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Green Initiative Low-Cost Solar Electric Vehicle

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ABSTRACT

Renewable energy is a type of energy that may be produced from a variety of resources, including sunlight, wind, tides, geothermal, etc. It delivers sustainable, clean energy that is derived from renewable natural resources. More renewable energy will be used, which will reduce the cost and demand for fossil fuels. The main uses of solar photovoltaic energy are for power generation, heating, and other things. The development of solar-powered cars was made possible by recent breakthroughs. This study discusses the design and development of a charge controller-based solar charging system for electric automobiles. The suggested system's implementation will lower the price of power and charging and discharging losses. Also, this is one of the steps taken to create a green campus by proposing a solar charging system. This paper will show how to create a solar-powered electrical vehicle system and analyse its performance.

Keywords: *EV Charging, Electric Vehicle, Solar PV Array, Maximum Power Point Tracker (MPPT), Renewable energy.*

I. INTRODUCTION

Regarding environmental, technological, and economic potential, the rapid progress in EV manufacturing and production becomes more intriguing in the future. The effect of carbon dioxide (CO2) generation from fossil fuels on climate change is presently one of the top concerns. The financial difficulties of employing battery banks as storage in automobile systems are a further problem. Renewable energy sources have been viewed as a viable technology choice for the transportation sector and the EV business. The EV's batteries are charged in part by renewable energy, extending the battery life and dependability. To increase system efficiency and minimize emissions that are damaging to the environment, renewable energy will be used to power EVs instead of the traditional electrical grid.

Comparing photovoltaic (PV) panels to other renewable energy sources, they are increasingly being acknowledged as competitive energy source solutions for charging EVs. Due to a number of benefits, including cheaper maintenance and operating costs, low greenhouse gas emissions output, and the possibility to be energy independent, PV systems have recently been employed as the primary source of energy to charge batteries. Recent advances in solar energy charging for EVs have resulted from extensive study and technological development. Several nations have started developing installation guidelines and PV charging station design requirements. The goal of the project is to create an electric-powered car that can produce power utilising solar energy. The need for gasoline would significantly decline if this kind of vehicle were to become a norm for commercial transportation. The main challenge is designing this car to be functional. The vehicle must be light in order to reduce the size of the motor necessary to meet urban transportation demands. The car is only intended to fit one driver, therefore more room would really be needed for other passengers and materials.

For the project, mechanical and electrical engineering considerations must be made. Components must be appropriate for use with the Shell Eco-urban marathon's idea category. To fit the application, components will be bought and made from raw materials. Due to the vehicle's unusual size, several components will need to be precisely machined. Financial limitations and the viability of fabrication will guide decisions.

II. COMPONENTS REQUIRED

For the project, mechanical and electrical engineering considerations must be made. Components must be appropriate for use with the Shell Eco-urban marathon's idea category. To fit the application, components will be bought and made from raw materials. Due to the vehicle's unusual size, several components will need to be precisely machined. Financial limitations and the viability of fabrication will guide decisions.
Using theoretical calculations of the power input necessary to operate our vehicle at the set speed and circumstances, we establish the requirements for the design of each component of our vehicle throughout the design process. We have switched the implementation and testing phases using simulation for the vehicle's analysis.
Components used are Battery, Electric Motor, MPPT Controller, PV Panels.

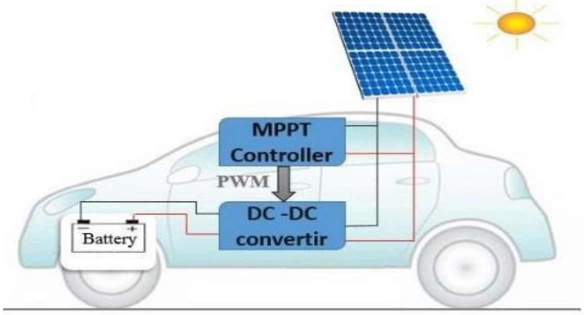
PV PANELS: The solar radiation is absorbed by the PV panels, which then converted it into direct current to charge the battery banks. PV current.

DC/DC CHARGE CONVERTER: An electronic gadget called a DC/DC charge converter controls the output dc power. Stepping up and down the output PV's voltage and current to control the output PV's power and accomplish MPPT is the primary purpose of a DC/DC charge controller.

BATTERY BANKS: A deep-cycle battery is employed instead of a traditional starting battery. The deep-cycle batteries have a long lifespan and can deliver a constant current. Even with frequent discharge and recharge operations, they also have a long lifespan.

DC MOTOR: The main element to drive the EV is a DC motor. The DC motor converts the electrical energy into mechanical energy to move the tires of the EV. The electrical energy is supplied from the battery banks while the mechanical energy is used for moving the EV.

MPPT SOLAR CHARGE CONTROLLER: An MPPT charge controller is a DC-DC converter that maximizes the efficiency of a solar system. It does this by optimizing the voltage match between the solar panel array and the batteries



III. LITERATURE REVIEW

[1] Jamaluddin MNI, "An Effective Salp Swarm Based MPPT for Photovoltaic Systems Under Dynamic and Partial Shading Conditions."
This study proposes a duty cycle-based direct search method that capitalizes on a bio inspired optimization algorithm known as the salp swarm algorithm (SSA). The goal is to improve the tracking capability of the maximum power point (MPP) controller for optimum power extraction from a photovoltaic system under dynamic environmental conditions. The performance of the proposed SSA is tested under a transition between uniform irradiances and a transition between partial shading (PS) conditions with a focus on convergence speed, fast and accurate tracking, reduce high initial exploration oscillation, and low steady-state oscillation at MPP. Simulation results demonstrate the superiority of the proposed SSA algorithm in terms of tracking performance.

[2] Marius Schwarz, Quentin Auzepy, Christof Knoer, "Can electricity pricing leverage electric vehicles and battery storage to integrate high shares of solar photovoltaics?"
Leveraging electric vehicles with controlled charging has the potential to advance the integration of high shares of residential solar photovoltaics. Time-varying electricity pricing is a promising tool to control EV charging indirectly through price signals, but also affects the diffusion and usage of other residential technologies. In this article, we develop an agent-based model to simulate California's residential market for electric-vehicle charging, and the adoption of solar photovoltaics and battery storage, between 2005 and 2030. We show that time-of-use and hourly rates have a substantial impact on the further diffusion and integration of these technologies. Time-of-use rates trigger the adoption of battery storage, but over-coordinate electric-vehicle charging.

[3] Chaoping Rao, Ali Hajjiah, Mohammed A. El-Melgigy, Mohammed Sharaf, Ahmed T. Soliman, and Mohammed A. Mohammed, "A Novel High-Gain Soft-Switching DC-DC Converter with Improved P&O MPPT for Photovoltaic Applications"

This paper proposes a novel high voltage gain structure of DC-DC converter with soft-switching ability for photovoltaic (PV) applications. A small size coupled inductor with one magnet core is utilized to improve the voltage conversion ratio in the proposed converter. The converter has one active MOSFET with low conducting resistance (RDS −ON), which in turn reduces the conduction losses and complexity of the control section. Due to the low input current ripple, the lifetime of the input PV panel is increased, and the maximum power point (MPP) of the PV panel can be easily tracked. The MOSFET's zero-voltage and zero-current switching and diodes are the other countenance of the proposed converter, which improve its efficiency.

[4] Umar Hanif Ramadhania, Mahmoud Sheperoa, Joakim Munkhammara, Joakim Widéna, Nicholas Etherden "Review of probabilistic load flow approaches for power distribution systems with photovoltaic generation and electric vehicle charging"
The currently increasing penetration of photovoltaic (PV) generation and electric vehicle (EV) charging in electricity distribution grids leads to higher system uncertainties. This makes it vital for load flow analyses to use probabilistic methods that consider the uncertainty in both load and generation. Such probabilistic load flow (PLF) approaches typically involve three main components: (1) probability distribution models, (2) correlation models, and (3) PLF computations. In this review, state-of-the-art approaches to each of these components are discussed comprehensively, including suggestions of preferred modelling methods specifically for distribution systems with PV generation and EV charging.

[5] Samir M. Shariff, Mohammad Saad Alam, Furkan Ahmad, Yasser Rafat, M. Syed Jamil Asghar, and Saadullah Khan, "System Design and Realization of a Solar-Powered Electric Vehicle Charging Station"
The alarming situation of global warming leads to the full adoption of the renewable energy-based transportation system. However, their sustainable deployment at a mass level has been a challenging task. This article presents the design aspects and practical implementation of the modern solar-assisted level-2 electric vehicle charging station which is controlled by a Type-1 vehicle connector. The designed model is developed in MATLAB/Simulink environment, the circuit operation is examined and its methodological model is derived to study the parametric design features.

[6] Akhil Raj P, Sabha Raj Arya, "Solar Fed DC-DC Converter for Small Power Applications"
This paper proposes an implementation of a Photo Voltaic (PV) array connected with dc-dc converters for small power applications. In this paper, the solar panel is modelled based on single diode model. At low level of solar irradiance also this model will perform with better accuracy. The same simulator can relate to solar Maximum Power Point Tracking (MPPT) algorithm for obtaining better efficiency. The Current v/s Voltage (I-V) and Power v/s Voltage (P-V) characteristic curves are obtained from the simulation and it is compared with the actual characteristic curves obtained from the hardware.

[7] Mehdi Seyedmahmoudian, Tey Kok Soon, Ben Horan, Alireza Safdari Ghandhari, Saad Mekhilef, and Alex Stojcevski, "New ARMO-based MPPT Technique to Minimize Tracking Time and Fluctuation at Output of PV Systems under Rapidly Changing Shading Conditions"
The presence of bypass diodes that mitigate the negative effects of partial shading (PS) conditions produces multiple peak characteristics at the output of a photovoltaic (PV) array. Conventional maximum power point tracking (MPPT) methods develop errors under certain circumstances and detect the local maximum power point (LMPP) instead of the global maximum power point (GMPP). Several artificial intelligence (AI)-based methods have been used to modify the performance of conventional controllers. However, these methods have either not completely solved the PS problem or resulted in considerably complicated and unreliable methodologies, as well as require further development to be used in high-speed applications. This study aims to design, develop, and verify a novel rapid, reliable, and cost-effective method called adaptive radial movement optimization (ARMO) to diminish the effect of the PS problem in the MPP detection for PV systems with additional dynamic applications.

IV. CALCULATIONS

Mechanical Power and Energy Needed

As shown in the diagram above, we map the forces exerted on our system {electric vehicle going up} while in an upward motion with an average constant velocity v = 6.0 m/s.
Along the x-axis, the net force is:
F = F acceleration – F drag – F rolling – F w
F acceleration =Acceleration force (= 0, since the velocity is constant)
F drag = Force opposing motion caused by the deformation of the tires
F rolling = Force opposing movement caused by the air surrounding the vehicle and moving opposite to it as seen by a reference frame attached to the vehicle.
F w = Force due to the total weight of the vehicle.

Finding F drag:

F drag = 1/2 ρair A Cd v_r^2 ρair [kg/m3] Density of air at a specified altitude
A [m²] Frontal area of the vehicle Cd [-] Coefficient of air drag vr [m/s] Velocity of the vehicle relative to that of the wind by interpolation,
we get: $\rho_{air} = 1.112 + (1.112-1.007)/(1000-2000) \times (1665-1000) = 1.04$ kg/m³
Thus, we take the following data inputs in order to calculate the air drag force:

ρ air = 1.04 kg/m3, A = 0.784 m², Cd = 0.25, V = 6.0 m/s
F drag = 1/2 (1.04 kg/m3) (0.784 m²) (0.25) (6.0 – 3.1) ² =
0.8571 N

Finding F w:
We have: F w = MT g sin θ

MT [kg]	Total mass of the vehicle
g [m/s²]	Gravitational constant
θ [rad]	Road Slope Angle

We approximate the total mass of the vehicle as estimates of
Mt = M (driver) + M (body) + M (chassis) + M (battery) +
M (solar panel) + M (motor) + M (wheel)
Mt = 120+100+5+8+10
Mt = 190kgs (approx.)

We have θ = 10° ≈ 0.17 rad
Thus, W = (190 kg) (9.81 m/s²) sin (0.17) = 295 N(approx.) **Finding F rolling:**
We know that: F rolling = Cr W cos θ = Cr m g cos θ
Cr [-] Coefficient of road rolling friction
W [N] Total weight of the vehicle
θ [rad] Road Slope Angle
Determining Cr:
At low speeds, the rolling friction varies linearly with speed such that:
Cr = 0.012*(1 + v/100); v is the speed in miles per hour v = 6.0 m/s = 21.6 kmph, thus Cr = 0.012*(1 + 21.6/100) = 0.0145
Therefore, F rolling = 0.0145(190 kg) (9.81 m/s²) cos (0.17) = 27.02N
Finding the power and energy need
From the previous results,
F = - F drag – F rolling – F w
F = –0.8571N – 27.02 – 295 =323 N (along negative x-axis)
Therefore, the power needed is:

P = FV = (323 N) (5 m/s) = 1.6kW

If the motor has an efficiency of 90%, the power needed is:
P in = 1.6 kW/ 0.86 = 1.8kW and E in = (1.8kW) (2 h/day) = 3.6kWh

THEREFORE, THE ELECTRIC MOTOR SPECIFICATION IS 1 KILLO WATT (KW)

THE BATTERY

From the previous section, the battery directly connected to the DC motors needs to supply a total of 1kW. Furthermore, we assumed that the vehicle would be operational for 2 hours per day, thus:
E out = (1.8kW) (2 h/day) = 3.6kWh/day
We now assume that we would like our battery to have an autonomy of 2 hours and that the depth of discharge of our battery should not exceed 80%. The minimum battery capacity is thus:

C = (2/24 day) *(3.6kWh/day) * 1/80% =240 Wh

We convert this capacity to Ah. For that, we choose a battery with a voltage of 12 V. Thus:

$$C = 240\ Wh/12\ V = 20Ah$$

THEREFORE, WE NEED 4 SUCH BATTIERES OF RATING 12 VOLTS (V), 20AMPHERE PER HOUR (Ah)

SOLAR PANELS

The monthly average for the year 2022 is thus 177.23 kWh/m². The daily average is thus 3.6 kWh/m². The formula to calculate the power peak of the PV panel is:
Pp = $E*Rs/\eta*Rav$

E [kWh] Energy
Rs [W/m²] Standard value of irradiance
η [-] PV yield and efficiency
R avg [W/m²] Average daily solar irradiance
Therefore, assuming the PV panel can charge the battery entirely in 4 hours,

Pp = $(295Wh) * 1\ kW/m^2\ 0.8 * 3.6\ kWh/m^2$ = 183.6 W

THEREFORE, THE NEWPOWA 200 WATT (W), 12 VOLTS (V) MONOCRYSTALLINE SOLAR PANELS FIT OUR SPECIFICATIONS

Fig: Image of the vehicle built

V. CONCLUSION

Solar powered electric vehicles (EVs) have the potential to revolutionize the transportation industry by offering a clean and sustainable mode of transportation. In this paper, we have explored the benefits and challenges of solar-powered EVs. One of the key advantages of solar-powered EVs is that they can reduce our dependence on fossil fuels and help mitigate climate change. Additionally, they offer lower operating costs and reduce air pollution. However, there are also some challenges that need to be addressed, such as the limited range and high upfront costs of solar-powered EVs. To overcome these challenges, researchers and engineers are developing new technologies such as higher efficiency solar cells and energy storage systems to increase the range and reduce the cost of solar-powered EVs. Governments and policymakers also have a crucial role to play in promoting the adoption of solar-powered EVs by offering incentives and implementing supportive policies. Overall, solar-powered EVs offer a promising solution to the environmental and economic challenges facing the transportation sector. While there are still some hurdles to overcome, with continued research and development, solar-powered EVs have the potential to transform the way we travel and help create a more sustainable future.

The charge controller plays a vital role in regulating the amount of power delivered to the battery, preventing overcharging or undercharging and ensuring the battery is charged optimally. The use of MPPT charge controllers can maximize the solar panel's energy conversion efficiency, thereby increasing the amount of power available to charge the electric vehicle's battery. The solar charging system's development faced some challenges such as the high upfront cost and limited range of electric vehicles, as well as the limited amount of energy that can be harvested from solar panels. However, with advancements in technology and the implementation of supportive policies, these challenges can be addressed. In conclusion, the development of a charge controller-based solar charging system for electric automobiles offers a promising solution to the environmental and economic challenges facing the transportation sector. Continued research and development, along with supportive policies, will enable the widespread adoption of this technology, paving the way for a more sustainable future.

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