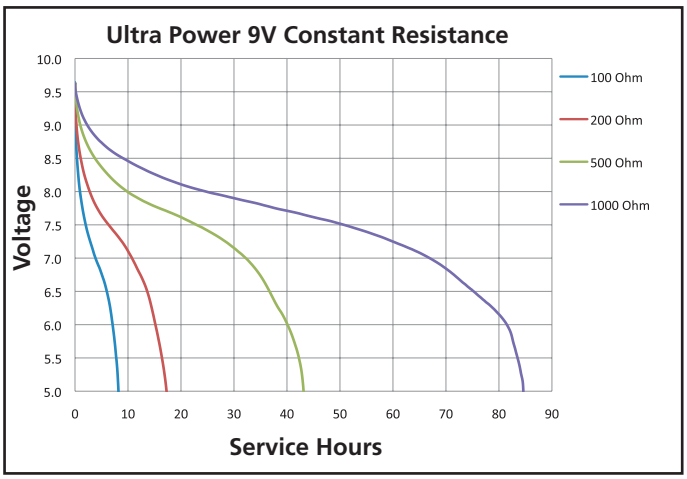
MX1604
Size: 9V (6LR61)

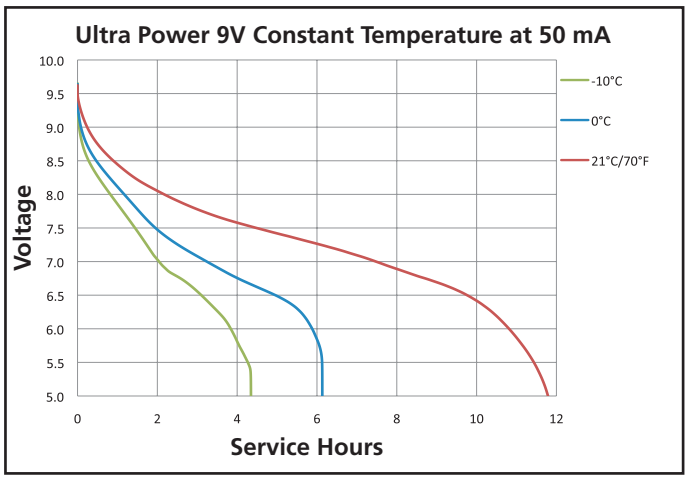
Alkaline-Manganese Dioxide Battery

Zn/MnO_2









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