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An Iot Based Electric Trolley System with Integrated on-off and Directional Drive Control

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Abstract - Material handling in industries, warehouses, hospitals, and shopping complexes requires efficient and user-friendly transportation systems. Conventional trolleys require manual effort and lack intelligent control features. T AN IoT BASED o overcome these limitations, an IoT-Based Electric Trolley System with Integrated ON–OFF and Directional Drive Control has been developed. The proposed system uses a Raspberry Pi Pico as the main control unit, integrated with an HC-05 Bluetooth Module for wireless communication. The trolley can be controlled remotely via a smartphone using Bluetooth connectivity. A two-channel relay module and single-channel relay module are used to control motor switching and direction. The motor driver circuit enables forward and reverse motion control of the trolley. The system provides efficient ON/OFF switching, directional control, reduced manual effort, and improved operational convenience. It is cost-effective, energy-efficient, and suitable for small-scale industrial and domestic applications.

Keywords - IoT, Electric Trolley, Raspberry Pi Pico, Bluetooth Control, Relay Module, Motor Driver.

Introduction

Electric trolley systems are widely used in industries for transporting goods. However, traditional systems require manual pushing or complex wired control mechanisms. With the advancement of IoT and embedded systems, wireless and smart control methods have become more reliable and affordable. With the rapid advancement of embedded systems and wireless communication technologies, smart transportation solutions have become more accessible and affordable. The integration of microcontrollers with wireless modules enables real-time control and monitoring of devices without complex wiring systems. IoT-based automation reduces human intervention, improves safety, enhances efficiency, and minimizes operational costs.

II. Literature Survey

Lei et al. (2024) proposed a project-based analog circuit experiment for lane detection and tracking in electric trolley systems. Their work focused on integrating analog electronics with real-time trolley navigation to enhance practical learning in engineering education. The study demonstrated improved tracking accuracy and provided a hands-on approach to understanding control systems in electric transportation applications.

Ogawa et al. (2017) developed a dual-mode operation system for electric vehicles using an active trolley pole integrated with an ultrasonic sensor. The system enabled automatic switching between overhead trolley power and onboard battery supply, improving operational flexibility and energy efficiency in electric vehicle systems.

Yu-Rong et al. (2018) investigated an auxiliary transportation system of double-electric trolleys in mining applications. The research focused on improving underground transportation efficiency, enhancing operational safety, and optimizing electric power usage in mine haulage systems.

Lindgren et al. (2022) conducted drive-cycle simulations of battery-electric large haul trucks operating with electric roads in open-pit mining. Their study evaluated energy consumption, battery performance, and environmental benefits, demonstrating significant potential for emission reduction through electrification.

Leonida et al. (2020) analysed the transition toward battery-electric vehicles in the mining industry. The study discussed technological advancements, sustainability benefits, and economic challenges associated with replacing conventional diesel-powered mining trucks with electric alternatives.

Knibbe et al. (2022) examined the application and limitations of battery and hydrogen technologies in heavy haul rail systems. Using Australian case studies, the authors highlighted infrastructure requirements, energy storage limitations, and operational trade-offs in adopting alternative energy solutions.

Linares-Flores et al. (2010) proposed load torque estimation and passivity-based control of a boost converter and DC motor combination. Their research demonstrated improved system stability, enhanced dynamic response, and efficient motor performance through advanced control techniques.

Bao et al. (2023) analysed electrification alternatives for open-pit mine haulage, comparing trolley assist systems, battery-electric trucks, and hybrid configurations. The findings emphasized cost-effectiveness, reduced emissions, and improved operational efficiency through electrified transport solutions.

Jain et al. (2023) presented closed-loop control methods for brushless DC motors used in lightweight electric vehicles. Their comparative analysis of different controllers showed improved speed regulation, stability, and overall motor efficiency.

Saxena et al. (2020) reviewed Manhattan's underground electric trolley system, explaining its historical development, engineering design, and power supply mechanisms. The study provided insight into early electric transportation innovations and their technical foundations.

Moore et al. (2022) discussed surface mining trucks and recent advancements in electric drive technologies. The study highlighted modernization trends in heavy-duty transportation systems and the increasing adoption of electric propulsion in mining operations. Smith et al. (2023) discussed electric railway catenary trolley construction, highlighting the structural design, power transmission mechanisms, and safety considerations of overhead electric traction systems. This work provided fundamental knowledge of trolley-based power delivery infrastructure.

Description of Existing System

Material handling systems currently used in industries and commercial environments are mainly based on manual or semi-automated mechanisms. The most common type is the manual push trolley, which requires continuous human effort for movement and

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directional control. Although simple and low-cost, these systems increase physical strain, reduce worker productivity, and are inefficient for long-distance or heavy-load transportation. In some industrial applications, electrically driven trolleys are used; however, they often rely on wired control systems or mechanical switches directly mounted on the trolley. These systems lack wireless accessibility and require the operator to remain physically close to the trolley. Additionally, wired systems may cause operational inconvenience due to cable management issues and limited mobility.

Fig.1.Steel Platform Trolley

Description of Proposed System

The proposed system, AN IoT-Based Electric Trolley System with Integrated ON–OFF and Directional Drive Control, is designed to provide a simple, low-cost, and wireless solution for material handling applications. The system integrates embedded control, Bluetooth communication, and relay-based motor switching to enable efficient trolley movement with minimal human effort. The core controller of the system is the Raspberry Pi Pico, which processes input commands received wirelessly and controls the trolley's operational functions. Wireless communication is achieved using the HC-05 Bluetooth Module, which allows the user to operate the trolley through a smartphone application within a specific range.

Block Diagram:

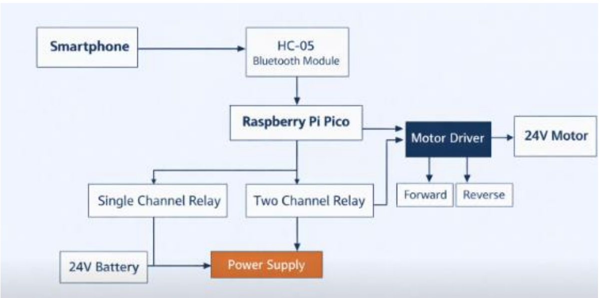

Fig.2. Block Diagram of the Proposed System

Flow Chart:

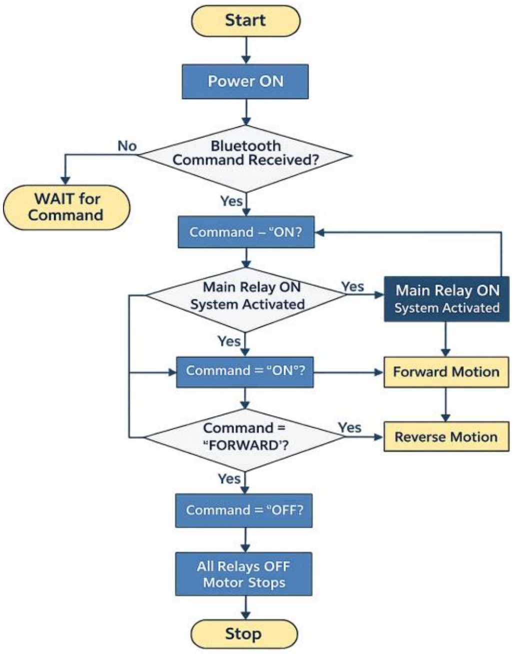

Fig.3. Flow Chart of the Proposed System

Hardware Implementation:

The hardware implementation of the proposed IoT-Based Electric Trolley System with Integrated ON–OFF and Directional Drive Control consists of a microcontroller unit, Bluetooth communication module, relay switching circuit, motor driver unit, 24V DC motor, and power supply section. The complete setup is designed to ensure reliable wireless control and efficient directional drive operation.

Hardware Components:

(i)Raspberry Pi Pico: The Raspberry Pi Pico acts as the main controller. It processes Bluetooth signals and controls relays for motor operation.

Fig.4.Raspberry Pi Pico

(ii)EHC-05Bluetooth Module: The HC-05 Bluetooth Module enables wireless communication between the trolley and the smartphone.

Fig.5.EHC-05Bluetooth Module

(iii)Motor Controller: The motor controller acts as an interface between the Raspberry Pi Pico and the 24V DC motor, allowing low-power control signals to drive a high-power load safely. It controls the motor's ON/OFF operation and enables forward and reverse rotation by switching polarity.

Fig.6. Motor Controller

(iv)Relay module: A relay is an electrically operated switch used to control high-power devices using low-power signals from the Raspberry Pi Pico. In this project, the single-channel relay is used for main ON/OFF control, while the two-channel relay controls forward and reverse motor direction

Fig.7. Relay module

(v) 24v dc motor: The 24V DC motor is used to drive the trolley and provide sufficient torque for carrying loads.

Fig.8. 24v dc motor

Table 1: Specifications

Name of the Components	Specifications
Microcontroller	Raspberry Pi Pico (3.3V)
Bluetooth Module	HC-05 (2.4GHz)
Motor	24V DC Motor
Relay Module	5V Two-Channel & Single-Channel
Motor Controller	BLDC motor drive

Control Logic:
If Bluetooth command = "ON"
→ Main Relay ON
→ System Activated
If command = "FORWARD"
→ Relay 1 ON
→ Motor rotates forward
If command = "REVERSE"
→ Relay 2 ON
→ Motor rotates reverse

If command = "OFF"
→ All relays OFF
→ Motor stops

Results and Discussion

The proposed IoT-Based Electric Trolley System was successfully designed and tested under practical conditions. The HC-05 Bluetooth Module provided stable wireless communication within a range of approximately 10 meters. The Raspberry Pi Pico accurately processed user commands and controlled the relay modules without delay. The single-channel relay effectively managed the main ON/OFF operation, while the two-channel relay ensured smooth forward and reverse movement of the 24V DC motor. The motor controller handled the high-current requirement efficiently and protected the control circuit from electrical disturbances. The trolley operated smoothly under moderate load conditions with stable torque output. Overall, the system demonstrated reliable performance, low power consumption, and suitability for small-scale material handling applications.

Description of the Making Model

The making model consists of a wheeled metal chassis driven by a 24V DC motor for smooth movement. The control unit, including the Raspberry Pi Pico, relay modules, motor controller, and HC-05 Bluetooth Module, is mounted securely on the trolley. The system is powered by a 24V battery and tested for proper wireless and directional operation.

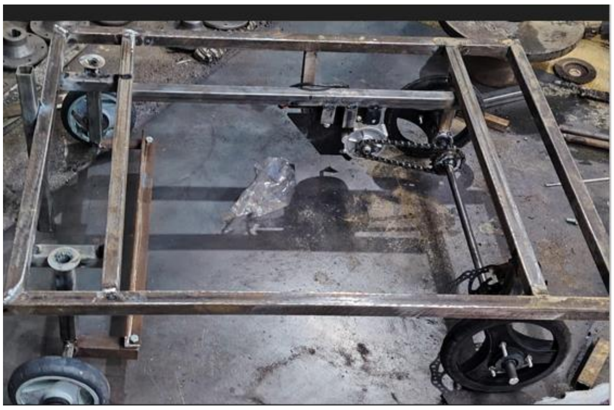

Fig.8.Making Model

Implementation of the Proposed System

The proposed system was implemented by integrating the Raspberry Pi Pico with the HC-05 Bluetooth Module for wireless command reception. The relay modules were connected to control the main power supply and the directional movement of the 24V DC motor through the motor controller. Proper voltage regulation and circuit isolation were ensured to protect low-power components. The system was tested by sending ON, OFF, FORWARD, and REVERSE commands via smartphone. The trolley responded accurately, demonstrating stable and efficient operation.

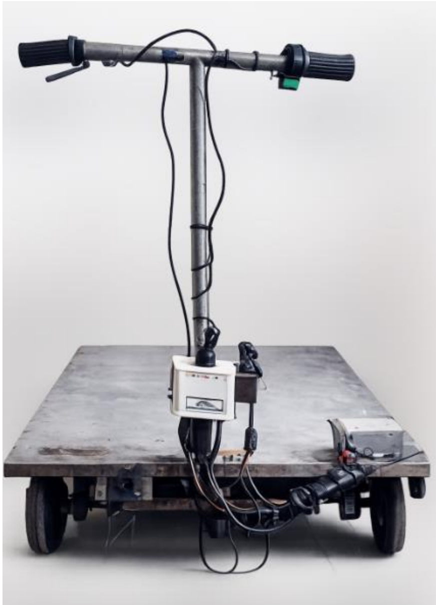

Fig.9.Implementation of the Proposed System

III. Conclusion

The IoT-Based Electric Trolley System was successfully developed using the Raspberry Pi Pico and HC-05 Bluetooth Module for wireless control. The system provides efficient ON/OFF operation and smooth forward and reverse directional movement of the 24V DC motor. It reduces manual effort and ensures safe, reliable performance. Overall, the project offers a low-cost and practical solution for smart material handling applications.

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