**BATTERY MANAGEMENT SYSTEM FOR SMALL ELECTRIC VEHICLE**

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**REZUMAT**

Lucrarea prezentată în cadrul proiectului de diplomă se concetrează asupra dezvoltării unui sistem eficient și sigur de încărcare a ansamblului de baterii din interiorul unui vehicul electric. Scopul acestui sistem este să realizeze o încărcare echilibrată a celulelor bateriei, urmărind eliminarea factorilor de risc precum supraîncălzirea și supraîncărcarea. Acești factori pot reduce semnificativ durata de viață a bateriilor, afectând performanța și utilitatea genereală a autovehiculelor electrice. În plus, prototipul vehicului electric este dotat cu metode de siguranță și protecție pentru a asigura o deplasare în condiții optime.

Întregul sistem poate fi împărțit în două categorii distincte: sistemul de încărcare și monitorizare, precum și sistemul de deplasare în condiții de siguranță al vehiculului electric.

Sistemul de încărcare asigură o alimentare eficientă și sigură a bateriilor, utilizând un convertor de tip "step-down" controlat de un microcontroller ESP32 și alimentat de o sursa de tensiune de current continuu. În același timp, sistemul monitorizează constant tensiunea bateriilor și curentul în timpul încărcării cu ajutorul unui senzor de current dedicat. Temperatura bateriilor este monitorizată cu ajutorul a doi senzori de temperatură. De asemenea, sistemul de monitorizare este echipat cu o conexiune către cloud, facilitând analiza în timp real a parametrilor anamblului de baterii.

Deplasarea în condiții de siguranță este asigurată de către patru motoare electrice, care sunt conectate la un controler de motoare L298N și care funcționează în strânsă legătură cu un senzor ultrasonic, amplasat în partea frontală a vehiculului electric. Acest sistem permite vehiculului să detecteze și să evite obstacolele în timp real, contribuind la o conducere sigură și fără incidente.

Controlul motoarelor electrice și monitorizarea în timp real se va face cu ajutorul unei aplicații mobile construită pentru sistemul de operare Android. Prin intermediul aplicației, utitlizatorul poate primi notificări în momentul în care parametrii bateriilor despășesc anumite limite iar siguranța vehicului în timpul încărcării poate fi pusă în pericol.

**ABSTRACT**

The main focus of the project relies on the development of an efficient and safe charging system for the battery pack found inside of an electric vehicle. The purpose of this system is to achieve balanced charging of the battery cells, aiming to eliminate risk factors such as overheating and overcharging. These factors can significantly reduce the life span of the batteries, affecting the performance and the overall utility of electric vehicles. Additionally, the electric vehicle prototype incorporates safety measures in order to optimize driving conditions.

The entire system can be divided into two distinct categories: the charging and monitoring system and the safety driving system of the electric vehicle.

The charging system ensures an efficient and safe power supply to the batteries, using a step-down converter controlled by an ESP32 microcontroller and powered by a DC voltage source. At the same time, the system constantly monitors the battery voltage and current during charging using a dedicated current sensor. The battery temperature is monitored using two temperature sensors. The monitoring system is also equipped with a cloud connection, facilitating real-time analysis of the battery pack parameters.

Safe driving is ensured by four electric motors, which are connected to an L298N motor controller. They operate in close relation with an ultrasonic sensor located at the front of the electric vehicle. This system allows the vehicle to detect and avoid obstacles in real time, contributing to safe and incident-free driving.

Management of the electric motors and and real-time monitoring will be accomplished through a dedicated mobile application for the Android platform. This application enables users to promptly receive notifications in case the battery metrics exceed predefined thresholds or if there is a potential compromise to the vehicle's safety during the charging process.

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1. **INTRODUCTION**
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A battery management system that ensures the safe charging of a pack of 2 NiMH batteries connected in parallel via a buck converter. This battery pack powers an L298N motor driver, which controls 4 electric motors and an ESP32-DevKitC development board, which serves as the control unit for the entire system.

To monitor and visualize the battery parameters, the system includes a mobile application specifically designed for Android users. The application displays relevant information related to the battery's charging process and its specific values, and it offers an intuitive interface for controlling the actuators. The connection between the ESP32 and the application is supported by Google Cloud Services, specifically utilizing Firebase's Realtime Database. Notifications are managed using Firebase Cloud Messaging (FCM) and Firebase Functions, while machine learning algorithms are used to predict and estimate battery lifespan and charging patterns using Google Datalab.

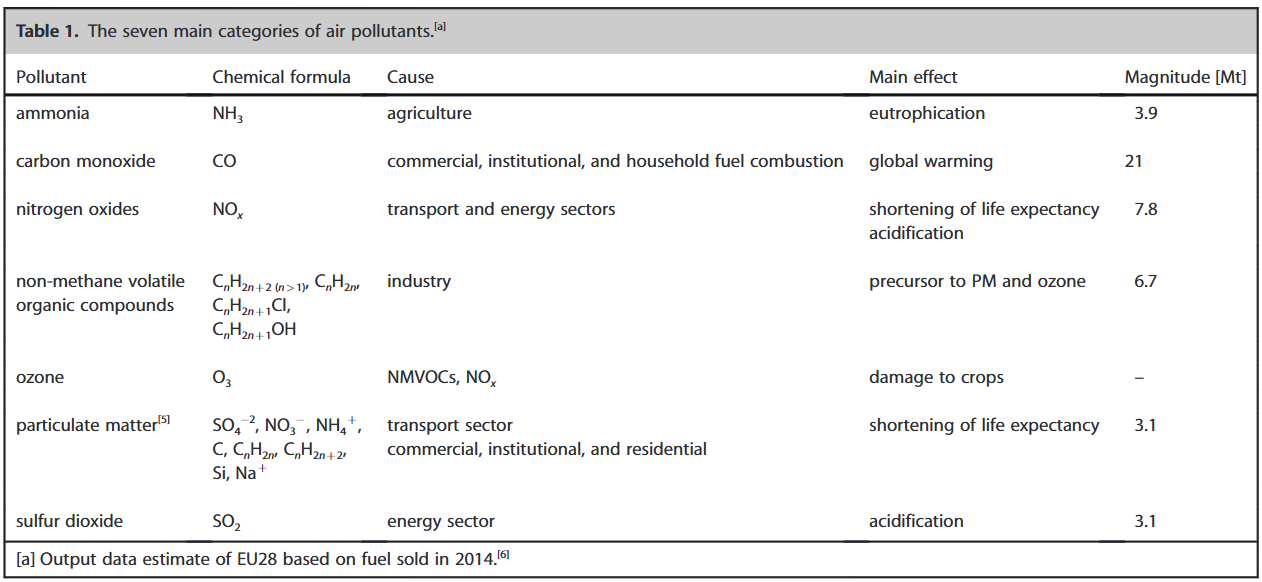
The system has a wide range of features based on the analysis of data collected from the sensors, providing dynamism and a touch of autonomy to the entire process. These features include:

* Monitoring the temperature of both batteries
* Monitoring battery level and voltage
* Monitoring the voltage value of the power source used for charging
* Dynamically charging the batteries using the buck converter
* Ensuring precise movement of the electric vehicle using the motor driver and actuators
* Sending notifications in case of high battery temperature
* Sending notifications when the batteries are fully charged or close to 10%
* Providing overcharging protection
* Utilizing machine learning algorithms to predict and estimate battery lifespan and charging patterns
  1. **CONTEXT**

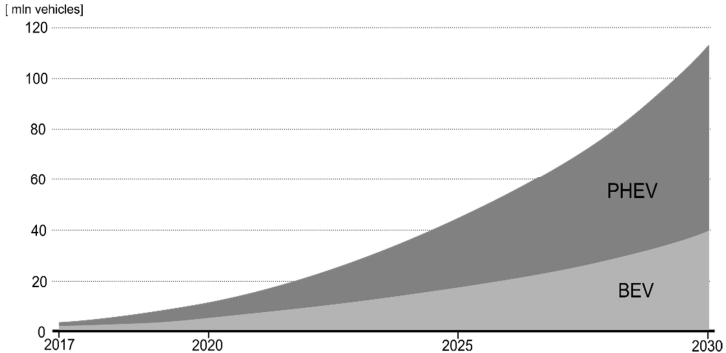
In today's era of advancing technology and growing environmental consciousness, moving toward sustainable transportation solutions is crucial. Electric vehicles (EVs) offer a promising alternative, significantly reducing emissions and improving energy efficiency. This initiative is very important in reducing pollution caused by internal combustion engine (ICE) vehicles, which heavily contribute to air pollution and greenhouse gas emissions. However, two critical challenges persists when reffering at electric vehicles: maximizing the lifespan of batteries and improving the overall autonomy and safety.

*„Legislative changes aimed at introduction of an increasing number of restrictions on the reduction of nitrogen oxides (NOx), hydrocarbons (HC), carbon oxides (CO) and particulate matter (PM) in exhaust gases of newly sold vehicles (e.g., introduction of EURO VI standard in the European Union and European Economic Area, EURO VII standard is under preparation) [1] and increased car users’ awareness have contributed to a new direction in automotive development, in which the implementation of a low-emission drive source has become a key factor.” [2]* These restrictions are based on the negative impact of exhaust gases on human health, particularly focusing on respiratory problems caused by inhaling these harmful particles.

Table 1: “Main pollutants together with their cause, effects, and magnitude” [3]

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Studies have shown a growing trend in EV sales over the last few years, despite the broader market decline caused by the COVID-19 pandemic. In 2020, while global passenger car sales fell by 16%, electric car sales grew by 43%, resulting in approximately 3 million new electric cars worldwide. This significant increase has created a need for enhanced safety and fire protection measures. [2]

Figure 1: “Worldwide car growth forecast by IEA” [4]

As EV adoption continues to rise, addressing the fire hazards associated with these vehicles has become a critical concern. There have been notable incidents of EV fires, indicating the importance of developing potent safety protocols and fire protection strategies.

There were some alarming fires involving Tesla Model S electric cars, some of the first mass-produced EVs. The first incident occurred in October 2013 on a highway in Washington state, where a piece of metal on the road punctured the car's battery, causing a fire. Two more Tesla fires happened that same month. In Mexico, a driver hit a tree and in Tennessee, a driver ran over a tow bar that damaged the battery compartment. Fortunately, no one was injured in these fires, but they raised concerns about electric car safety. [2]



Having in regard the points made by the studies shown below, it is straight-forward the importance of a close monitor and alert system. Essentially, the proposed solution tries to highlight the fact that electric cars are a good alternative for the future. However, both drivers and manufacturers must exercise great care in their use and construction.

* 1. **MOTIVATION**

As a young teenager, I graduated the national college and made the decision to pursue my dream of becoming an engineer. I started this journey by enrolling at the University Politehnica of Timisoara where I rediscovered myself and my passions. While my first year of university was not without challenges, particularly due to the pandemic, the second year proved to be an entire adventure.

During this time, I discovered my passion for cars and robots and so, my desire was to merge this interest with my enthusiasm for programming and software development.

Over the course of these four years, I dedicated myself in order to learn and grow. I extensively researched topics related to engineering, programming and software development through resources such as YouTube and specialized websites. Simultaneously, I progressed in my programming skills through my university studies.

Eventually, my dedication and expertise led to an employment opportunity at Vitesco Technologies, where I was hired to apply my knowledge and skills professionally in the Embedded Systems area.

The idea for my bachelor's project was inspired by my team leader, who noticed my burning desire and attraction to cars and my knowledge of the current literature in this field. Gradually, my focus shifted towards electric vehicles, based on current trends in the automotive industry and my previous experiences related to invention competitions in which I participated in the past.

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