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E-Highway: Robot As a Heavy Vehicle Electric Highway

Sahil Arjun[1*], Tejas Patil[2], Vivek Gogule[3]

[1,2,3]Student, Department of Electronics And Telecommunication Engineering ,,Imperial College of engineering and research Wagholi , Pune

Prof.Sonali bhabad

Professor, Department of Electronics And Telecommunication Engineering, College of engineering and research, Wagholi , Pune

Abstract: The burgeoning demand for electric vehicles (EVs) is set to significantly alter the landscape of road transportation. Yet, despite this surge in interest, current commercial EVs confront several limitations, including constrained battery range, inadequate charging infrastructure, and high upfront costs. As urban sprawl persists and prosperity increases, traffic congestion emerges as a pressing concern. In response to these fundamental challenges within the transportation realm, the E-highway emerges as a promising remedy, boasting twice the efficiency of internal combustion engines. This pioneering approach entails shifting from individually powered combustion vehicles to grid-powered transportation. By furnishing trucks with power from overhead contact lines, this innovation not only mitigates local air pollution but also makes substantial strides towards decarbonizing the transport sector...

Keywords: E-Highway, Electric vehicles.

1. Introduction

As detailed in the Transportation Energy Data Book, world petroleum consumption stood at 95.3 million barrels per day in 2015, with transportation accounting for 86.2% of this consumption. A recent study by the Environmental Protection Agency highlights the complex environmental impacts associated with powering personal and commercial vehicles, emphasizing the need for sustainable solutions. With the anticipated growth in transportation demand, the International Transport Forum predicts that global emissions from road freight transport will surge from 1.36 gigatons of carbon dioxide in 2015 to 2.40 gigatons by 2050.

Recognizing these challenges, an electrically augmented road emerges as a pivotal factor in addressing pressing issues such as global warming, air pollution, and ecosystem degradation. While numerous studies have explored the While there has been considerable attention on the potential of electrifying passenger vehicles, there has been a comparative lack of focus on transitioning road freight transport to sustainable energy sources. This study aims to address this gap by examining the Electric Road system in comparison to the current diesel system. The E-highway system integrates the efficiency of electrified railroads with the flexibility of trucks, offering an innovative freight traffic solution that is efficient, cost-effective, and environmentally friendly.

However, shifting freight transport to rail presents limitations, including time-consuming recharging processes. Simply increasing battery size is technologically complex and currently cost-prohibitive. To overcome these challenges, the Electric Road system proposes drawing power from grid-connected power plants via catenary cables, potentially incorporating renewable energy sources and carbon sequestration to provide cleaner power directly to vehicles. Hybrid diesel-electric trucks are equipped with rods that are raised when entering roads with overhead electric lines, allowing them to access power from the overhead contact line at speeds of up to 60mph. This innovative approach not only reduces local air pollution but also significantly contributes to the decarbonization of the transport sector.

2. Literature Survey

1) In the first literature survey, conducted by K. Adam, M. Müller-Mienack, M. Paun, G. Sanchis, K. Strunz, and their colleagues, the e-highway 2050 project is outlined. This project aims to address the uncertainties associated with long-term planning by adopting a modular approach organized into five-year periods. The project encompasses various key topics, including power generation and consumption, power source placement, power flow calculation, corridor and architecture mapping, and the study of implementation strategies. Additionally, the study acknowledges not only the engineering challenges but also the broader issues of governance, economics, stakeholder acceptance, social welfare, and environmental impact. Furthermore, it describes how the work

In another study by Zhang Bin, Fang Pin, Xu Guoqing, and their team, the focus shifts from emissions reduction in hybrid vehicle development of the 1980s-1990s to reducing reliance on traditional fuels in recent years. This paper investigates the fuel consumption of trucks, developing diesel and road cycle modules for truck simulation using ADVISOR. Simulations are then conducted for hybrid electric trucks and plug-in hybrid electric trucks using these modules. Analysis reveals that plug-in hybrid electric trucks are preferable under certain conditions, with fuel consumption in the shipside cycle being 52.3% lower compared to hybrid electric trucks.

2)

3) Furthermore, T. H. Pham, J. T. B. A. Kessels, P. P. J. van den Bosch, R. G. M. Huisman, and colleagues explore energy management strategies in hybrid trucks. The study highlights the use of batteries to reduce fuel consumption and associated emissions. However, limited battery life poses challenges, leading to additional costs for battery replacement. To address this, the paper develops a quasi-static battery cycle-life model and formulates a model-based integrated energy management (IEM) strategy. This IEM strategy optimizes power split and clutch system operation to minimize fuel consumption while ensuring sufficient battery life, with the problem solved analytically using optimal control theory.**3. Block Diagram**

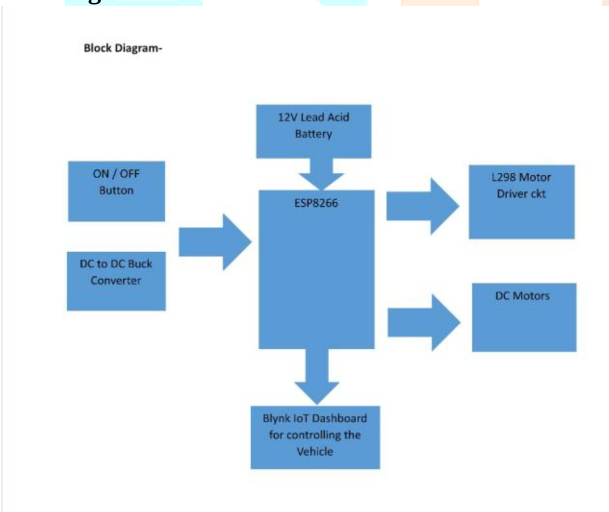

Fig. 1. Block diagram of the system

A. Description

ESP8266:
Specifications:
Microcontroller: ESP8266-12E/F
Estimated Cost: ₹150 to ₹350 (depending on brand and quantity)
L298 Motor Driver:
Specifications:
Motor Driver IC: L298N or L298D
Operating Voltage: 5V to 35V
Output Current: Up to 2A per channel
Estimated Cost: ₹75 to ₹225
12V DC Motors (4 Qty):
Specifications:
Voltage: 12V
RPM: Varies based on the specific motor you choose
Estimated Cost: ₹300 to ₹900 for a set of four motors
4 Wheels:
Specifications:
Type: Rubber or plastic wheels, size and type will depend on your chassis and application.
Estimated Cost: ₹250 to ₹1,000 for a set of four wheels
Metal Chassis:
Specifications:
Material: Aluminum or steel
Size: Varies based on your project requirements
Estimated Cost: ₹500 to ₹1,500
SG90 Servo Motor:
Specifications:
Voltage: 4.8V to 6V
Torque: Around 1.5 kg/cm
Estimated Cost: ₹150 to ₹350
230V to 12V Charging Circuit:
Specifications:
Transformer: 230V AC to 12V AC transformer
Rectifier: Bridge rectifier to convert AC to DC
Voltage Regulator: 12V voltage regulator (e.g., LM7812)
Estimated Cost: ₹350 to ₹1,000 (excluding additional components like capacitors).

4. Methodologies

Design and prototyping involve developing a preliminary design for the robot, incorporating elements such as the pantograph mechanism, motor control system, battery system, and other necessary components based on the literature review. Following this, a prototype is constructed to test the design and identify any issues or areas for improvement.

Testing and evaluation entail subjecting the prototype to trials in a controlled environment to assess its performance, efficiency, and safety. The results obtained from testing are used to make essential modifications and enhancements to the design.

Optimization and finalization involve refining the design based on the findings from testing and evaluation. This phase aims to optimize the robot's components and systems, ensuring that the final design meets the project's objectives and requirements. Final tests are conducted to validate the effectiveness of the optimized design.

Deployment and demonstration encompass deploying the robot on a highway or a suitable testing ground to demonstrate its functionality and efficiency in heavy vehicle electric transport. Feedback is gathered from stakeholders such as transportation companies, policymakers, and environmentalists to evaluate the robot's potential impact and identify areas for further improvement.

Documentation and dissemination are critical aspects of the project, involving the thorough documentation of the entire process of design, development, testing, and deployment of the robot. This includes highlighting any challenges encountered and lessons learned throughout the project. The findings are disseminated through publications, presentations, and other means to promote the project's outcomes and potential impact.

Overall, the methodology entails a systematic and iterative approach to design, development, testing, and evaluation, with a keen focus on sustainability, safety, and efficiency.

The proposed methodology for the development of an ESP8266-based robot with a pantograph mechanism for heavy vehicle electric transport on highways includes the following steps:

1 Research and analysis of existing solutions: Conducting a comprehensive review of the literature and available solutions related to electric highways and pantograph mechanisms to gain insights into the technical requirements and challenges associated with the development of the proposed robot.

2. Design and development of the robot: Designing and developing the robot, integrating the pantograph mechanism and ESP8266 microcontroller. The robot will be engineered to carry heavy loads and operate on rechargeable batteries, with the pantograph mechanism facilitating efficient power transfer from overhead electric lines. The design will prioritize energy efficiency, load carrying capacity, and safety.

3. Testing and evaluation: Subjecting the developed robot to rigorous testing and evaluation to assess its performance, energy consumption, and safety. Testing will be conducted in a controlled environment to ensure the safety of both testing personnel and the public.

4. Optimization and refinement: Improving the performance, energy efficiency, and safety of the robot based on the results obtained from testing and evaluation. Refinements will be made to the design to enhance its overall effectiveness.

These steps outline a comprehensive approach to the development of the ESP8266-based robot, with a focus on addressing the challenges associated with heavy vehicle electric transport on highways.

5. Economic Aspect

An E-Highway project encompasses three primary costs: construction, power supply, and maintenance. Construction represents a fixed capital expenditure, while power supply and maintenance costs are contingent on electricity prices and road usage. Shifting away from a petroleum-based transport system poses a challenge in replacing revenue from gas taxes, which currently partially funds road maintenance.

To address this challenge, a demand-based rate system integrating smart meters and fast lane highway passes could be implemented within the E-Highway pricing scheme. This approach would facilitate efficient revenue collection while incentivizing the use of electric lanes, which are expected to be less congested, for a fee. Vehicles fueled by non-electric sources could pay for the time-saving advantage of driving in the electric lane.

Additionally, cost recovery measures could be further enhanced by the cost savings derived from the safety benefits of the E-Highway system. The proposed automated vehicle features are anticipated to significantly reduce the number of collisions by minimizing human error. This reduction in accidents would lead to benefits such as lower vehicle insurance premiums, reduced auto repair costs, and decreased healthcare expenses.

6. Conclusion

Given the demands of a growing global population, it's imperative to establish an efficient and safer driving experience. Our strategy is designed to mitigate the reduction of greenhouse gases like CO_2, NO_x, and particulate matter emissions, while simultaneously enhancing the efficiency of heavy trucks. The E-Highway represents a significant advancement in battery storage, car electronics, and emerging technologies such as wirelessly charging moving vehicles and cutting-edge vehicle automation. These innovations aim to create a cleaner and safer roadway environment.

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