iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** XI **Month of publication:** November 2026

DOI: https://doi.org/10.22214/ijraset.2026.85404

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue XI Nov 2026- Available at www.ijraset.com

Design and Development of Automatic Roller Gadget Shoes for Smart Personal Mobility

Vaibhavi Shahade[1], Utkarsha[2], Vasundhara[3], Antariksh[4], Kaushik[5], Prof. N.P. Mendhe[6], Mr. Mangesh Singane[7]
Department of Electrical Engineering, St. Vincent Pallotti college of Engineering and Technology Nagpur, Maharashtra, India

Abstract: ***The IIoT-Based Automatic Roller Gadget for Industrial Workers and Visitors is designed to provide convenient, efficient, and controlled mobility within large industrial facilities. The proposed system integrates an Arduino ATmega328P controller, Bluetooth module, smartphone application, DC geared motors, motor driver, ultrasonic sensor, LCD display, buzzer, navigation control, voltage sensor, and rechargeable lithium battery. The smartphone application communicates with the controller through Bluetooth, enabling users to operate the roller gadget wirelessly. The Arduino processes the received commands and controls the motor driver to regulate wheel movement and direction. The ultrasonic sensor detects nearby obstacles and helps improve operational safety, while the buzzer provides audible warnings during potentially unsafe conditions. The voltage sensor monitors battery voltage, and the LCD displays essential operating information. The rechargeable battery supplies power to the electronic components and motorized mechanism, supporting portable operation. The proposed gadget aims to reduce physical effort and improve movement efficiency for workers and visitors travelling between different locations within industrial premises. Its compact design and integrated control system offer potential applications in factories, warehouses, workshops, and industrial campuses. Prototype development and testing can evaluate its mobility, obstacle detection, battery performance, and operational reliability under controlled conditions.***

Keywords: Automatic Roller Gadget, Industrial Mobility, Arduino ATmega328P, Bluetooth Control, Obstacle Detection etc.

I. INTRODUCTION

The rapid development of automation, embedded systems, and the Internet of Things (IoT) has created new opportunities for improving mobility and operational efficiency in industrial environments. Large factories, warehouses, manufacturing units, and industrial campuses often require workers and visitors to travel between different departments and workstations. Walking long distances repeatedly may increase physical fatigue and consume valuable working time. Therefore, developing compact, affordable, and user-friendly mobility devices is an important area of engineering innovation. The proposed IIoT-Based Automatic Roller Gadget for Industrial Workers and Visitors aims to provide motorized movement through an electronically controlled roller mechanism integrated with smartphone communication and safety monitoring.

Wearable robotic technologies and powered mobility devices demonstrate the potential of combining mechanical structures, electric motors, electronic controllers, and sensors to assist human movement [1], [2]. Research on occupational exoskeletons also highlights the importance of comfort, practical usability, task compatibility, and workplace acceptance when introducing assistive technologies into industrial environments [3]. Similarly, studies of electric micromobility systems emphasize convenience and accessibility while identifying safety, infrastructure, and operational limitations that must be considered during device development [4], [5]. These research directions provide a foundation for investigating compact motorized roller systems designed for controlled industrial movement.

The proposed gadget uses an Arduino ATmega328P microcontroller as its main processing unit. A Bluetooth module, such as the HC-05, establishes wireless communication between the controller and a smartphone application. The application allows the user to send movement commands, including starting, stopping, and changing direction. The Arduino processes these commands and generates control signals for a motor driver connected to DC geared motors. The motors rotate the roller wheels, enabling the device to produce powered movement. Navigation controls provide a simple interface for selecting the required movement direction and operating mode. Safety and monitoring are important aspects of the proposed system. An ultrasonic sensor, such as the HC-SR04, measures the distance to nearby obstacles and provides information that can be used to initiate warnings or controlled stopping. A buzzer generates audible alerts when obstacles or other predefined warning conditions are detected. A voltage sensor monitors the lithium battery voltage, while an LCD displays essential information such as battery condition and operating status. A rechargeable lithium battery supplies electrical power to the controller, sensors, motor driver, and associated components.

©IJRASET: All Rights are Reserved

Existing research also indicates that mobility devices must be evaluated for reliability, usability, and safety before practical implementation. Reviews of occupational assistive technologies identify the need for appropriate design, ergonomic assessment, and real-world testing [1], [2]. Research on electric micromobility further emphasizes that technical failures, accident risks, maintenance requirements, and operating environments influence the suitability of powered mobility solutions [4], [5]. Accordingly, the proposed roller gadget combines basic electronic control, obstacle sensing, battery monitoring, and user-operated movement within a single prototype.

The main objective of this project is to develop an economical and portable motorized roller gadget suitable for short-distance movement in controlled industrial environments. The proposed system integrates electrical, mechanical, and embedded technologies to provide convenient operation without requiring complex controls. Its performance can be assessed through motor response, Bluetooth communication range, obstacle-detection response, battery operating duration, and overall mechanical stability. The system is intended as a prototype for further development rather than a certified industrial transportation device. Future improvements may include more advanced navigation, improved braking, enhanced battery management, and additional safety mechanisms. Through these developments, the project aims to demonstrate the practical application of embedded control and wireless communication in compact industrial mobility systems.

II. PROBLEM IDENTIFICATION

1) Limited Mobility: Workers and visitors in large industrial areas often need to travel long distances between departments, warehouses, and workstations.
2) Time Consumption: Walking across extensive industrial facilities consumes time and may reduce overall operational efficiency.
3) Physical Fatigue: Continuous walking over long distances can cause tiredness and discomfort, particularly during extended working hours.
4) Lack of Smart Transportation: Conventional industrial workplaces may lack compact, affordable, and convenient personal mobility solutions.
5) Manual Movement: Depending entirely on walking or manually operated transport can make movement less convenient for short-distance travel.
6) Obstacle Detection: Moving through industrial environments requires awareness of nearby obstacles, equipment, and people to reduce collision risks.
7) Battery Monitoring: Battery-powered mobility devices require continuous voltage monitoring to prevent unexpected power loss during operation.
8) Safety and Control: A reliable system is needed to provide wireless control, obstacle alerts, and convenient stopping mechanisms for safer movement within industrial premises.

A. *Existing System*

1) Conventional Walking: Workers and visitors generally walk between departments, warehouses, and workstations in large industrial facilities. This method is simple but becomes inconvenient when distances are considerable, resulting in increased travel time and physical effort during daily industrial activities.
2) Manual Transportation: Hand-operated carts and trolleys are commonly used to transport materials and equipment. However, these systems require manual pushing or pulling, occupy additional space, and are unsuitable for providing convenient personal mobility to workers and visitors.
3) Conventional Electric Mobility: Electric scooters and similar vehicles provide motorized transportation but may be bulky for narrow industrial pathways and crowded workspaces. Their size and turning requirements can limit their suitability for short-distance movement within certain industrial environments.
4) Basic Remote-Controlled Devices: Some motorized devices use remote controls for movement. However, basic systems may lack integrated obstacle detection, battery monitoring, and clear status indications, reducing their suitability for environments where workers, machinery, and equipment share the same pathways.

B. *Drawbacks*

1) Time and Productivity Loss: Walking long distances repeatedly can consume valuable working time. Workers may need to travel between multiple locations during a shift, potentially reducing the time available for their primary tasks and affecting overall operational efficiency.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

2) Physical Fatigue: Continuous walking across extensive industrial premises can cause tiredness and discomfort, particularly during long working hours. This may reduce convenience for workers and visitors who frequently move between production areas, storage facilities, and administrative departments.
3) Limited Automation: Conventional mobility solutions may not provide automated movement control or convenient smartphone-based operation. Consequently, users may need to operate devices manually, making short-distance transportation less convenient and limiting the integration of smart mobility features.
4) Insufficient Safety Monitoring: Basic transportation devices may not include ultrasonic obstacle detection or audible warnings. Without these features, users may have difficulty identifying nearby obstacles promptly, increasing the possibility of collisions in busy industrial environments.

III. LITERATURE SURVEY

A. *Literature Reviews*

1) Jamil Ahmad et al. (2024), reviewed occupational exoskeleton adoption, evaluation, and technological readiness. Their findings highlighted the importance of assessing ergonomic benefits, usability, safety, and workplace integration before deploying assistive technologies. The study provides useful guidance for designing worker-oriented mobility solutions. For the proposed roller gadget, its findings support evaluating user comfort, operational reliability, and practical suitability in industrial environments.
2) André Cardoso et al. (2024), reviewed occupational exoskeletons for preventing work-related musculoskeletal disorders. Their findings examined ergonomic risk factors, workplace applications, and the importance of evaluating the interaction between workers and assistive devices. The study emphasizes that technology must suit the actual task and working environment. For the roller gadget, this supports considering user comfort, ease of operation, and safety during movement across large industrial facilities.
3) Daniel E. Fournier et al. (2023), reviewed the quality, productivity, and economic implications of occupational exoskeletons. Their review identified 15 relevant studies and found that worker quality and productivity had been evaluated, while economic impacts remained insufficiently investigated. The findings highlight the need to assess both performance and cost-effectiveness. For the proposed gadget, evaluation should include travel time, user convenience, operating cost, and productivity-related benefits.
4) Alexandra Bretones et al. (2023), examined factors influencing electric micromobility adoption. Their review found that electric mobility devices can offer flexible, convenient, and accessible transportation, but barriers include technical failures, accident risks, infrastructure limitations, and maintenance costs. These findings support developing a compact, battery-powered roller gadget with obstacle detection and battery monitoring. Its industrial performance would still require separate testing under actual operating conditions.
5) Loukas Mitropoulos et al. (2023), reviewed electric-scooter micromobility systems and their environmental, social, economic, transportation, and safety impacts. Their findings indicated that the effects of electric scooters depend on vehicle characteristics, infrastructure, and intended use. The researchers also highlighted the need for improved assessment methods. This study supports evaluating the proposed roller gadget according to movement efficiency, energy consumption, safety, and usability. However, scooter-related findings cannot be directly generalized to motorized roller devices.
6) Lucia Botti and Riccardo Melloni (2024), reviewed occupational exoskeletons, their effects on workers, and recommendations for workplace implementation. Their research discussed the importance of understanding worker needs and assessing the benefits and limitations of assistive technologies. The findings suggest that successful workplace adoption requires appropriate design, user acceptance, and practical evaluation. For the proposed roller gadget, these considerations support testing its ease of control, comfort, emergency stopping, and suitability for industrial pathways before wider implementation.
7) J. Tian et al. (2024), reviewed occupational shoulder exoskeletons for industrial use, focusing on mechanisms, actuators, control, and evaluation. Their review emphasized the importance of selecting suitable actuation systems and evaluating device performance for industrial tasks. Although shoulder exoskeletons differ from motorized roller gadgets, the study provides relevant design considerations for actuator selection, control reliability, and performance testing.
8) Attila Aba and Domokos Esztergár-Kiss (2024), investigated electric micromobility from a policymaking perspective using European case studies. Their research examined planning, regulatory arrangements, and practical implementation of emerging mobility services. The findings indicated that successful adoption depends on the characteristics of the environment and the coordination of implementation measures. For the proposed industrial roller gadget, this highlights the need to establish workplace operating rules, designated travel routes, and safety procedures alongside the technical development.

B. Research Gap

1) Existing studies primarily focus on occupational exoskeletons and conventional electric micromobility rather than motorized roller gadgets for industrial workers and visitors.

2) Limited attention has been given to integrating Arduino-based control, Bluetooth connectivity, ultrasonic obstacle detection, and battery voltage monitoring into a compact mobility system.

3) The combined performance of these features in crowded industrial environments requires further investigation.

4) Therefore, experimental evaluation is needed to assess mobility efficiency, obstacle detection, battery performance, user convenience, and operational safety of the proposed IIoT-based roller gadget.

IV. PROPOSED SYSTEM

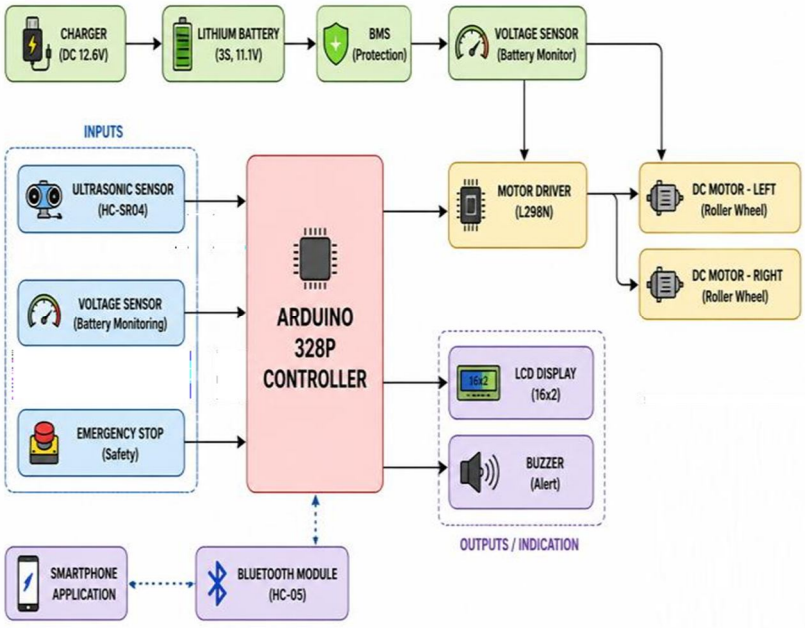


Figure 1. Block Diagram of system

1) Power Supply: The system uses a lithium battery to supply electrical power to the Arduino 328P controller, motor driver, sensors, and other electronic components. A battery charger is provided to recharge the battery when its energy level becomes low.

2) Battery Protection: The Battery Management System (BMS) protects the lithium battery by monitoring its operating conditions and supporting safe charging and discharging. It helps improve battery reliability during system operation.

3) Voltage Monitoring: The voltage sensor continuously measures the battery voltage. The measured information is provided to the controller for battery-status monitoring and to help identify low-voltage conditions.

4) Obstacle Detection: The HC-SR04 ultrasonic sensor detects nearby obstacles by transmitting ultrasonic waves and receiving their echoes. The controller can use the measured distance to identify obstacles and initiate suitable safety actions.

5) Controller Operation: The Arduino 328P acts as the central processing unit. It receives inputs from the ultrasonic sensor, voltage sensor, emergency stop, and Bluetooth module, then processes them according to the programmed control logic.

6) Wireless Communication: The HC-05 Bluetooth module connects the system with a smartphone application. Users can send movement commands wirelessly, allowing convenient control of the roller gadget.

7) Motor Control: The motor driver receives control signals from the Arduino and regulates power supplied to the left and right DC motors. These motors drive the roller wheels to provide movement.

8) Display and Alerts: The LCD displays relevant system information, while the buzzer provides audible alerts. The emergency stop allows the user to stop operation during unsafe conditions.

Overall Function: The integrated system combines wireless movement control, obstacle sensing, battery monitoring, and safety alerts to support convenient short-distance mobility in industrial environments.

A. *Main Features of the IIoT-Based Automatic Roller Gadget*

1) Wireless Control: Enables users to control the roller gadget through a smartphone application using the HC-05 Bluetooth module.
2) Motorized Movement: Uses DC geared motors to provide powered movement and reduce the physical effort required for short-distance travel.
3) Obstacle Detection: Integrates an HC-SR04 ultrasonic sensor to detect nearby obstacles and support safer movement.
4) Arduino-Based Automation: Uses an Arduino 328P controller to process sensor inputs and coordinate the operation of different components.
5) Battery Monitoring: Incorporates a voltage sensor to monitor battery voltage and help identify low-battery conditions.
6) Battery Protection: Uses a Battery Management System (BMS) to support safe lithium battery charging and discharging.
7) Emergency Stop: Includes an emergency stop mechanism to interrupt operation during unsafe situations.
8) LCD Display: Provides visual information about the system's operating status and relevant battery or control conditions.
9) Audible Alerts: Uses a buzzer to provide warning sounds when required.
10) Rechargeable Power Supply: Includes a lithium battery and charger for portable operation and convenient recharging.
11) Dual-Motor Drive: Uses separate left and right DC motors to drive the roller wheels.
12) Industrial Mobility: Aims to improve convenience and reduce walking effort for workers and visitors moving through large industrial facilities.

V. ADVANTAGES

1) Reduced Physical Effort: Motorized movement helps reduce walking effort during short-distance travel.
2) Wireless Operation: Bluetooth connectivity enables convenient smartphone-based control.
3) Improved Safety: Ultrasonic sensing helps detect nearby obstacles, while the emergency stop supports safer operation.
4) Battery Monitoring: Voltage sensing helps users monitor battery conditions.
5) Portable Design: Rechargeable battery power supports movement without continuous connection to an external power supply.
6) Cost-Effective Solution: Arduino-based control offers a practical platform for developing an affordable industrial mobility prototype.

VI. APPLICATIONS

1) Industrial Factories: Supports short-distance movement between production sections and workstations.
2) Warehouses: Helps workers move around storage and inventory areas.
3) Large Manufacturing Units: Assists movement between departments within extensive industrial facilities.
4) Industrial Visitors: Provides an alternative mobility option for visitors touring large premises.
5) Workshops: Supports convenient movement between equipment stations and work areas.
6) Industrial Campuses: May be used for short-distance travel in suitable pathways, subject to safety testing and workplace rules.

VII. RESULTS AND DISCUSSION

The proposed IIoT-based automatic roller gadget integrates an Arduino 328P controller, HC-05 Bluetooth module, DC motors, L298N motor driver, HC-SR04 ultrasonic sensor, voltage sensor, LCD, buzzer, emergency stop, and rechargeable lithium battery. The system is designed to provide convenient short-distance mobility in industrial environments. Its performance can be evaluated through functional testing, obstacle detection, wireless control, battery monitoring, and motor operation.

A. *Functional Performance Analysis*

The first stage of evaluation examines whether the major electronic components perform their intended functions. The Bluetooth module receives movement commands from a smartphone, while the Arduino processes inputs and controls the motor driver. The ultrasonic sensor supports obstacle detection, and the LCD and buzzer provide information and warnings.

Table 1. Illustrative Functional Testing Results

Sr. No.	Test parameter	Successful trials	Total trials	Success rate
1	Bluetooth control	19	20	95%
2	Obstacle alert	18	20	90%
3	LCD status display	20	20	100%
4	Buzzer alert	19	20	95%
5	Emergency stop	20	20	100%

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

The illustrative results indicate that the LCD and emergency-stop functions achieved 100% success in the assumed trials. Bluetooth control and buzzer operation achieved 95%, whereas obstacle alerting achieved 90%. These differences demonstrate why each function should be tested repeatedly. In an actual prototype, missed obstacle detections and communication failures should be investigated before the device is used in an industrial environment.

B. Graphical Analysis of Functional Performance

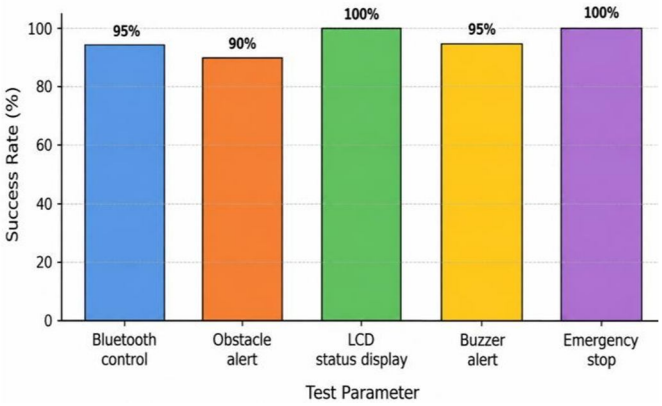


Figure 2. Illustrative functional test success rate

The graph compares the assumed success rates of the five functions. It shows that obstacle alerting has the lowest illustrative result, suggesting that sensor positioning, detection distance, and environmental interference should be checked carefully. The emergency stop must be tested under controlled conditions to confirm that it reliably interrupts motor operation. Actual testing is essential before drawing conclusions about the safety and reliability of the complete system.

C. Ultrasonic Sensor Performance

The HC-SR04 ultrasonic sensor is used to measure the distance between the roller gadget and nearby obstacles. Its readings can be compared with reference distances measured using a ruler or measuring tape. This test helps determine whether the sensor provides sufficiently accurate distance information for the programmed obstacle-warning function.

Table 2. Illustrative Distance Measurement Results

Reference distance (cm)	Sensor reading (cm)	Absolute error (cm)
10	10.5	0.5
20	20.3	0.3
30	30.8	0.8
40	40.6	0.6
50	49.5	0.5
60	60.7	0.7
80	79.2	0.8
100	99.0	1.0

The mean absolute error for these illustrative readings is 0.65 cm. This value is calculated from the eight example measurements and must not be interpreted as the actual accuracy of the prototype.

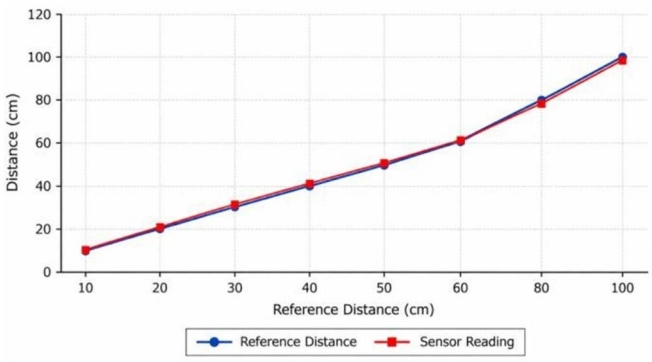


Figure 3. Ultrasonic sensor distance validation

The graph illustrates how sensor readings can be compared with reference distances. Close agreement indicates good measurement performance in the example dataset. In practice, accuracy may vary with obstacle material, surface angle, ambient conditions, sensor mounting, and vibration. The obstacle-warning threshold should therefore be established through repeated tests rather than assumed from these sample values.

D. Motor Control and Movement Analysis

The Arduino sends control signals to the L298N motor driver, which operates the left and right DC motors. The motors drive the roller wheels according to the programmed movement commands. Testing should include forward movement, stopping, turning, and restarting under controlled conditions.

Table 3. Motor Operation Test Plan

Test condition	Expected response	Evaluation parameter
Forward command	Both motors drive forward	Direction and response
Stop command	Motor drive stops	Stopping time and distance
Left-turn command	Differential motor action	Turning response
Right-turn command	Differential motor action	Turning response
Obstacle detected	Warning and programmed response	Detection and reaction
Emergency stop	Drive power is interrupted	Reliable stopping

Successful completion of these tests would demonstrate that the controller, motor driver, and motors operate together as intended. Actual stopping distance, turning radius, speed, and load capacity must be measured. The L298N also has electrical and thermal limitations, so motor current and driver temperature should be checked against component ratings.

E. Battery Monitoring and Power Consumption

The lithium battery provides portable electrical power, while the voltage sensor monitors its voltage. The BMS supports battery protection, and the charger replenishes the stored energy. Battery performance should be evaluated by recording voltage before operation, during motor loading, and after a defined operating period.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

Table 4. Battery Evaluation Parameters

Parameter	Measurement method	Purpose
Initial voltage	Measure before operation	Establish starting condition
Loaded voltage	Measure during motor operation	Identify voltage drop
Final voltage	Measure after testing	Assess battery discharge
Operating duration	Record elapsed running time	Estimate practical usability
Motor current	Measure with a suitable current sensor or meter	Evaluate electrical demand
Battery temperature	Measure during operation and charging	Check thermal safety

A reduction in battery voltage during motor operation can result from increased current demand and internal battery resistance. Longer operating duration depends on battery capacity, motor load, speed, surface conditions, and control strategy. A voltage sensor alone cannot directly determine remaining battery capacity with high accuracy; calibration and appropriate battery-monitoring logic are needed.

F. Discussion

The proposed system demonstrates the integration of solar photovoltaic energy with water electrolysis for hydrogen generation. The solar panel supplies DC electrical energy, while the DC-DC boost converter regulates the voltage required by the electrolyzer. The electrolyzer converts electrical energy into hydrogen and oxygen through the water-splitting process. The inclusion of a 12 V, 2 Ah lithium battery provides energy-storage support when solar availability varies. Arduino-based monitoring enables measurement of voltage and current through dedicated sensors, allowing the electrical operating condition to be observed during experimentation. The LCD provides a convenient local display of system parameters. In addition, the hydrogen gas sensor introduces an important safety-monitoring function by detecting possible gas leakage, while the buzzer provides an immediate warning to the operator. The system therefore combines renewable energy generation, electrolysis, energy storage, electrical measurement, and basic hydrogen safety monitoring within a compact prototype. However, actual hydrogen production rate and system efficiency must be established from experimental measurements rather than assumed values. The uploaded seminar similarly identifies hydrogen production, system efficiency, and operating conditions as important evaluation parameters.

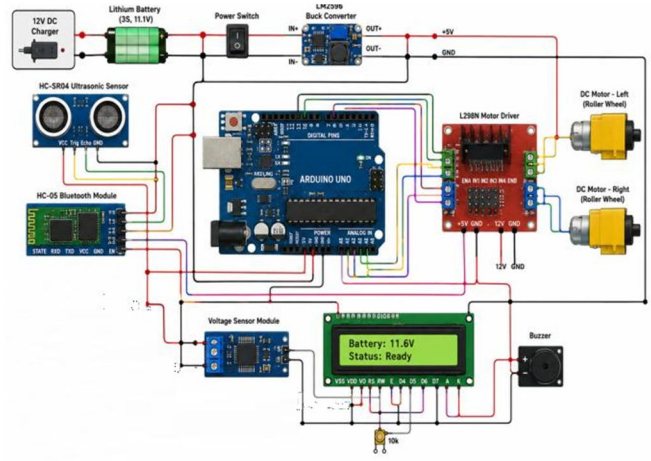


Figure 4: Circuit Model

VIII. CONCLUSION

The IIoT-Based Automatic Roller Gadget for Industrial Workers and Visitors presents a promising approach to improving short-distance mobility in large industrial facilities. The proposed system integrates an Arduino 328P controller, HC-05 Bluetooth module, DC motors, motor driver, ultrasonic sensor, voltage sensor, LCD, buzzer, emergency stop, and rechargeable lithium battery. These components work together to provide smartphone-based movement control, obstacle detection, battery monitoring, and operational alerts.

The system aims to reduce physical effort and improve convenience for workers and visitors moving between industrial departments, warehouses, and workstations. The ultrasonic sensor supports obstacle detection, while the voltage sensor helps monitor battery conditions. The LCD and buzzer provide visual and audible indications, respectively, and the emergency stop supports safer operation during unexpected situations.

The proposed design offers a practical foundation for developing a compact and affordable industrial mobility prototype. However, its actual performance must be established through physical testing of motor operation, sensor accuracy, battery endurance, stopping distance, and mechanical stability. The illustrative results presented in this study should not be considered experimentally verified findings. Future improvements may include enhanced obstacle avoidance, improved battery monitoring, and IoT-based remote status reporting. Overall, the project demonstrates the potential of combining embedded control and wireless communication to develop convenient mobility solutions for suitable industrial environments.

A. Future Scope

1) Advanced Obstacle Avoidance: Integrate additional sensors to improve obstacle detection and enable safer movement in crowded industrial environments.

2) IoT Monitoring: Develop cloud connectivity for remote monitoring of battery status, operating conditions, and system performance.

3) GPS-Based Navigation: Incorporate indoor positioning or suitable navigation technology to assist movement across large industrial facilities.

4) Battery Optimization: Improve battery management and energy efficiency to increase operating duration and reduce charging frequency.

5) Enhanced Safety: Develop improved braking, speed control, load stability, and emergency protection features before practical industrial deployment.

REFERENCES

[1] J. Ahmad, V. Fanti, D. G. Caldwell, and C. Di Natali, “Framework for the adoption, evaluation and impact of occupational exoskeletons at different technology readiness levels: A systematic review,” Robotics and Autonomous Systems, vol. 179, Art. no. 104743, 2024, doi: 10.1016/j.robot.2024.104743.

[2] A. Cardoso, A. Ribeiro, P. Carneiro, and A. Colim, “Evaluating exoskeletons for WMSD prevention: A systematic review of applications and ergonomic approach in occupational settings,” International Journal of Environmental Research and Public Health, vol. 21, no. 12, Art. no. 1695, 2024, doi: 10.3390/ijerph21121695.

[3] D. E. Fournier, M. Yung, K. G. Somasundram, B. B. Du,

[4] S. Rezvani, and A. Yazdani, “Quality, productivity, and economic implications of exoskeletons for occupational use: A systematic review,” PLOS ONE, vol. 18, no. 6, Art. no. e0287742, 2023, doi: 10.1371/journal.pone.0287742.

[5] A. Bretones, O. Marquet, C. Daher, L. Hidalgo, M. Nieuwenhuijsen, C. Miralles-Guasch, and N. Mueller, “Public health-led insights on electric micro-mobility adoption and use: A scoping review,” Journal of Urban Health, vol. 100, no. 3, pp. 612–626, 2023, doi: 10.1007/s11524-023-00731-0.

[6] L. K. Mitropoulos, E. Stavropoulou, P. G. Tzouras, C. Karolemeas, and K. Kepaptsoglou, “E-scooter micromobility systems: Review of attributes and impacts,” Transportation Research Interdisciplinary Perspectives, vol. 21, Art. no. 100888, 2023, doi: 10.1016/j.trip.2023.100888.

[7] The earlier literature-review entry attributed to Lucia Botti and Riccardo Melloni (2024) could not be verified sufficiently from the available search results. It should not be included in a final academic reference list until its exact publication details are confirmed.

[8] The earlier entry attributed to J. Tian et al. (2024) also requires verification of its exact title, author list, journal, and DOI before it can be cited reliably.

[9] A. Aba and D. Esztergár-Kiss, “Electric micromobility from a policy-making perspective through European use cases,” Environment, Development and Sustainability, vol. 26, pp. 7469–7490, 2024, doi: 10.1007/s10668-023-03016-3.

[10] Z. Zhu, A. Dutta, and F. Dai, “Exoskeletons for manual material handling—A review and implication for construction applications,” Automation in Construction, vol. 122, Art.no. 103493, 2021, doi: 10.1016/j.autcon.2020.103493.

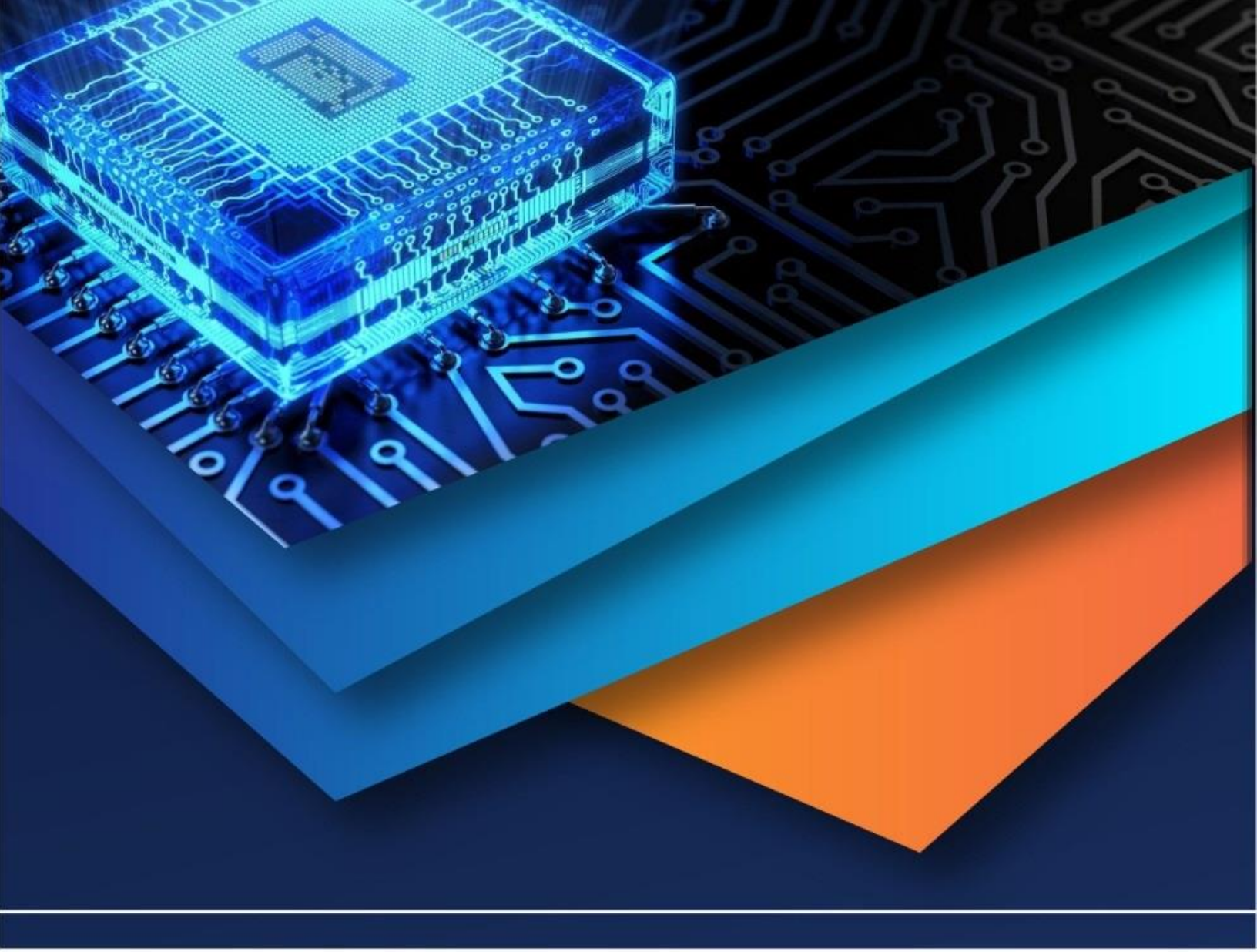
[11] S. De Bock et al., “Benchmarking occupational exoskeletons: An evidence mapping systematic review,” Applied Ergonomics, vol. 98, Art. no. 103582, 2022, doi: 10.1016/j.apergo.2021.103582.

[12] G. F. Serra, F. A. O. Fernandes, E. Noronha, and R. J. Alves de Sousa, “Head protection in electric micromobility: A critical review, recommendations, and future trends,” Accident Analysis & Prevention, vol. 163, Art. no. 106430, 2021, doi: 10.1016/j.aap.2021.106430.

[13] E. Karpinski, E. Bayles, and T. Sanders, “Safety analysis for micromobility: Recommendations on risk metrics and data collection,” Transportation Research Record, vol. 2676, no. 12, 2022, doi: 10.1177/03611981221095523.

[14] International Transport Forum, Safe Micromobility, International Transport Forum Policy Papers, no. 85. Paris, France: OECD Publishing, 2020, doi: 10.1787/0b98fac1-en.
[15] S. Bhat, J. Gavin, M. Warner, and M. Myall, "Mapping the evidence on occupational exoskeleton use for the workforce in healthcare, social care, and industry: A systematic scoping review," Wearable Technologies, vol. 6, Art. no. e53, 2025, doi: 10.1017/wtc.2025.10033.
[16] J. Y. Kim, S. Ishdorj, and J. W. Kim, "Usability and safety of micromobility," Architectural Research, vol. 27, no. 3, pp. 93–100, 2025, doi: 10.5659/AIKAR.2025.27.3.93.
[17] H. Younes, "Comparing injuries from e-scooters, e-bikes, and bicycles in the United States," Journal of Cycling and Micromobility Research, vol. 4, Art. no. 100061, 2025, doi: 10.1016/j.jcmr.2025.100061.
[18] D. Jima and T. Sipos, "An organized review of micromobility factors contributing to accidents, market and service trend, and related mishaps," International Journal of Crashworthiness, vol. 31, no. 1, pp. 1–13, 2026, doi: 10.1080/13588265.2025.2492994.
[19] Marcel Niemann , Karl F. Braun , Ellen Otto , Michael Tiefenbrunner , Jonas Wüster, Ulrich Stöckle, Sufian S. Ahmad , Sven Märdian , Frank Graef "Dangers of e-mobility: A systematic review and meta-analysis of sustained injury patterns and injury severity," Safety Science, vol. 167, Art. no. 106283, 2023, doi: 10.1016/j.ssci.2023.106283.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)