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Solar Powered Foot Over Bridge – A Sustainable Solution for Urban Pedestrian Mobility

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Abstract*— Urban areas are facing increasing challenges in pedestrian mobility due to growing population and traffic congestion. Foot Over Bridges are also known as pedestrian bridges, are crucial for providing safe and efficient passage for pedestrians across busy roads or intersections. However, the effectiveness of Conventional FOBs is not much based on the factors like design, accessibility, surrounding infrastructure etc., and also using escalators and elevators to make the foot over bridges more accessible results in powering them with conventional energy which raises environmental concerns and operational costs. In this context, the integration of solar energy in foot over bridge equipped with automated escalators presents a sustainable solution to address these challenges. The proposed system works on the concept of using solar energy to run the automated escalators that are equipped to a foot over bridge and explore it as a sustainable solution for urban pedestrian mobility.

***Index Terms*— Solar energy, Foot over bridge, Automated escalators, Solar charge controller, Sustainability**

I. INTRODUCTION

According to [6] pedestrians are highly exposed to vehicular traffic. Ensuring pedestrian safety is a critical aspect of urban planning. Conventional FOBs are elevated structures that provide safe means for pedestrians to cross busy roads, railway tracks etc., they are commonly used in urban areas to separate pedestrian traffic from vehicular traffic and reduce the risk of accidents involving pedestrians.

However, the Conventional FOBs are less feasible to access and the others often consume significant energy to power escalators or elevators, leading to environmental concerns and increasing operational costs. The escalator comprises a motor-driven chain with interconnected steps to facilitate upward and downward motion while keeping the step treads level[3]. Using solar energy and automated escalators in foot over bridge presents a promising sustainable approach to address these challenges. The solar powered foot over bridge is a revolutionary concept that has been designed to provide a sustainable and eco-friendly solution for pedestrians. The bridge is equipped with solar panels that generate electricity which powers the escalators used for the movement of Pedestrians. The paper aims at making a model of the solar powered foot over bridge equipped with automatic escalators.

II. PROBLEM SUMMARY

Despite their significance, FOBs often face several problems that hinder their effective usage, resulting in low pedestrian usage, lack of convenience for pedestrians etc., use of escalators or elevators for the FOBs results in adding burden to the power demand, environmental concerns and increase in operational costs.

III. PROPOSED METHODOLOGY

The foundation point of our research is to find a sustainable solution for pedestrian mobility across roads. In this proposed system, a foot over bridge is designed taking the considerations of the length, width and height. The Escalators are modeled by considering the (angle of elevation 35deg), height of the bridge, load considerations etc., the battery is modeled based on the power requirements of the motors used.

IV. WORKING PRINCIPLE

The flow diagram of the system is shown below. Solar radiation emitted by the sun when it hits the solar panels gets absorbed by PV cells inside the panel. This absorbed radiation/energy is responsible for electricity generation through movement of electrical charges which moves in response to the electric field inside the cell. This electricity is flown to solar charge controller where it gets stabilized to a constant value and is connected to battery and the load parallelly in order to maintain constant voltage across battery and the load. If the availability of solar energy is less than the load is supplied with the battery power. The initial point of the load consists of an Arduino which is power from the solar charge controller, and the Arduino is connected to motor drives and the IR sensors[7]. The motor drives are connected to the PMDC motors which are drivers for the escalators. The IR sensors get powered from the Arduino and it is programmed in a way that when the IR sensors detect a motion the Arduino powers the motor drivers there by the

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motors get powered and the escalators work. The concept is to minimize power consumption during periods of no-load and light load conditions for the escalator by cutting down the voltage applied which significantly reduces the magnetizing current which accounts for most of the losses[1].

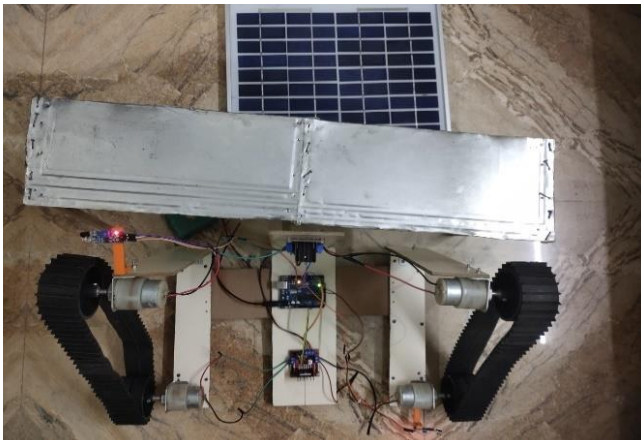

Figure 1: Proposed System

V. FABRICATION DETAILS

The frame structure for the total units is fabricated using wooden frames and iron sheets. They are held to proper dimensions and are attached to form a unit. The platform of the foot over bridge is fabricated using the iron sheet and is held in support with the wooden sticks(pillars). The escalators are made up of wooden structures. In between the wooden supports two rollers are connected which in turn are connected using conveyor belt. Two PMDC motors are fitted in the wooden support which is then connected to the rollers using a shaft. The use of two motors is for the equal load sharing on both the motors. One of the IR sensors is fixed at the bottom of the one escalator and the other is fixed at the top of another escalator to detect passenger motion.

VI. COMPONENTS OF THE SYSTEM

1. Foot Over Bridge: It is a bridge solely designed for passengers, to use it to cross the roads, railway tracks etc., [According to the 'Ministry of Road Transport and Highways' the minimum vertical height of the foot over bridge should be 5.5mtr (18feet)].

2. Solar Panel: A photovoltaic module, commonly referred as a photovoltaic assembly, comprising a frame housing a collection of interconnected solar cells. Sunlight serves as a primary source of radiant energy, which is subsequently converted into electrical energy in the form of Direct current (DC) without emitting greenhouse gases or pollutants. However, their efficiency is affected by factors such as shading, temperature, and the angle of the sun. Proper installation and maintenance are important for optimizing the performance. As technology has been advancing, the efficiency of most of the systems is going up and there by cost is counting down[2].

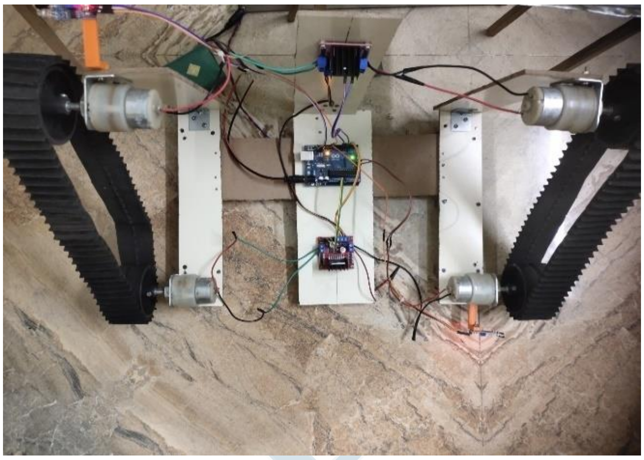

Figure 2: Automated Escalator model

3. Solar charge controller: It is an electronic device that controls voltage and current from solar panels to the batteries or other electrical loads in a solar power system. It is an essential component of solar power system, as it ensures that the battery is charged efficiently and protected from overcharging or undercharging. The solar charge controller efficiently drives the load using the solar current generated and if necessary, utilizes the battery power, resulting in energy savings and maximizing the utilization of renewable energy resources [4].

4. Lithium-ion battery: A rechargeable battery that uses lithium-ion reversible reduction to store energy. Li-ion batteries are characterized by their high energy densities, absence of memory effect and low self-discharge properties. The capacity of the battery used is 12 volts and 6600mah.

5. Arduino Uno: The Arduino Uno is a micro controller board based on the ATmega328 chip. As an open-source prototyping tool, Arduino is highly favored by both consumers and professionals due to its user-friendly nature. The board features 14 I/O pins of which 6 work as PWM outputs. It also includes 6 analog pins, A 16MHz crystal oscillator, a USB connection, an ICSP header, a power jack and a reset button. It comes with all the necessary components equipped to support a microcontroller. The PID gains within the Arduino are responsible for compensating and determining the appropriate voltage to be supplied to the system [5].

6. IR sensors: An infrared sensor (IR sensor) is an optoelectronic component that is sensitive to radiation within the infrared wavelength range of 780nm-50um. At a specified angular distance, the sensor element detects the heat radiation caused by the movement of people which varies with time and space.

7. L298N Motor Driver: It is a dual H-Bridge motor driver module that enables simultaneous control of two DC motors. This module can handle DC motors with voltage ranges between 5v and 35v, with a peak current of 2Amp.

8. Permanent magnet DC motor (PMDC): It is a DC motor that relies on permanent magnets to generate the necessary magnetic field required for its operation. The motor used here rotates at a speed of 1000 rpm which is reduced to 10 rpm using the gear box.

9. Gear Box: It is a combination of several gears attached accordingly to obtain the required gear ratio to run the escalator.

VII. FLOW CHART

The flow chart below represents the complete working flow of the system.

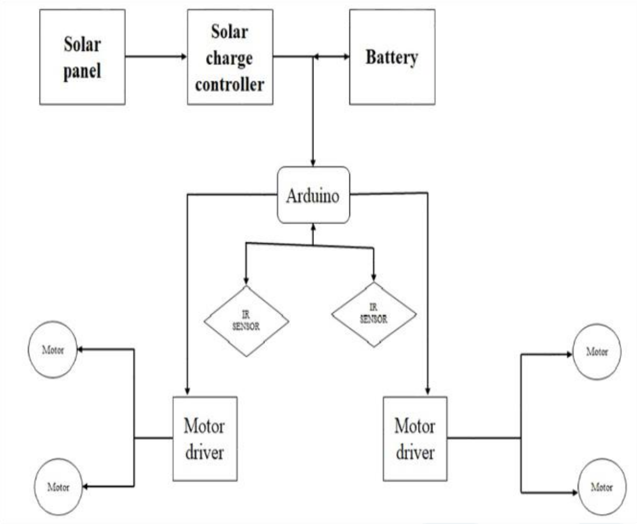

Figure 3: Flow chart of the working Model

VIII. RESULTS

ESCALATOR:

The power consumed by the motor is defined as:

$$P_{in} = V * I \text{ watts}$$

Where,

P_{in} – power input
I – Current
V – Voltage supplied

Torque applied on the motor is:

$$T = 9.81*W*D \text{ N-m}$$

Where,

T – Total torque applied on the motor
D – total distance between the rollers
W – Total mass (roller, belt and steps together)

Mechanical output power of the motor is calculated as:

$$P_{out} = T*rpm*0.1047 \text{ watts}$$

Where,

P_{out} – Mechanical output power of the motor (shaft power)
T – Torque on the motor
rpm – Speed ofmotor

The efficiency of the motor is determined by diving the mechanical output power by the input electrical power.

$$\textbf{Efficiency} = [(P_{out}/P_{in})x100]$$

No-load calculations:

- Current I_a = 333mA
- Voltage V = 12Volts
- Torque T = 0 N-m

Input power at No load:

P_{in} = V*I
= 12*0.333
= 4 watts

Output power at No load:

P_{out} = T*rpm*0.1047 = 0 watts
Efficiency = P_{out}/P_{in} * 100 = 0%

Full load calculations:

- Current (I_a)= 833Ma
- Voltage (V) = 12Volts
- Torque (T) = $9.81*3*30*10^{-2}$
= 8.2404 N-m

Input power:

P_{in} = V*I
= 12*0.833
= 10 watts

Output power:

P_{out} = T*rpm*0.1047
= 8.2404*10*0.1047
= 8.627 watts

Efficiency = $[(P_{out}/P_{in})$x 100]
= 8.627/10 * 100
= **86.27%**

IX. CONCLUSION

The solar powered foot over bridge is a sustainable and eco-friendly solution for pedestrian infrastructure. Its innovative design and use of solar power make it a symbol of progress and innovation in the field of infrastructure development and also in Electrical Field. With its numerous benefits, low-maintenance requirements, and affordability, the solar powered foot over bridge is a viable option for communities looking to improve their pedestrian infrastructure while also reducing their impact on the environment.

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