REPUBLIC OF TURKEY
ADANA ALPARSLAN TÜRKEŞ SCIENCE AND TECHNOLOGY UNIVERSITY

FACULTY OF COMPUTER AND INFORMATICS
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I2-C2 ROBOT HARDWARE COMPONENTS AND CONTROL PANEL

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ABSTRACT

I2-C2 ROBOT Hardware

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In this study, the movement of motors powered by lithium-ion batteries was controlled using relays. The project aimed to integrate motion components into a robotic system while ensuring structural stability and minimizing potential environmental damage in case of failure. The design utilizes a total of five relays and wheels, enabling omnidirectional movement. A Battery Management System (BMS) was implemented to prevent damage to the batteries during charging. Additionally, a polymer enclosure was used to enhance safety by protecting the relays and battery units. The robot's movement is controlled via the **ICBYTES C++** library.

Keywords:Lithium-ion,Robot moves, Relays, polymer,Protection of Battery,polymer, BMS,ICBYTES

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First of all, I would like to express my gratitude to my future wife "*SARE AYDIN*" for all the support she has given me. And I want to thank my mother (Hüsne Özden) with my endless gratitude. Because he helped me understand relays, Prof.Dr.Lütfü Sarıbulut I would like to thank my teacher and Dr. İbrahim Cem Baykal, who gave me experience in team management. Finally, I would like to thank my father (Mustafa Özden) for his support.

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1. INTRODUCTION

With the rapid advancement of robotics technology, autonomous systems have become essential in various fields such as logistics, security, and industrial automation. The ability of robots to process and track images on land introduces new opportunities for improving efficiency and safety in daily operations.

This project aims to develop a cost-effective autonomous robot while ensuring stability and safety. The system is powered by lithium-ion batteries, and the wheels and motors are repurposed from an RC car. To enhance safety, the batteries are enclosed in metal casings to minimize potential damage in the event of an explosion. Additionally, fixing the electronic components between two polymer sheets provides structural stability and serves as the base for the onboard computing unit, which controls the robot's movement.

The system is powered by lithium-ion batteries, divided into two groups:

- The first group consists of three 3.7V batteries connected in series to power the relay mechanism. Since the relay system requires a minimum of 8V to function, a three-battery configuration was necessary.
- The second group consists of two sets of three batteries connected in series, with these two series circuits arranged in parallel. This configuration ensures sufficient power for motor operation.

2. Relay Circuit and Battery System

Although the system receives power from the batteries, controlling this power effectively is crucial. Relays enable power regulation and directional control of the motors.

A relay consists of five terminals. Terminals 1, 2, and 3 serve as switching contacts, while terminals 4 and 5 form the control circuit. When current flows through terminals 4 and 5, an internal electromagnetic field activates, changing the switching state:

- When the relay is **inactive**, terminal 2 is connected to terminal 3.
- When the relay is **active**, terminal 2 is connected to terminal 1 due to the magnetic current.

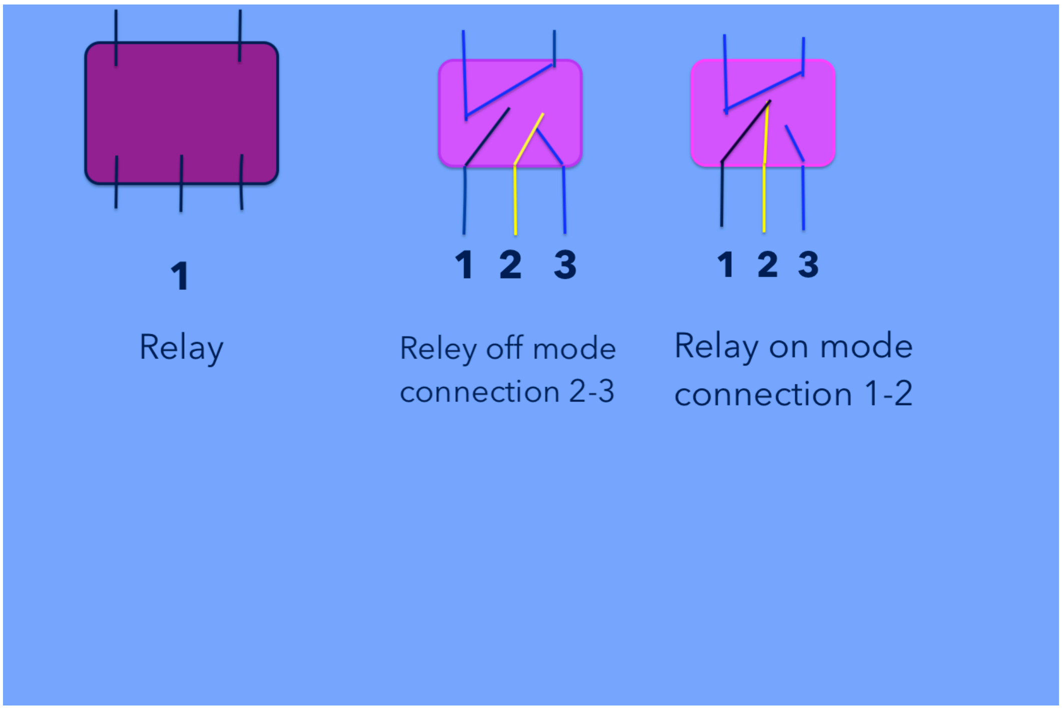

Figure 1: Relay

In the picture above, you can first see Relay (with 5 legs). Then it is shown how to tie the feet when closed and opened respectively.

2.1. Relay Circuit and Motor Control

To reverse motor direction, the polarity of the power supply must be switched. Instead of physically rotating the battery, this can be achieved using one or two relays.

- In the default state, the negative terminal (green wire) is connected to the left relay's terminal 1, and the positive terminal is connected to the right relay's terminal 1. Since terminals 1 and 2 are connected in the open state, the motor rotates in a designated direction.
- When the relays are activated, the polarity reverses, causing the motor to rotate in the opposite direction.

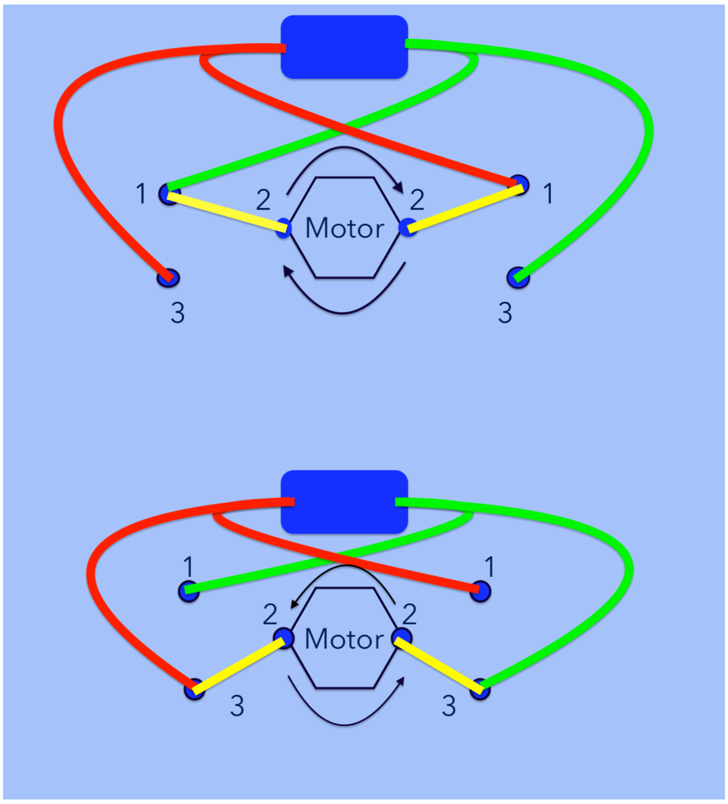

Figure 2: Reley On and Reley off Changing the pole

2.2. Reley Circuit Configuration

Two relays are needed to control the forward and backward motion of a motor. Since our vehicle has four motors, a total of **eight relays** would be required. However, similar to tank mechanisms, we synchronize the left and right motors, effectively reducing the relay count to **four**.

Additionally, a **fifth relay** is used to control the power supply to the system.

- **Relay 8:** Controls system power on/off.
- **Relays 7 and 5:** Drive the left and right motors forward.
- **Relays 6 and 4:** Reverse the motor direction.

To optimize power efficiency:

- **Two batteries** are sufficient for motor operation.
- **Three batteries** are required to power the relay system.

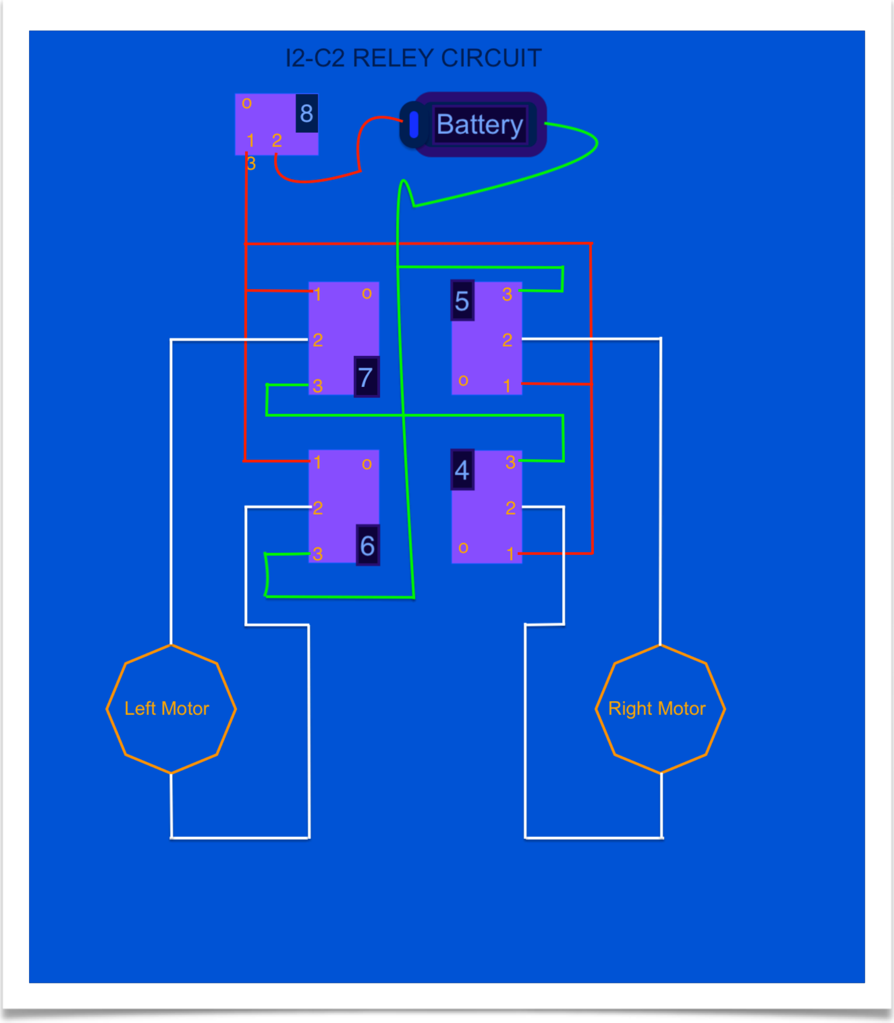

Figure 3: Reley Circuit

Move Table

Reley number	8	7	6	5	4	Result
	0	0	0	0	0	STOP
	1	1	0	0	0	Left forward
	1	0	1	0	0	Left Back
	1	0	0	1	0	Right forward
	1	0	0	0	1	Right Back
	1	1	0	1	0	FullForward
	1	0	1	0	1	FullBack
	1	1	0	0	1	Turn Left
	1	0	1	1	0	Turn Right

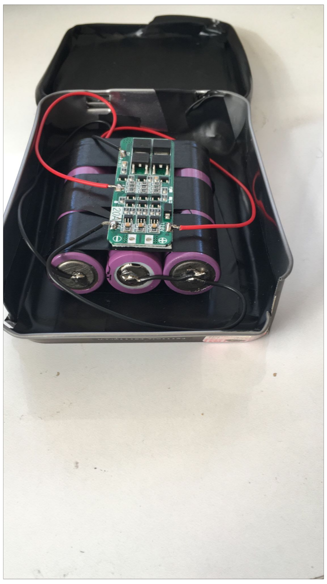

Figure 4: Relay Battery

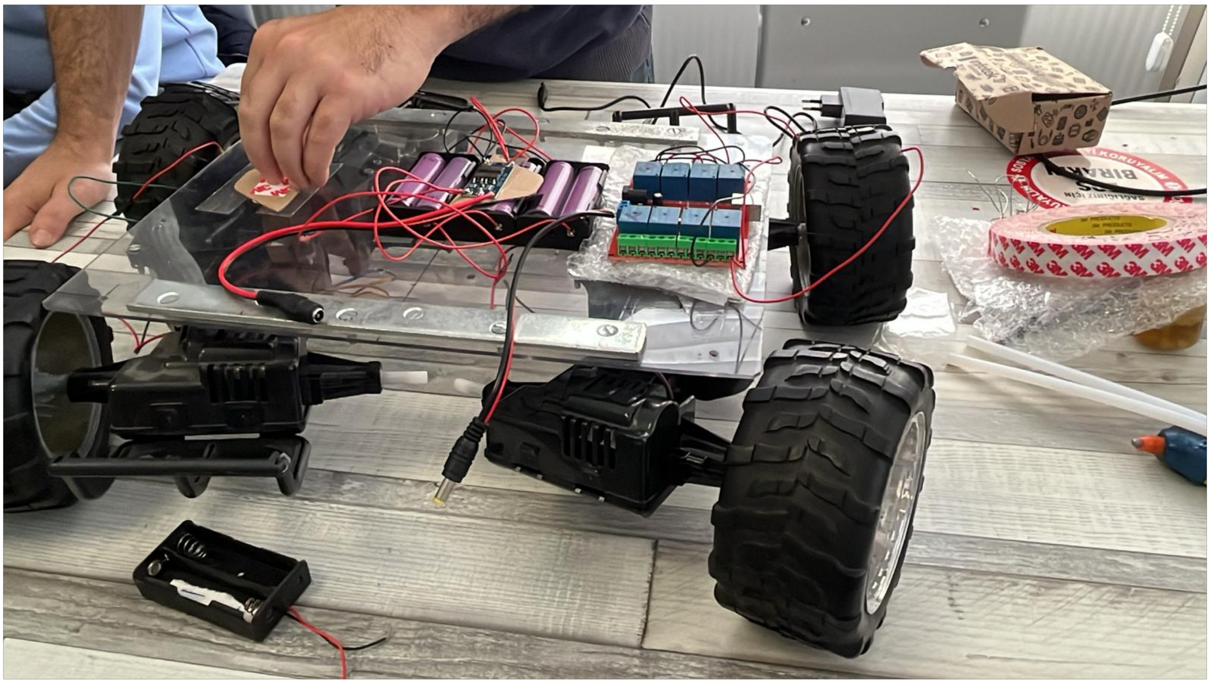

Figure 5 : I2-C2 Robot entegration.

2.3. ROBOT CONTROL PANEL

A user interface (UI) was developed to control the relays and monitor motor operations. The initial software framework was provided by my advisor, and several enhancements were implemented to improve functionality:

- Real-time visualization of motor activity and directional movement.
- Adjustable motor operation time using a progress bar.
- Directional control buttons for omnidirectional movement.
- Camera integration for image capture and processing.

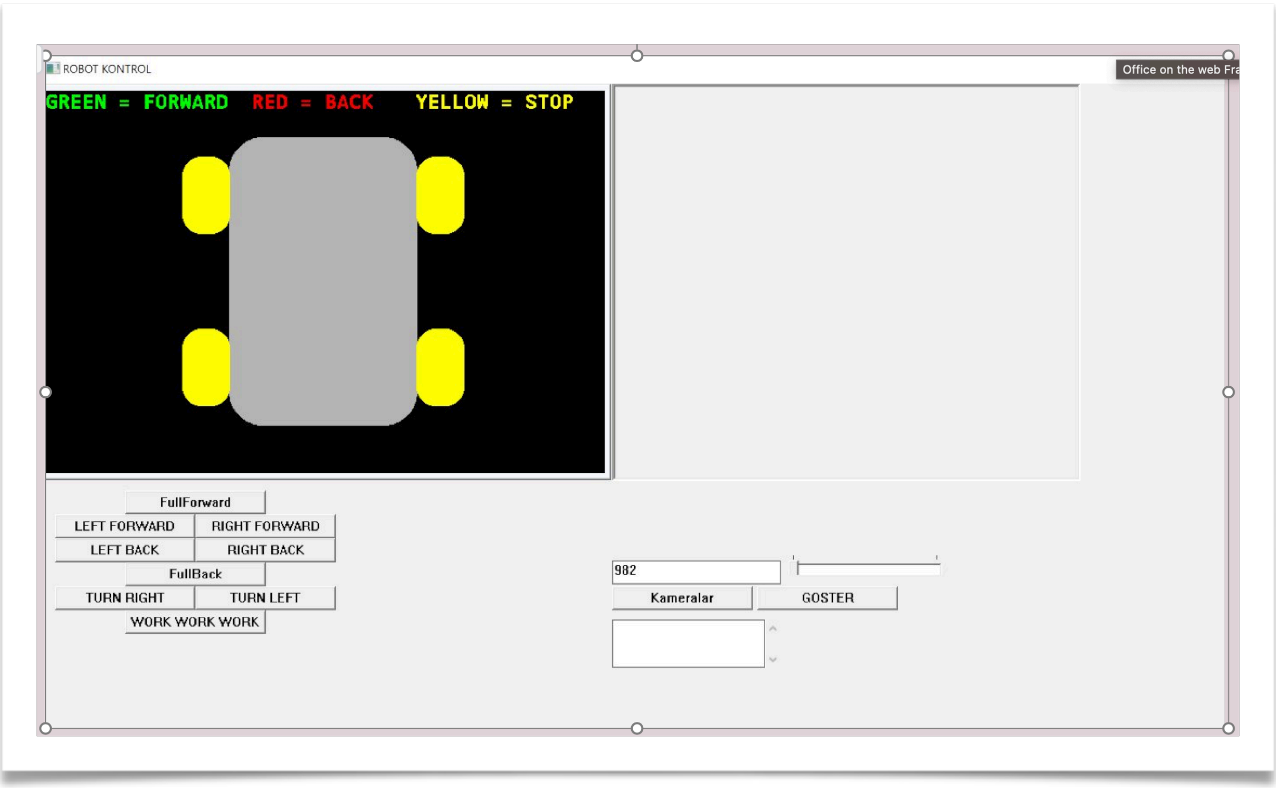

Figure 6: Robot Control Panel

3. RESULTS AND DISCUSSIONS

The successful integration of batteries and relay circuits into the robotic system demonstrates the feasibility of the proposed design. The **Battery Management System (BMS)** prevents potential overcharging hazards, ensuring battery longevity. Additionally, the use of repurposed materials, such as **cigar boxes** as battery compartments, introduced an innovative approach to sustainability.

However, lithium-ion batteries require careful handling, as improper charging may lead to hazardous failures. During testing, one battery malfunctioned due to excessive voltage input, highlighting the importance of safety precautions.

The structural stability of the circuit components was another key observation. Wires and connectors within the system are highly sensitive to external forces, requiring robust reinforcement to prevent disconnection or failure during operation.

4. CONCLUSIONS

This study successfully implemented a low-cost autonomous robot control system utilizing relays and lithium-ion batteries. The system effectively manages power distribution while maintaining a high level of operational safety through protective enclosures and a Battery Management System. The developed user interface provides an intuitive platform for controlling robot movement and monitoring system parameters in real time.

Future research can focus on:

- Optimizing power consumption for extended operational efficiency.
- Enhancing circuit durability to improve long-term reliability.
- Exploring microcontroller-based control alternatives to replace relay-based switching.

This project contributes to the development of affordable and practical robotic solutions, emphasizing safety, sustainability, and adaptability in autonomous systems.

5. REFERENCESS

1.ICBYTES C++ Library İbrahim Cem Baykal

2.Reley Prof.Dr.Lütfü Sarıbulut