EasyChair Preprint

№ 15783

Development Features of Solar-Powered Green Cars

Murad Rzayev, Konul Hasanaliyeva and Shahsuvar Mammadov

January 30, 2025

Development Features of Solar-Powered Green Cars

Murad Rzayev
Department of Energy efficiency and green energy technologies
Azerbaijan Technical University
Baku, Azerbaijan
murad.rzayev@aztu.edu.az

Konul Hasanaliyeva
Department of Energy efficiency and green energy technologies
Azerbaijan Technical University
Baku, Azerbaijan
konul.hesenaliyeva@aztu.edu.az

Shahsuvar Mammadov
Second year master's student of
Azerbaijan Technical University
mamedovsahsuvar@gmail.com

Abstract – **The article examines the structure, electric energy management, and application of a solar-powered vehicle. Some calculations related to the design of the solar-powered vehicle are provided. The solar panel collects energy from the sun throughout the day and stores it in a lead-acid battery via an energy regulator to power the vehicle's motor. An energy control circuit is employed to provide the battery with the maximum possible charge while protecting it from overloading from the solar panels or power source and preventing the motor from complete discharge. Compared to other renewable energy sources, solar energy is the most effective power supply for electric vehicles. Other renewable energy sources cannot be used in electric vehicles. The body of the vehicle can serve as a solar panel capable of supplying the vehicle with its overall power requirements.**

Keywords – **Solar panels, energy charger, battery, controller.**

I. INTRODUCTİON

The sun is a non-renewable energy source. Oil and gas supplies are depleting rapidly, and efficient utilization of solar energy can meet the growing demand for electricity by ensuring an uninterrupted power supply. Compared to other renewable energy sources, solar energy is the most effective power supply for electric vehicles. The vehicle's body frame can be utilized as a solar panel to supply the overall energy required for the vehicle. Considering that Azerbaijan experiences 300 sunny days annually, the prospects for utilizing solar energy in the country are promising.

II. DESCRIPTION OF THE SYSTEM

The project describes the development of schematics for a solar-powered vehicle system. The solar panel collects energy from the sun during the day and stores it in a battery via an energy controller to power the vehicle's motor. A charge controller circuit is employed to provide the battery with the maximum possible charge while protecting it from overcharging by the solar panels or power source and preventing the motor from excessive discharge. The functionality of both the driver circuit and the charge controller circuit is managed by the PIC16F876A microcontroller.

For the energy controller circuit, the PIC microcontroller detects the battery's current and voltage and, depending on the battery's state, supplies a Pulse-Width Modulated (PWM) charging current from the panel to the battery. The driver circuit for controlling the speed of the DC motor is implemented both theoretically and practically. In the theoretical part, an equation is derived from the relationship between voltage, current, and torque to control the speed of the DC motor. Practically, the DC motor's speed is managed using the Analog-to-Digital Converter method combined with the Pulse Width Modulation technique to implement the driver circuit for the PIC16F876A.

In the absence of sunlight during rainy days or nighttime, the battery will be charged from an electrical source using an AC-DC converter. A rectifier circuit converts AC current to DC current to charge the battery.

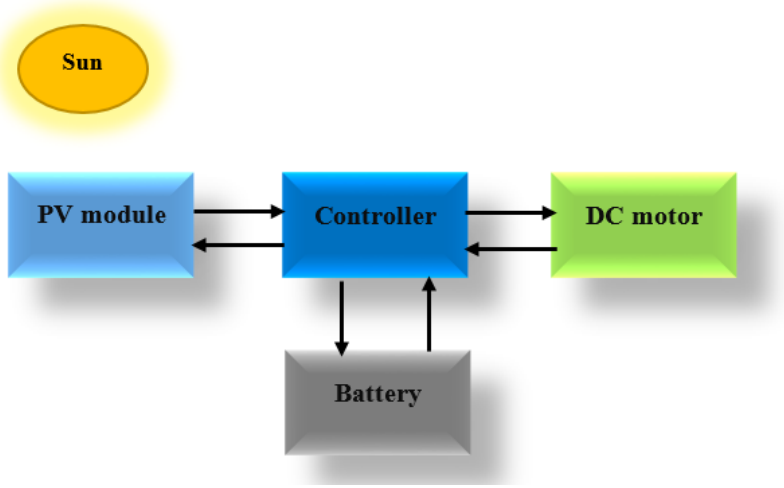

Figure 1. Schematic diagram.

The scope of this project includes building a prototype of the driver circuit for a solar-powered vehicle. A 12V lead-acid battery provides energy collected from the solar panel to the motor. The various components involved in the design of this project include an AC-DC converter, a charge controller circuit, and a controller circuit, all managed through microcontroller programming. The PIC 16F876A microcontroller helps regulate the amount of charge flowing from the panel to the battery and the current supplied to the motor.

III. SOLUTIONS

The electric control system of the solar-powered vehicle comprises components such as the Solar Panel, Battery, Battery Charger, Motor, Motor Controller, AC-to-DC Converter, and connecting wires.

There are different ways to generate electricity. However, using solar panels for electricity generation offers certain advantages, which are briefly explained below:

- **Free Fuel:** The primary fuel for solar-powered systems is sunlight, a free and globally available resource. Since there are no harmful byproducts, the environmental impact is minimal.
- **Independent Electricity Generation:** Electricity is generated independently without relying on fossil fuels or conventional power distribution lines.
- **Low Maintenance:** Since photovoltaic systems do not have rotating parts like engines, maintenance is very simple.
- **Easily Expandable:** Photovoltaic systems can be expanded by adding solar modules as needed. This is simpler and cheaper compared to conventional energy systems.
- **Maximum Reliability:** As long as sunlight is available, the system will continue to provide uninterrupted electricity, reducing the risk of power outages significantly.

The primary feature of photovoltaic cells is their ability to directly generate electricity when exposed to sunlight. The efficiency of this conversion mainly depends on the type of solar panel used. There are three types of commercially available solar panels used in both standalone and grid-tied systems. All three are silicon-based and can be classified into one of the following types:

1. Polycrystalline Solar Panels
2. Monocrystalline Solar Panels
3. Amorphous Silicon “Thin Film” Modules

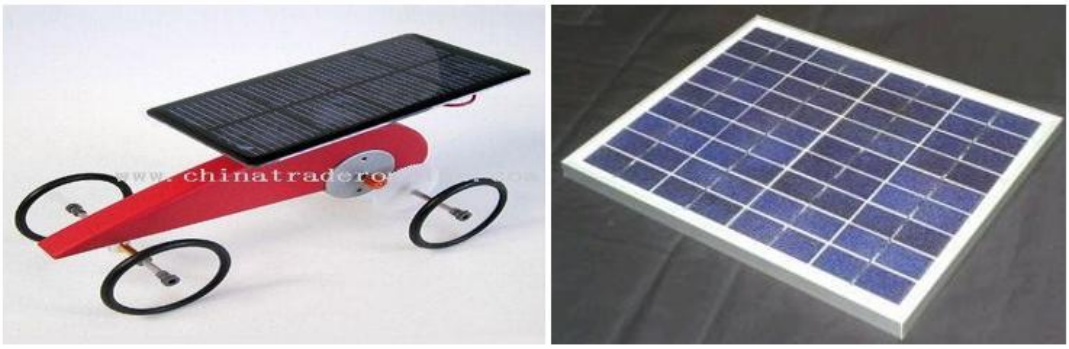

Figure 2. Solar-Powered Vehicle Panel.

Power Evaluation of the Motor
The power required to drive the vehicle can be calculated as follows:

$$P = F \times v \quad (1)$$

Here:

- v - the speed of the vehicle
- F - the force required to overcome the frictional resistance between the road and the tires

$$F = m \times g \times C_{\text{r.r.}} \quad (2)$$

Here:

- m - the mass of the vehicle
- g - the acceleration due to gravity
- $C_{r.r.}$ - the coefficient of rolling resistance (the resistance between the vehicle tires and the road when the vehicle is rolling).

The rolling resistance depends on factors such as the type of tires, the load, road type, pressure, etc. For the solar vehicle, the tires used are typical bicycle tires, which have a rolling resistance of 0.0055 on asphalt/concrete roads.

For a vehicle speed of v = 60 km/h, a mass of m = 500 kg (this is an approximate value and includes the mass of two passengers), and g = 9.81 m/s², the power required to drive the vehicle is calculated as follows:

$$P = F \cdot v = m \cdot g \cdot C_{r.r.} \cdot v$$
$$= 500\ kg \cdot 9{,}81\ m/sec^2 \cdot 0{,}0055$$
$$\cdot \frac{60 \cdot 10^3}{60 \cdot 60\ sec} = 449{,}625\ W$$

Considering the higher friction on city roads due to their uneven quality, a motor with a power rating of 1 kW, which is twice the value calculated above, will be used. For durability, a DC motor is planned for use.

Additionally, calculations were carried out for the battery capacity, the dimensions of the solar panels, and the charging devices.

IV. CONCLUSION

The control system of a solar-powered vehicle is energy-efficient in many ways. Firstly, using solar energy as a power source instead of oil saves a significant amount of energy, as the former is free, inexhaustible, and renewable. The solar car operates on an electric motor, unlike gasoline/diesel cars. While gasoline cars generate loud noise and pollute the air, electric cars are smooth and silent, producing no pollution during operation.

The concept of a solar-powered vehicle is innovative. The components of a solar car include DC electric motors, an electric controller, batteries, 12V lead-acid batteries, a battery charger, and multiple motors to control smaller parts.

From this project, we can draw several observations, which are listed below:

Management of a 3-stage charger based on PWM to charge the battery.

The converter provides the required voltage and current to the battery through an energy regulator.

A motor driver circuit to control the speed. From these observations, we gain a clear understanding of how a driver system for a vehicle that operates successfully on solar power can be implemented.

V. REFERENCES

1. Abas, N., Kalair, A., & Khan, N. (2018). **Review of fossil fuels and future energy technologies**. *Futures, 91*, 28-40. https://doi.org/10.1016/j.futures.2017.11.007
2. Ali, M., Shad, M. T., Arshad, M. U., & Iqbal, M. (2020). **Design and development of solar-powered electric vehicles: Challenges and future prospects**. *Renewable and Sustainable Energy Reviews, 131*, 110037. https://doi.org/10.1016/j.rser.2020.110037
3. Choma, K. J., & Goodarzi, S. (2016). **The role of renewable energy in reducing greenhouse gas emissions from road transport**. *Energy Policy, 92*, 121-130. https://doi.org/10.1016/j.enpol.2016.01.025
4. Hannan, M. A., Hoque, M. M., Mohamed, A., & Ayob, A. (2018). **Review of energy storage systems for electric vehicle applications: Issues and challenges**. *Renewable and Sustainable Energy Reviews, 69*, 771-789. https://doi.org/10.1016/j.rser.2016.11.171
5. Kumar, R., & Kumar, P. (2021). **Performance analysis of solar-powered vehicles: A case study**. *International Journal of Energy Research, 45*(5), 7456-7470. https://doi.org/10.1002/er.6462
6. Liu, X., Cao, J., & Li, X. (2020). **Integration of photovoltaic and energy storage systems for electric vehicle charging stations**. *Applied Energy, 259*, 114173. https://doi.org/10.1016/j.apenergy.2019.114173
7. Ma, T., Yang, H., & Lu, L. (2014). **Development of hybrid solar-wind power generation systems: A review**. *Renewable and Sustainable Energy Reviews, 43*, 524-534. https://doi.org/10.1016/j.rser.2014.11.010
8. Patel, M., & Patel, J. (2022). **Emerging trends in solar-powered electric vehicles: Challenges and innovations**. *Journal of Cleaner Production, 364*, 131008. https://doi.org/10.1016/j.jclepro.2022.131008
9. Raza, M. Q., Nadarajah, M., & Ekanayake, J. B. (2017). **On recent advances in PV output power forecast**. *Solar Energy, 136*, 125-144. https://doi.org/10.1016/j.solener.2016.06.003