

**Ukrainian Scientific  
and Practical  
Conference**

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**SRM**

**«Scientific Research  
Methodology – 2024»**



**November, 2024**

# Proceedings

## Ukrainian Scientific and Practical Conference

# Scientific Research Methodology – 2024



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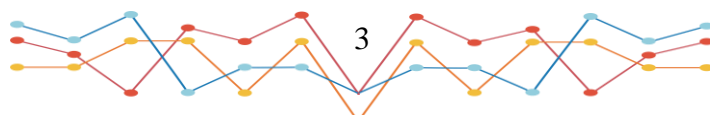
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**Methods and materials.** The research builds upon existing work in the field of lithium-ion battery modeling, particularly using equivalent electrical circuit models. The most common of these is the Thevenin model, which uses resistors and capacitors to simulate the dynamic behavior of the battery during charge and discharge cycles. However, the complexity of such models often makes them impractical for real-time applications.

To reduce computational complexity, we propose a modified Thevenin model with spline functions that interpolate the battery's behavior at different states of charge and temperature ranges. This approach allows for a more efficient computation of the battery's parameters without sacrificing accuracy.

The SOC estimation algorithm integrates this mathematical model with real-time current and voltage measurements. The algorithm uses a simplified version of the Kalman filter to adjust the SOC estimate based on the measured data, while also accounting for the battery's self-discharge and degradation over time.

The SOH estimation is based on the comparison of the current battery performance with its original capacity and internal resistance. The model continuously updates the battery's state parameters as it undergoes charge-discharge cycles, allowing for accurate prediction of battery degradation.

All simulations were performed using MATLAB Simulink to validate the theoretical model. Additionally, a test bench was developed to experimentally verify the accuracy of the model and the proposed algorithms under real operating conditions.

The simulations showed that the proposed mathematical model of the LIB, combined with the SOC and SOH estimation algorithms, achieves a high level of accuracy while maintaining low computational demands. The model's accuracy for SOC estimation was found to be within  $\pm 7\%$ , and for SOH estimation within  $\pm 10\%$ , across a wide range of operating temperatures and discharge rates.

The use of lithium-ion batteries in various applications presents unique challenges due to the need for high reliability over extended periods. Traditional battery management systems, which rely on complex algorithms or ground-based monitoring, are not always suitable for real-time applications.

The proposed ECU overcomes these limitations by offering a low-power, low-complexity solution for real-time SOC and SOH estimation. The use of spline functions and simplified filtering techniques allows the system to run on microcontrollers with minimal computational overhead, while still providing accurate and reliable data for decision-making.

This approach can be extended to other battery chemistries and applications, where the need for efficient and reliable power management is critical. The system's flexibility also allows for the integration of additional features, such as thermal management or more advanced fault detection.

**Conclusions.** The developed ECU for lithium-ion batteries offers a significant improvement in the real-time monitoring of SOC and SOH. The use of a simplified mathematical model and low-complexity algorithms ensures that the system can operate efficiently on microcontrollers with limited processing power and energy consumption, while still providing accurate assessments of the battery's health and charge state.

Future work will focus on further optimizing the algorithms for different battery chemistries and exploring ways to integrate advanced diagnostic features into the control unit.

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## CONTROL SYSTEM FOR URBAN TRAFFIC LIGHT NETWORK

**Abstract.** This study focuses on developing and implementing IoT technologies to modernize traffic light systems in urban environments. The objective is to reduce traffic congestion, minimize environmental impact, and improve road safety. By integrating IoT-based adaptive traffic light control and data analytics, the proposed system adjusts signal phases in real time, allowing for a more responsive approach to traffic flow. Experimental modeling demonstrates substantial improvements in vehicle throughput and reductions in wait times, illustrating the potential of smart traffic light systems to transform urban mobility.

**Key words:** IoT, traffic lights, urban traffic, adaptive control, intelligent transportation systems, traffic congestion, GIS integration.

**Introduction.** Urbanization and the growth of vehicle usage have intensified traffic congestion in metropolitan areas, affecting the environment and public health. Traditional traffic light systems, which rely on fixed timings and predefined cycles, lack adaptability to fluctuating traffic volumes throughout the day. This inefficiency results in longer travel times, increased fuel consumption, and higher emissions.

Intelligent traffic management systems, particularly those integrating IoT (Internet of Things) technology, present a potential solution by enabling real-time data collection and dynamic traffic signal adjustments. This study explores the design and simulation of an IoT-based traffic light management system, utilizing GIS (Geographic Information System) data and machine learning algorithms to create an adaptive network of “smart” traffic lights capable of responsive adjustments based on real-time traffic conditions.

The primary objective is to develop a smart traffic light control system that adapts in real time to current traffic patterns, aiming to reduce congestion and improve traffic flow. The system focuses on optimizing signal phase durations at intersections by integrating IoT sensors and machine learning models that process and respond to real-time traffic data. This study also seeks to address scalability, considering the potential application of these systems in multiple intersections across high-density urban areas.

**Methods and Materials.** The approach includes a combination of software simulations and hardware modeling. Software Simulation in AnyLogic: The AnyLogic platform is used to simulate traffic flows and model the adaptive control of traffic lights. This simulation environment allows the integration of GIS data to map real intersections and traffic patterns. Through these simulations, various scenarios are tested to evaluate the effectiveness of dynamic adjustments in traffic signal phases.

Microcontroller Integration: For hardware implementation, Siemens microcontrollers (LOGO! 230 RCE and S7-1200) serve as the basis for creating programmable traffic light controllers. These devices are chosen for their reliability and scalability, providing a robust platform