

Solar Powered Battery Charging System by Using Arduino: Experimental design

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Abstract: In recent years, the need for efficient and sustainable energy solutions has become increasingly important. One potential solution is the use of solar power for battery charging systems. In this project, an Arduino-based solar-powered battery charging system is designed and implemented. The system consists of a solar panel that collects energy from the sun, an Arduino microcontroller that regulates the battery's charging, and a battery that stores the energy for later use. The solar panel converts sunlight into DC electrical energy, which is then fed to the battery through a charging circuit. The implementation of this system is fairly straightforward. The solar panel is connected to an input pin of the Arduino microcontroller, which then controls the charging of the battery through a charging circuit connected to an output pin. The charging circuit is designed to limit the charging current and voltage to prevent damage to the battery.

Keywords: Solar PV system, Battery storage system, Charge controller, Arduino

1. Introduction

A solar-powered battery charging system using an Arduino can be an excellent project for those who want to learn about renewable energy and microcontroller programming. Here are the basic steps to create such a system [1].

Choose the solar panel: The first step is choosing the right one. The discussion should be able to produce enough power to charge the battery. You can use online calculators to determine the solar panel size needed.

Choose the battery: The battery should have enough capacity to store the energy produced by the solar panel. Choose a battery that is compatible with the Arduino and can be charged using the solar panel.

Connect the solar panel to the battery: Connect the solar panel to the battery using a charge controller. The charge controller ensures that the battery is charged at the correct voltage and current levels.

Connect the Arduino to the battery: Connect the Arduino to the battery using a voltage regulator. The voltage regulator ensures that the Arduino is powered at the correct voltage level.

Programming Arduino: The program should monitor the battery voltage and current levels and adjust the charging current accordingly.

Add safety features: Add safety features to the system to prevent overcharging and overheating of the battery. For example, you can add a temperature sensor to monitor the battery temperature and shut down the charging process if the temperature exceeds a certain level.

Test the system: Test the system to make sure that it is working correctly. Monitor the battery voltage and current levels and ensure that the battery is charging at the correct rate. You can create a solar-powered battery charging system using an Arduino with these basic steps. This system can charge batteries for

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various applications, such as powering a small electronic device or an LED light [2].

2. Brief literature review

A solar-powered battery charging system for electric vehicles using Arduino. (P. Kumar et al., 2020). This study presents a solar-powered battery charging system for electric vehicles that uses an Arduino-based charge controller. The system is capable of monitoring the battery's charging status and providing real-time feedback to the user. Design and implementation of an Arduino-based solar-powered battery charging system. (A.A. Salawu et al., 2020) - This paper describes designing and implementing an Arduino-based solar-powered battery charging system for household use. The system uses an Arduino microcontroller to control the charging process and ensure optimal charging efficiency. An Arduino-based solar-powered battery charging system for a small household. (B. O. Osundare et al., 2021) - This study presents an Arduino-based solar-powered battery charging system for a small household that is capable of charging multiple devices simultaneously. The system includes a battery management system that monitors the battery's charging status and provides protection against overcharging and overheating. A solar-powered battery charging system for remote areas using Arduino. (S. K. Reddy et al., 2019) - This paper presents a solar-powered battery charging system for remote areas that uses an Arduino-based charge controller. The system is designed to be low-cost and easy to maintain, making it ideal for use in remote locations. Development of a solar-powered battery charging system for a smart home using Arduino. (O. S. Adeyemi et al., 2020) - This study presents the development of a solar-powered battery charging system for a smart home using an Arduino-based charge controller. The system is capable of monitoring the battery's charging status and adjusting the charging rate based on the available sunlight [3].

3. Methodology

In Fig 1, we used solar panels to generate power from sunlight. The solar panel collects sunlight and converts it into Direct Current (DC) Electricity. Using Charge controller will regulate the over voltage and the condition when there is no sunlight for solar

panel. The battery voltage will be displayed on LCD. The battery pin is connected to the voltage sensor and current sensor will give current value. So that the voltage and current in the battery will be known. If we supply power to a deeply discharged battery, the battery will be damaged. Suppose we leave the battery in charging mode for a long time (overcharge). In that case, the hydrogen and oxygen will vaporize on the electrode plates and the energetic material coated on the plates will be washed away, causing the battery to break down again. battery. In these paintings, one lowcost solar battery charger can be used for hundreds of DC (DC lighting equipment i.e. LEDs, DC equipment such as laptops, phones, satellite TVs, etc., for computer TV controllers, etc.) is rough and advanced [4].

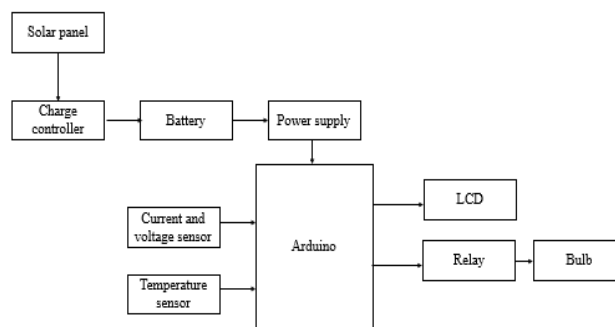


Fig. 1: Block diagram of system design

The battery voltage will be displayed on LCD. The battery pin is connected to voltage sensor and current sensor will give current value. So that the voltage and current in the battery will be known. Advanced machines monitor, record and store data remotely, mainly to better protect battery safety, thereby extending battery life. A standard solar PV standalone setup consists of a solar panel, an Arduino-connected PWM charge controller, and a load that supplies usable power to a lightning arrester [5].

4. Hardware implementation

4.1 Arduino

In Fig 2, Arduino is an integrated development environment for board programming and opensource microcontroller-based board physics processing software.

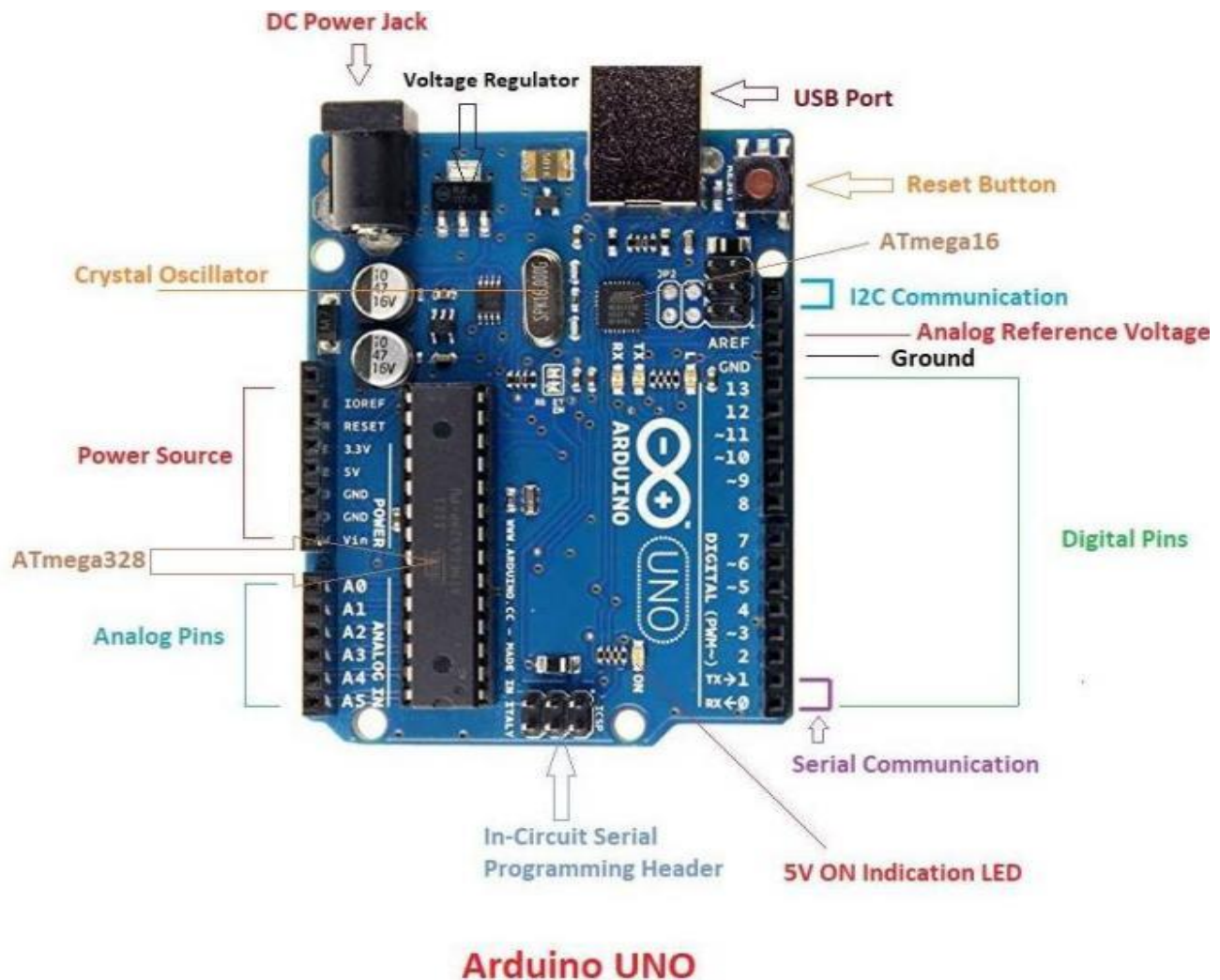


Fig. 2: Arduino uno

An Arduino controls several outputs, such as lights, motors, and so on, using specific inputs like a switch or sensor. Most microcontroller frameworks only support Windows, whereas Arduino programs are compatible with Linux, Macintosh, and Windows operating systems (OS). Programming with Arduino is simple enough for hobbyists and beginners. Arduino is a tool for building a better computer that can do more than just control, interact, and perceive. It is an open-source actual handling stage fixated on a straightforward microcontroller board and a climate to gather programs for the board. Arduino can be used to create interactive projects that control lights, motors, and other physical outputs and receive inputs from a variety of switches or sensors. Flash, Processing, and Maxmsp are examples of programs that can be used with Arduino Activities.) Cards can be put together by hand or bought already put

together; Free download of an open-source IDE is available. The Arduino programming language is an implementation of Wiring, a comparable physical computing platform, and focuses on managing the multimedia programming environment.

Why choosing Arduino

Open Source: Arduino is an open-source platform, which means the hardware and software designs are freely available for anyone to use, modify, and distribute. This has resulted in a large community of developers who have created a wide range of projects and libraries that can be easily adapted and reused.

Easy to Use: Arduino has a simple and easy-to-learn programming language similar to C/C++. The integrated development environment (IDE) provides

a user-friendly interface for writing and uploading code to the board.

Low Cost: Arduino boards are relatively inexpensive, making them accessible to many people. They can be purchased online or at electronics stores for as little as \$10.

Versatile: Arduino boards can be used for various projects, from controlling LEDs and motors to building robots and data loggers. They can be easily expanded with shields and other hardware components to add additional functionality. Large

Community: The Arduino community is large and active, with many online resources, including tutorials, forums, and libraries. This makes it easy to find help and support for your projects [6].

4.2. Voltage Sensor

A device that measures voltage is called a voltage sensor. From detecting low current levels to high voltages, voltage sensors can measure the voltage in a variety of ways. Many applications, such as power systems and industrial controls, require these devices. Electrostatic induction is typically used to detect voltage in no-metal-contact voltage detectors. In Fig 3, There is capacitance between the voltage detector and the measurement target, such as a power outlet, when the voltage detector comes into contact with the target. Similarly, there is capacitance between the user of the voltage detector and the ground. If the measurement target is active, a tiny AC current will flow through the voltage detector and its user. The voltage detector uses a high resistance to detect this tiny AC current, which is then converted into light and sound and displayed to the user. There is no danger to the user from the flowing current, which is less than one [7].

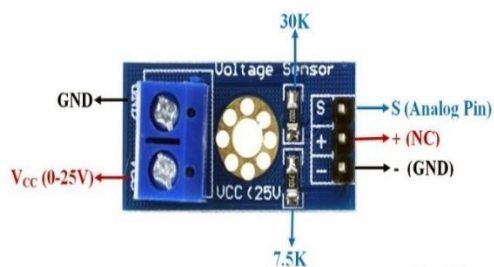


Fig. 3: Voltage Sensor

4.3. LCD

The below Fig 4, is explain in detail module has a built-in controller that receives data and commands from a microcontroller, such as an Arduino, and then displays the information on the screen. The LCD 16x2 is a low-cost and easy-to-use device that can provide visual feedback for various applications, such as temperature and humidity monitoring, digital clocks, and other projects that require displaying text information. It is widely used in various electronic projects for displaying text information. The module has a built-in controller that receives data and commands from a microcontroller, such as an Arduino, and then displays the information on the screen. The LCD 16x2 is a low-cost and easy-to-use device that can provide visual feedback for various applications, such as temperature and humidity monitoring, digital clocks, and other projects that require displaying text information [8].



Fig. 4: LCD – Front View



Fig. 5: LCD – Back View

4.4. Lithium-Ion Rechargeable Batteries

This is about the above Fig 6. The 18650 battery is a rechargeable lithium-ion battery with a capacity of 2500 mAh. This is not a standard AA or AAA battery, but is useful for applications that require sustained high current or short bursts of high current, such as

cameras, DVD players, iPods, etc. 18650 batteries can be charged and discharged for up to 1000 cycles without much loss of battery capacity. They are safe to use, environmentally friendly and have long battery life. It has a high energy density and provides excellent continuous power to your devices. It should be used with a protection circuit board to prevent the battery from overcharging, over-discharging and avoiding excessive current consumption [9].



Fig. 6: Lithium-Ion Rechargeable Batteries

4.5. Temperature sensor

There are many different types of temperature sensors, Fig 7, including thermocouples, resistance temperature detectors (RTDs), and thermistors. Thermocouples work by measuring the voltage difference between two metals joined at one end. The voltage generated by the thermocouple is proportional to the temperature difference between the two ends of the metals. RTDs are sensors made from a material that changes resistance as its temperature changes.

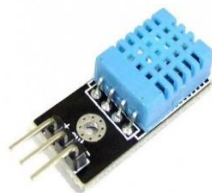


Fig. 7: Temperature Sensor

The resistance of the RTD is measured, which is used to calculate the temperature. Thermistors work on the principle that the resistance of a material changes as its temperature changes [10]. A thermistor is a type of resistor that has a very large change in resistance with temperature, making it an excellent temperature sensor. Temperature sensors can be used in many applications, such as HVAC systems,

industrial processes, and consumer electronics. In an Arduino project, a temperature sensor can be connected to an Arduino board to measure the environment's temperature and use that information to control other components or trigger certain actions. For example, a temperature sensor could control a fan or heater in a greenhouse or trigger an alarm if the temperature in a room reaches a certain threshold [11].

4.6. Charge controller module

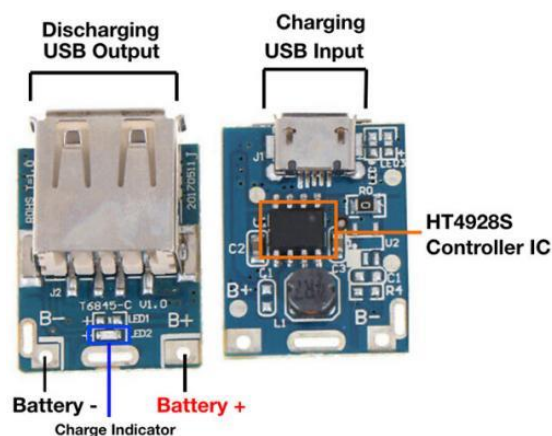


Fig. 8: Charge controller module

A single chip with multiple uses can be found in the Power bank module or 5V Step-Up Power Module Lithium Battery Charging Protection Board. This module is frequently utilized as a power bank application because it can provide large load currents and large discharge currents up to 1 A, making it ideal for charging devices. The onboard LEDs can see the module's charging and discharging status. The charge controller module works by monitoring the voltage and current output of the solar panel and adjusting the charging current accordingly to ensure that the battery is charged at an optimal rate. It also has built-in safety features, such as overcharge protection and short-circuit protection, to prevent battery or solar panel damage. There are two main types of charge controller modules: PWM (pulse-width modulation) and MPPT (maximum power point tracking). MPPT controllers are more advanced and can increase the overall efficiency of the solar power system by up to 30%, making them more suitable for larger systems or systems with limited space for solar panels. In addition to regulating the flow of electricity, some charge controller modules also include features such

as LCD displays for monitoring system performance, USB ports for charging devices, and temperature sensors for protecting the battery from extreme temperatures [12].

4.7. Relay module

In Fig.9, The switch contacts that open and close the relay are powered by the current supply. Typically, a coil is used to magnetize the switch contacts and drag them together when activated. After the weakening of the coil, a spring separates them.



Fig. 9: Relay module

There are primarily two advantages to using this system. The first is that activating the relay requires less current than switching the relay contacts do. Another advantage is that there is no electrical connection between the contacts and the coil because they are galvanically isolated [13].

4.8. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a software tool for writing, compiling, and uploading code to Arduino boards. It provides an easy-to-use interface for beginners and advanced users to create and edit Arduino sketches. The IDE includes a code editor, a compiler, a debugger, and a serial monitor for testing and debugging Arduino programs. Arduino IDE is open-source software licensed under GPL v2. It is available for free and runs on Windows, Mac OSX, and Linux platforms [14].

5. Results

The voltage and current sensors sense the voltage and current values, which are displayed in LCD Display. And also the temperature sensor sense the temperature values and the values are displayed in

LCD Display, and also display the battery percentage, power of the load and if the battery is in charging it shows 1 otherwise, it shows 0. Here the voltage of the batteries and current from load (LED) sense from the sensors along with Arduino we may display the values in LCD.

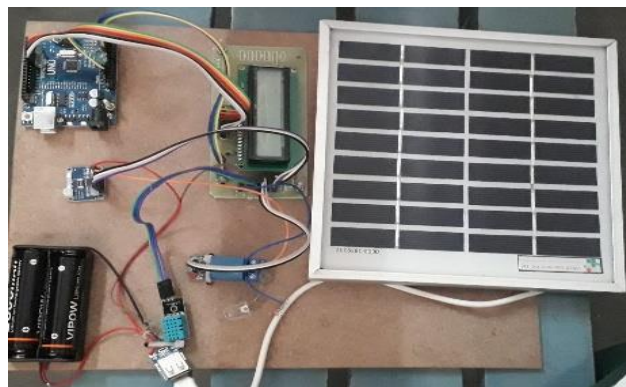


Fig. 10: Experimental total kit

This is image of total hardware model with connections to solar panel

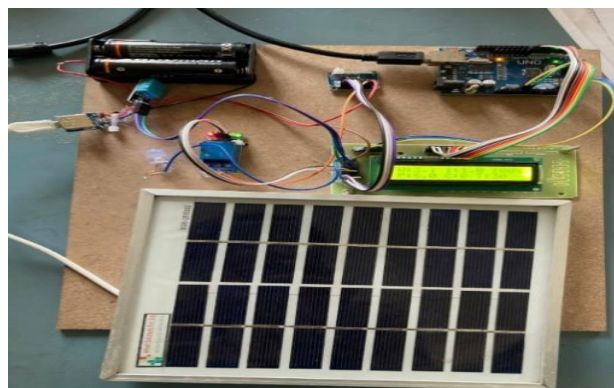


Fig. 11: After switch on the supply the values display in LCD



Fig. 12: Charging status on LCD Display

In this project, the main use is to protect the batteries from overcharging, discharging etc. When the load temperature increases above 40C by using relay module, the process will stunt down automatically. If the battery is overcharging, discharging, also the process will stop automatically.

Table.1: Data collected in sunny weather

Sl.no	Temperature (C)	Current (A)	Voltage (V)	Power (W)
1	30	6	5	30
2	32	5.9	4.8	27.73
3	34	5.7	4.7	25.6
4	36	5.5	4.5	23.8
5	38	5.4	4.4	21.12
6	40	5.0	4.1	20.89

Table.2: Data collected in cloudy weather

Sl.no	Temperature (C)	Current (A)	Voltage (V)	Power (W)
1	28	4	5	20
2	26	3.8	4.8	18.24
3	30	3.5	4.6	16.1
4	29	3.0	4	12
5	27	2.8	3.8	11.09

6. Conclusion

It has been shown that this undertaking's equipment execution of an Arduino Uno-based sun powered charge regulator can charge the battery utilizing sun oriented energy. The ability to reduce the supply keeps the battery from overcharging and extends its lifespan. The solar panel was the system's input, and the DC load was the system's output. The utilized algorithm works well for the charge and discharge operation. Last but not least, the Things Net server-connected Wifi Module and Arduino Uno were used to create an effective smart monitoring system. It is necessary to monitor the battery's real-time status from a distance for users to be able to monitor and control a photovoltaic system. The Internet of Things and cloud computing technologies also make data logging and report generation possible.

Future scope: There is more demand for renewable energy for home appliances, electric vehicles, etc.; in the future, it also requires reliable charging systems

and dynamic monitoring. Therefore, in upcoming years, the applications that run on renewable energy sources have much demand and further growth. As the days increase, in the competitive world, the usage of time in an efficient way plays a vital role in all perspectives. So, this product kills the unwanted waste of time and benefits everyone.

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Conflict of Interest

The authors declare no conflict of interest

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