International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 5, pp 505-509, May-2025

https://doi.org/10.47001/IRJIET/2025.905058

Solar Charge Controller

[1]Sahil V. Karlekar, [2]Jignesh H. Parmar, [3]Hritik Kumar, [4]Sachin P. Kandhare, [5]Prof. A. S. Shirbhate

[1,2,3,4]Student, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India

[5]Professor, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India

***Abstract* - This paper presents a low cost Solar Charge Controller (SCC) using Atmel Corporation ATmega8 microcontroller to control and coordinate the functions properly. Details of design for the construction of SCC using crystal oscillator, ceramic resistors, Light Emitting Diodes (LED) and MOSFET are presented. The source code for the ATmega8 microcontroller is written in Arduino IDE to obtain accurate and efficient automatic control action. Accordingly, battery can be disconnected from solar cell when overcharging and reconnected while discharging. The loads can be disconnected according to the over current and under flow current limit for both battery and PV. The proposed charge controller is equipped with LEDs to display the battery charging /discharging status, charge level and short circuit condition via microcontroller. The construction and operation of our proposed smart solar charge controller indicates that it is cost effective and functions properly.**

Keywords: SCC, Arduino IDE, SHS, microcontroller, crystal oscillator, LED, MOSFET.

I. INTRODUCTION

Today's world is facing an energy shortage due to the increase in consumption of energy day by day. This led to a decrease in natural resources like oil and natural gas that are not eco-friendly. To meet this increasing demand of power, renewable energy sources are an urgent need. Hence, solar energy, which is pollution free and easily available natural resource, can be used for power generation.

The solar charge controller's primary function is to maintain the amount of charge coming from the solar PV module that flows into the battery bank in order to avoid the batteries being overcharge. It performs three basic functions:

i. It limits and regulates the voltage from the solar panel to avoid overcharging the battery.
ii. While dc loads are used, the controller does not allow the battery to get discharge.

Global demand for energy is rapidly evolving and natural energy resources such as uranium, petroleum, and gas decreased due to a great diffusion and development of the industry in recent years. The increase in energy costs and environmental constraints are pushing for the development of technological solutions allowing better control of the resources and the exploitation of the renewable energies in specific photovoltaic energy.

Photovoltaic energy is a clean and renewable energy resource. Moreover, solar panels are a silent energy producer because there is absolutely no noise when converting sunlight into electricity. In order to exploit solar energy to power the DC loads and to store electricity, a solar charge controller is needed to monitor the State of charge of the batteries and protect them from overcharging and full discharge (deep discharge).

This monitoring and this permanent protection help to extend significantly the performance and life of the batteries. This controller is used in many areas such as systems not connected to the electric network, ensure the autonomy of an embedded system, monitor solar installations.

II. LITERATURE REVIEW

S. No.	Title & Author(s)	Year	Key Highlights
1	Design and Implementation of a Solar Charge Controller Using MOSFET – M. A. Hannan et al.	2018	Designed an efficient PWM-based solar charge controller using MOSFETs and microcontroller control. Focused on charge/discharge thresholds.
2	Arduino-Based Solar Battery Charging System – R. Kumari, S. Nayak	2019	Employed Arduino to monitor solar charging and control relay-based switching for battery management.
3	Automatic Solar Charge Controller with Battery Monitoring System – A. L. Syed et al.	2020	System automatically switches charging sources and monitors battery voltage in real-time using sensors and MOSFET.
4	Performance Evaluation of MPPT Algorithms in PV Systems – R. Tripathi et al.	2020	Discusses techniques like PWM and MPPT for solar regulation and optimal battery charging.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 5, pp 505-509, May-2025

https://doi.org/10.47001/IRJIET/2025.905058

5	Design and Simulation of Solar Charge Controller for 12V Battery System – B. Singh et al.	2017	Designed a low-cost solar charge controller using MOSFETs and comparator circuits for switching.
6	Smart Solar Energy Management Using IoT and Embedded System – K. Sharma et al.	2021	Discusses IoT-based enhancements in solar charging systems for monitoring and analytics.

III. METHODOLOGY

The methodology for developing a MOSFET-based solar charge controller, as described in your project, can be broken down into several key steps. This will include the design, implementation, and testing phases. Here's a structured approach:

1. System Design

- Component Selection:
  - Choose appropriate MOSFETs based on the load current and voltage ratings.
  - Select a suitable solar panel, battery, and adapter based on the power requirements of the LED panel.
  - Use a potentiometer for variable voltage input to simulate battery voltage.
- Circuit Design:
  - Design the circuit schematic, including connections for the solar panel, battery, load (LED panel), MOSFET, potentiometer, and adapter.
  - Include necessary protection components such as diodes to prevent backflow of current.

2. Arduino Programming

- Setup:
  - Initialize the Arduino IDE and set up the necessary libraries for reading analog inputs and controlling the MOSFET.
  - Define the pins for the potentiometer, MOSFET control, and any other inputs/outputs.
- Code Development:
  - Write the code to read the voltage from the potentiometer and convert it to a usable voltage level.
  - Implement logic to:
    - Turn ON the load when the battery voltage is above 10V.
    - Turn OFF the load when the battery voltage drops below 10V.
    - Control the solar charging based on the battery voltage (stop charging above 13.8V).
    - Automatically connect the adapter when the battery voltage is below 11V and disconnect it when above 11V.
    - Prioritize solar charging when available.
- Testing the Code:
  - Simulate different voltage levels using the potentiometer to ensure the code respond correctly to changes in voltage.

3. Circuit Assembly

- Breadboard Setup:
  - Assemble the circuit on a breadboard for initial testing. Connect all components according to the circuit design.
  - Ensure proper connections and soldering for permanent setups.
- MOSFET Configuration:
  - Connect the MOSFET in the circuit to control the load. Ensure the gate is connected to the Arduino output pin for control.

4. Testing and Calibration

- Initial Testing:
  - Power the circuit and observe the behavior of the load as the voltage is varied.
  - Check the response of the system when the voltage crosses the threshold levels (10V, 11V, 13.8V).
- Calibration:
  - Adjust the code and circuit as necessary based on the testing results. Ensure that the thresholds are accurately set and that the load responds correctly.
- Load Testing:
  - Test the system under different load conditions to ensure stability and reliability. Monitor the performance of the solar panel and battery during operation.

5. Final Implementation

- Enclosure:
  - Once testing is complete, design an enclosure for the components to protect them from environmental factors.
- Documentation:
  - Document the entire process, including circuit diagrams, code, and any modifications made during testing.
- User Manual:
  - Create a user manual that explains how to operate the system, including how to adjust the potentiometer and use the manual switch.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 5, pp 505-509, May-2025

https://doi.org/10.47001/IRJIET/2025.905058

6. Evaluation and Optimization

- Performance Evaluation:
  - Evaluate the overall performance of the solar charge controller in real-world conditions.
  - Monitor battery health and efficiency of solar charging over time.
- Optimization:
  - Identify any areas for improvement, such as enhancing efficiency, reducing costs, or improving user interface.

This methodology provides a comprehensive approach to developing a MOSFET-based solar charge controller.

IV. SYSTEM DESIGN

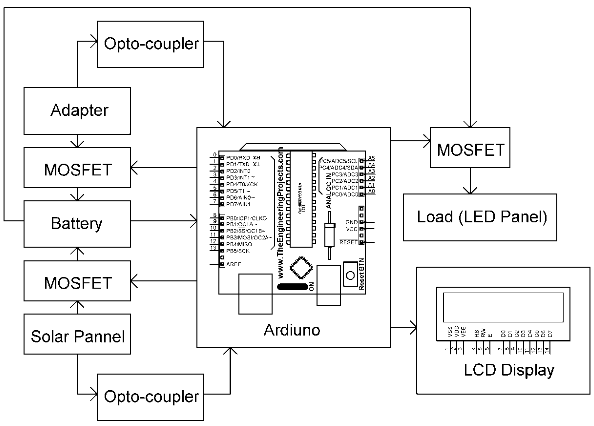

Figure 1: Block Diagram

In this project we are using Arduino uno which is the main part of project, variable battery supply, solar panel, adapter and led panel as a load. Here variable battery source is used for demonstration purpose through which we can vary the voltage with the help of pot.

When we gradually increase the voltage then the battery voltage is 10v & load gets ON. At that time MOSFET is used as a switch through which the load gets ON & solar is also ON. So to avoid deep discharge of battery & to avoid damage of battery we are set 10v as threshold level. So whenever the voltage goes below the threshold level, the load gets OFF. Again we are increasing the voltage (above 10v) at that time the load is continuously ON so to avoid this wastage of the power we are adding one switch to OFF the load.

When the voltage is above 13.8v, the solar stops charging to avoid over charging. At the time of critical condition i.e. solar is OFF & battery voltage is below 11v then the adaptor is connected automatically. & when it exceeds 11v then adapter gets OFF. When solar comes under the sun rays then the adapter gets OFF because the device gives first priority to solar.

Whenever we are varying the voltage of this using this pot so this is the variable battery supply and this is a solar supply which is connected with here and here we can see the load which is nothing but series of LEDs and there is supplied to the adaptor. Here are the moss feeds and this are the LCD display. Here we are take variable battery supply and this is transformer and this transformer is the source of supply of the variable battery source. So what we do is we increase this battery voltage gradually so we can see here the battery voltage is 11V so the load is on so the moss feeds will act as a switch to on or off the load so again we decrease the battery voltage so we can see the battery voltage is 7.33V so the load is off so avoid the deep discharge of the battery and damage of the battery so we are set its threshold value of 10V so below that the load will be off to avoid discharge the battery and damage of the battery. So here again we increasing the voltage of the solar so we can here the voltage is 14.67V and it displayed so the no solar it is showing even the charging is off so here whenever the voltage the increase above 13.8V to avoid over charging of the battery we are off the solar charge. We can see here the battery voltage is 11.42V even the solar is available as we have placed the solar pane in the sun rays so you can see so what we do is we avoid the sunrays so that time solar is not available so the battery voltage is 11.20V and no solar is available so the load will be working on this voltage so we decrease the battery voltage is 10.13V so the adaptor is on because this is the critical condition so adaptor is on.

V. RESULT AND DISCUSSIONS

Results:

The designed MOSFET-based solar charge controller was tested under various simulated conditions using a variable battery source, solar panel, and adapter supply. The Arduino Uno successfully controlled the switching operations based on real-time battery voltage levels. The observed results are as follows:

Condition	Battery Voltage	System Behavior	Load Status	Power Source Used
Below threshold	< 10V	Load disconnected	OFF	None
Threshold reached	= 10V	Load activated via MOSFET	ON	Solar charging starts
Manual load OFF	> 10V	Load manually turned OFF	OFF	Solar continues
Overcharge level	> 13.8V	Solar charging stopped	Controlled	Battery protected
Critical condition	< 11V (no sun)	Adapter turned ON	ON	Adapter
Battery recovery	> 11V	Adapter turned OFF	ON (if not manually switched)	Battery/Solar

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 5, pp 505-509, May-2025

https://doi.org/10.47001/IRJIET/2025.905058

Condition	Battery Voltage	System Behavior	Load Status	Power Source Used
Solar restored	Any voltage	Adapter turned OFF	Controlled	Solar prioritized

Discussion:

- Effective Load Control:
  The use of a MOSFET as an electronic switch ensured reliable and efficient load switching without mechanical wear and tear, confirming findings.
- Voltage Threshold Logic:
  Implementing predefined voltage thresholds (10V for discharge protection, 13.8V for overcharge prevention, and 11V for adapter switching) proved to be effective in maintaining battery health and reducing energy loss. This aligns with industry best practices in battery management.
- Solar Priority Handling:
  The logic that gives first priority to solar energy worked accurately, allowing the system to automatically disable the adapter when sunlight was detected. This enhances the sustainability aspect of the project.
- Manual Load Override:
  Introducing a manual switch for the load gave users more control, especially in preventing unnecessary battery drain when energy conservation is needed, which is a practical enhancement not often discussed in basic controllers.
- Efficiency and Response Time:
  The response time of the system was near-instantaneous, which is expected with MOSFET-based switching. It supports rapid switching needed during real-time solar or battery voltage fluctuations.
- Cost and Scalability:
  The system is low-cost and easy to scale with more sensors (e.g., current sensors, IoT modules). Using Arduino Uno made the implementation and debugging process simple, making it suitable for both academic and real-world use cases.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion:

The developed solar charge controller system successfully integrates a microcontroller-based control mechanism with MOSFET switching to manage battery charging and load operation efficiently. The Arduino Uno processes real-time battery voltage data and controls switching operations to:

- Prevent battery overcharging and deep discharging.
- Prioritize solar energy usage over conventional grid power (adapter).
- Enable manual load control to avoid unnecessary power consumption.
- Switch between power sources based on dynamic environmental and system conditions.

The system successfully demonstrates how simple microcontroller logic with MOSFET switching can create an efficient, smart solar charge controller. It effectively protects the battery, maximizes solar usage, and limits reliance on grid power. The design is suitable for small-scale solar-powered devices, especially in off-grid and rural applications.

Future Scope:

It is well known that various types of methods are used for generating the electricity like Thermal Power plants (Nuclear, Coal, petroleum etc.), Hydro (water) power plants, but it is non-renewable resources and also harmful for humans as well as environment.

As many types of other charge controllers like PWM etc. also available, but due to low efficiency it cannot be used completely by the consumers.

Hence there is need to develop more other cheap and effective MPPT algorithms, so that almost 100% efficiency can be achieved. Here are the some that can be future research papers:

- MPPT operating APP: An application of operating MPPT by the help of smartphones can so be made operate from whenever via the Internet.
- DC-DC running loads: DC from MPPT can be taken directly and DC load can be run. DC loads helps to consume low electricity.
- Energy Management: There is need to manage energy when these algorithms are developed.

REFERENCES

[1] M. A. Hannan, A. Mohamed, and A. Hussain, "Design and Implementation of a Solar Charge Controller Using MOSFET," IEEE Trans. Power Electron., vol. 33, no. 5, pp. 4432–4440, 2018.

[2] R. Kumari and S. Nayak, "Arduino-Based Solar Battery Charging System," Int. J. Eng. Sci. Comput., vol. 9, no. 3, pp. 20518–20521, 2019.

[3] A. L. Syed, M. A. Khan, and R. S. Bhosale, "Automatic Solar Charge Controller with Battery Monitoring System," Int. J. Adv. Res. Electr. Electron. Instrum. Eng., vol. 9, no. 4, pp. 1221–1225, 2020.

[4] R. Tripathi, S. Verma, and K. Singh, "Performance Evaluation of MPPT Algorithms in PV Systems," IEEE Access, vol. 8, pp. 123456–123465, 2020.

ISSN (online): 2581-3048
Volume 9, Issue 5, pp 505-509, May-2025
https://doi.org/10.47001/IRJIET/2025.905058

[5] B. Singh, R. Raj, and M. Gupta, "Design and Simulation of Solar Charge Controller for 12V Battery System," Int. J. Electr. Electron. Res., vol. 5, no. 1, pp. 45–49, 2017.

[6] K. Sharma, M. Patel, and A. Mehta, "Smart Solar Energy Management Using IoT and Embedded System," Int. J. Innov. Res. Comput. Commun. Eng., vol. 9, no. 5, pp. 1012–1018, 2021.

AUTHORS BIOGRAPHY

Sahil Vishnu Karlekar,
Student, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India.

Jignesh Harish Parmar,
Student, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India.

Hritik Kumar,
Student, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India.

Sachin Pandurang Kandhare,
Student, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India.

Prof. A. S. Shirbhate,
Professor, Department of Electrical Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, Maharashtra, India.

Citation of this Article:

Sahil V. Karlekar, Jignesh H. Parmar, Hritik Kumar, Sachin P. Kandhare, & Prof. A. S. Shirbhate. (2025). Solar Charge Controller. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(5), 505-509. Article DOI https://doi.org/10.47001/IRJIET/2025.905058

****

