In-House Product Transportation using IOT

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Abstract
This project introduces an innovative Electric Vehicle (EV) system designed to automate the internal transportation of industrial products, making operations more efficient, safer, and less physically demanding for workers. By replacing traditional fuel-powered vehicles with electric ones, the system helps reduce carbon emissions and significantly lowers operational costs. It integrates seamlessly with existing infrastructure and operates 24/7 with minimal downtime, ensuring continuous productivity. With its low-maintenance design, the system offers long-term reliability and scalability, making it a cost effective investment for businesses. Additionally, the system's ability to reduce reliance on fossil fuels aligns with sustainability goals, contributing to a greener, more eco-friendly industrial environment. Ultimately, this EV system presents a smarter, more sustainable approach to internal transportation, benefiting both businesses and the planet.
Keywords: Electric Vehicle, Hydraulic Unloading System, Load Carrying, Battery Management System, Lithium-ion Battery, Power Efficiency, Cargo Unloading, BLDC Motor

OPEN ACCESS

Volume: 1

Issue: 1

July 2025 to December 2025

E-ISSN: Applied

Introduction

Electric vehicles (EVs) have emerged as a key solution to reducing carbon emissions and addressing environmental concerns associated with conventional internal combustion engine (ICE) vehicles. The adoption of EVs is accelerating due to significant advancements in battery technology, charging infrastructure, and vehicle energy management systems. The transition to electric mobility is not only shaping the consumer automotive market but also revolutionizing industrial applications such as material handling, logistics, and warehouse automation. However, despite these technological advancements, challenges such as battery efficiency, energy management, and charging infrastructure persist, requiring further research and development. A critical aspect of EV development is battery performance optimization, which directly impacts range, efficiency, and reliability. Various studies have explored energy management strategies for battery-powered and fuel-cell hybrid EVs to enhance energy distribution and vehicle longevity. Researchers have also investigated adaptive energy management strategies for extended-range EVs, allowing for improved power regulation and efficiency during operation.

In addition, advancements in solid-state battery technology are expected to enhance energy storage capacity and safety, further improving EV performance. Another crucial factor in the widespread adoption of EVs is charging infrastructure and grid integration. Studies on electric two wheeler charging technologies and fast-charging solutions have demonstrated the importance of optimizing power delivery systems for increased accessibility and efficiency. The integration of EVs into smart grids, particularly through vehicle-to-grid (V2G) technology, allows bidirectional energy flow, enabling EVs to support grid stability during peak demand periods.

Wireless charging infrastructure has also been explored as a viable solution for enhancing convenience and reducing downtime in industrial EV applications. The incorporation of autonomous navigation and artificial intelligence in EVs has further expanded their capabilities in industrial applications. Research on AI-driven predictive maintenance has demonstrated how real-time monitoring can reduce downtime and maintenance costs in electric fleets. The development of autonomous driving technologies for industrial EVs has enhanced navigation efficiency, particularly in controlled environments such as warehouses and factories. Additionally, regenerative braking systems have been integrated into EVs to recover kinetic energy and improve overall efficiency. Lightweight materials play a crucial role in increasing the efficiency of EVs, as reducing vehicle weight directly improves energy consumption and extends driving range. Researchers have explored the use of advanced composite materials and high strength alloys to optimize vehicle design without compromising structural integrity.

Moreover, studies on next-generation motor efficiency developments have focused on improving torque control and energy conversion rates, further enhancing EV performance. This paper presents the design and implementation of an industrial EV system that integrates an optimized power distribution network, real-time obstacle detection, and an advanced Battery Management System (BMS) to maximize energy efficiency. The proposed system aims to address existing challenges in material relocation within controlled industrial environments while incorporating sustainable energy solutions. The subsequent sections discuss the methodology, system components, working process, challenges, advantages, and limitations of the proposed system.

Literature Review

According to Pattnaik et al. (2021), the efficiency and lifespan of an EV battery system are influenced by charge cycles, thermal stability, and degradation, making battery optimization a key factor in improving EV performance.

Kumar et al. (2021) examined the retrofitting of conventional two-wheelers into electric alternatives, highlighting cost-effective electrification strategies that can accelerate EV adoption.

Diwanji et al. (2019) explored the development of autonomous fire-detecting and extinguishing robots, demonstrating how automation and sensor-based navigation enhance safety in industrial applications.

Ahmed et al. (2021) investigated suspension system modeling for EVs with in-wheel motors, focusing on improved ride comfort and handling.

According to Departure et al. (2017) and Amaya et al. (2017), efficient energy management strategies in fuel-cell/battery hybrid vehicles play a crucial role in maximizing energy distribution and vehicle longevity.

Lee et al. (2018) introduced an adaptive energy management strategy for extended-range EVs, which optimizes power allocation based on driving conditions.

Methodology and System Components

The electric vehicle is designed to carry up to 100 kg of cargo while ensuring stability, efficiency, and ease of operation. Its frame is built using lightweight yet robust materials to enhance durability without compromising maneuverability. A high-efficiency Brushless DC (BLDC) motor is employed to provide the necessary torque and speed, ensuring smooth operation across various industrial terrains. The vehicle's navigation and control are managed by a PIC Microcontroller, which processes sensor data and optimizes movement to prevent collisions. A 72V 60Ah Lithium-Ion battery supplies energy to the motor and sensors, with a motor controller regulating speed and acceleration for seamless operation. The Battery Management System (BMS) enhances energy efficiency by effectively distributing power, extending battery life, and preventing over-discharge.

The power distribution board ensures stable energy allocation, with voltage regulators and fuses included for added safety. Ultrasonic sensors enable real-time obstacle detection and avoidance, enhancing the vehicle's autonomy. The microcontroller continuously processes input from sensors to adjust motor speed and direction, ensuring smooth and reliable performance. The integration of these components into a single, cohesive system allows for efficient operation, and rigorous testing is conducted to validate performance under different industrial conditions. The design focuses on low maintenance requirements and high durability, making it a long-term solution for material transportation in industries.

Working Process

The electric vehicle operates autonomously or under manual control, depending on industrial requirements. Upon activation, the PIC Microcontroller receives input from sensors and the user interface to determine movement commands. The vehicle's BLDC motor is powered by the 72V battery, which is continuously monitored and regulated by the BMS to optimize power consumption. When in motion, the ultrasonic sensors scan the surroundings for obstacles, and if a potential collision is detected, the microcontroller processes the data and instructs the motor controller to adjust speed or stop the vehicle. The power distribution board ensures stable energy supply across all components, prioritizing efficient energy use. When the battery charge depletes, the system signals for recharging, and the fast-charging capabilities reduce downtime. The vehicle's navigation system, integrated with real-time feedback mechanisms, allows smooth transportation of materials without human intervention, enhancing industrial automation.

Figure 1 Working Process Flowchart

The ability to operate under varying terrains and load conditions ensures adaptability, making it a highly reliable asset for logistics within industrial environments. Additionally, the vehicle's control system allows for manual override if needed, providing flexibility in different operational scenarios.

Block Diagram

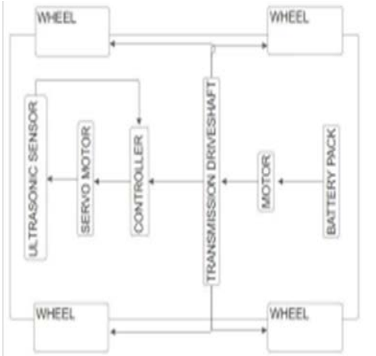

Figure 2 Electric Vehicle

The block diagram of the proposed automated Electric Vehicle (EV) system provides a structured representation of the primary components and their interactions. The system is powered by a 72V 60Ah lithium-ion battery, which supplies energy to the brushless DC (BLDC) motor and other functional units. A motor controller regulates the power delivery to ensure efficient speed and torque control for industrial transportation.

A microcontroller, such as a PIC or ARM-based unit, acts as the central processing unit, managing motor operations, user inputs, and safety features. The sensor module, which includes ultrasonic sensors, enables real-time obstacle detection and avoidance, ensuring safe navigation in an industrial environment. A battery management system (BMS) ensures optimal power distribution, monitoring battery health, and preventing overcharging or deep discharge. The block diagram illustrates the logical flow of signals and power, highlighting how different modules work in coordination to achieve an automated and reliable transportation system.

Diagram

Forklifts are super helpful in warehouses and factories, but they do come with a few downsides. Traditional ones that run on fuel can create a lot of pollution, especially in indoor spaces, and they're pretty noisy. On top of that, they need a lot of maintenance, which can add up, and the cost of fuel can be unpredictable.

Figure 3 Forklift

Circuit Diagram

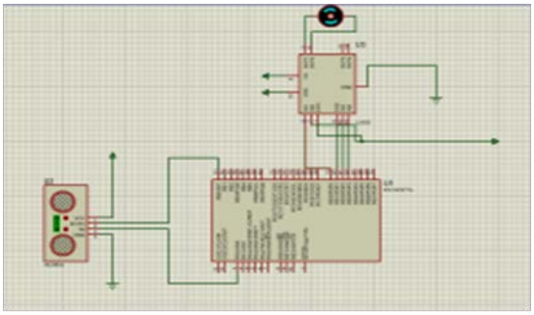

Figure 4 Automatic Braking System

The circuit diagram represents the interconnection of key components, including the BLDC motor, battery, microcontroller, motor controller, ultrasonic sensors, and power distribution system. The PIC Microcontroller acts as the main control unit, processing sensor data and managing motor functions. The BLDC motor is powered by a 72V 60Ah battery, with the motor controller ensuring optimal speed and torque. The BMS regulates battery usage, preventing overcharging and excessive discharge. Ultrasonic sensors continuously scan for obstacles, sending real-time data to the microcontroller for navigation adjustments. The power distribution board efficiently allocates energy to all components, incorporating safety measures like voltage regulators and fuses to prevent electrical faults. Together, these components enable the smooth and efficient operation of the electric vehicle, making it an ideal solution for industrial applications.

Code

```
#include <htc.h>
#define _XTAL_FREQ 8000000 // 8MHz Crystal
Frequency

// Corrected Configuration Bits for HI-TECH C
#pragma config FOSC = HS // High-Speed Oscillator
#pragma config WDTE = OFF // Watchdog Timer
Disable #pragma config PWRTE = ON // Power-
up Timer Enable #pragma config BOREN = ON //
Brown-out Reset Enable #pragma config LVP = OFF
// Low Voltage Programming Disable
#pragma config CPD = OFF // Data EEPROM Memory
Code Protection Disable
#pragma config WRT = OFF // Flash Program Memory
Write Enable Disable
#pragma config CP = OFF // Flash Program Memory
Code Protection Disable
// Pin Definitions
#define TRIG RA0
#define ECHO RB0
#define M1A RD0 // Motor 1 Forward
#define M1B RD1 // Motor 1 Backward
#define M2A RD2 // Motor 2 Forward
#define M2B RD3 // Motor 2 Backward

// Function Prototypes
unsigned int measure_distance();
void stop_motors();
void run_motors();

unsigned int measure_distance() {
unsigned int time, distance;

// Trigger Pulse
TRIG = 1;
__delay_us(10);
TRIG = 0;

// Wait for Echo HIGH
while (!ECHO);
// Clear Timer1
TMR1H = 0;
TMR1L = 0;

// Enable Timer1
T1CON = 0x01;
// Wait for Echo LOW
while (ECHO);

// Read Timer1 Value
time = (TMR1H << 8) | TMR1L;

// Convert to Distance (cm)
distance = time / 58;
```

```
return distance;
}
void stop_motors() {
M1A = 0; M1B = 0; // Stop Motor 1
M2A = 0; M2B = 0; // Stop Motor 2
}
void run_motors() {
M1A = 1; M1B = 0; // Motor 1 Forward
M2A = 1; M2B = 0; // Motor 2 Forward
}
void main() {
// Set Pin Directions
TRISA0 = 0; // TRIG as Output
TRISB0 = 1; // ECHO as Input
TRISD = 0x00; // Motors as Outputs
// Timer1 Configuration
T1CON = 0x01; // Enable Timer1
while (1) {
if (measure_distance() < 10) {
stop_motors();
} else {
run_motors();
}
// Fix: Use smaller delays to prevent exceeding cycle limit
for (int i = 0; i < 10; i++) __delay_ms(10); // 100ms delay in chunks
}
}
```

Challenges

Developing an efficient electric vehicle for industrial transportation presents several challenges. One of the primary concerns is maintaining effective power management to ensure the vehicle operates for extended periods without frequent recharging. Implementing smart power distribution techniques and an advanced BMS is essential to optimizing battery performance and lifespan. Additionally, the complexity of the control system requires a user-friendly interface to ensure seamless operation by industry personnel. The vehicle's load capacity and additional weight from the battery and control components may affect stability, necessitating careful design considerations and extensive testing to enhance balance and safety.

Another critical challenge is the risk of battery depletion over prolonged use, which highlights the importance of an optimized charging system that maximizes energy efficiency. Environmental factors such as dust, moisture, and extreme temperatures can also impact the durability of electronic components, making it necessary to incorporate protective enclosures and weather-resistant materials

Advantages and Disadvantages

Advantages

The electric vehicle offers numerous advantages that make it a viable alternative to traditional fuel-powered transportation solutions. One of its most significant benefits is environmental sustainability, as it reduces carbon emissions and minimizes air pollution, contributing to a cleaner industrial environment. Cost-effectiveness is another major advantage, as the operational expenses associated with fuel consumption and maintenance are considerably lower than those of conventional vehicles. The EV's design incorporates fewer moving parts, reducing the likelihood of mechanical failures and lowering maintenance costs over time. Additionally, the quiet operation of electric motors makes the vehicle ideal for noise-sensitive environments such as warehouses, factories, and residential areas.

The inclusion of an intuitive user interface ensures that operators can control the vehicle efficiently with minimal training, enhancing productivity and ease of use. Moreover, the advanced BMS and energy-efficient power management system extend battery life, reducing downtime and increasing overall efficiency.

Disadvantages

Despite its numerous advantages, the electric vehicle has some limitations that must be considered. One of the primary drawbacks is its limited range, which may pose challenges for extended operations without frequent recharging. This constraint makes it less suitable for continuous heavy-duty applications unless supplemented by additional charging solutions. Another disadvantage is the charging time, as EVs require more time to recharge compared to the refueling process of conventional fuel-powered vehicles, potentially causing operational delays.

The vehicle's maximum load capacity is restricted to 100 kg, limiting its ability to transport heavier goods, which may require additional design modifications for higher payload applications. Over time, battery efficiency may degrade, reducing the operational lifespan and necessitating periodic replacements. Environmental conditions such as extreme temperatures or exposure to moisture can affect long-term performance and reliability, requiring additional protective measures. Lastly, while retrofitting an existing system with electric components is more cost-effective than purchasing a completely new EV, the initial investment for batteries, controllers, and sensors may still be a significant financial consideration for some industries.

Result

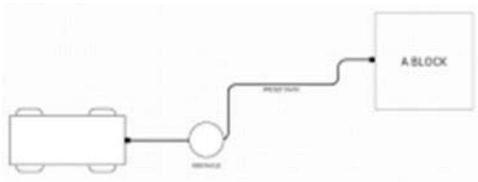

Figure 5 Simulation of the EV

The vehicle moves along a predefined route programmed in its control system, ensuring efficient transportation. Equipped with sensors, it can detect and avoid obstacles, making real-time adjustments to prevent collisions. The system enhances automation in industries by streamlining material transport, reducing manual effort, and improving operational efficiency.

Conclusion

The electric vehicle designed for industrial applications presents a practical and sustainable alternative to traditional fuel-powered transport systems. By leveraging advancements in battery technology, smart power management, and autonomous control, the vehicle significantly improves efficiency while reducing carbon emissions. The combination of real-time obstacle detection, intuitive control mechanisms, and a robust framework ensures seamless operation across different industrial environments. Although challenges such as limited range, charging time, and load capacity persist, continuous research and development can help overcome these limitations. Future enhancements, including improved battery efficiency, regenerative braking systems, and AI driven automation, will further optimize its functionality.

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