Jurnal Scientia
Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

The Performance Testing Analysis Of Electric Wheelchair Batteries Under Various Operational Conditions

Rani Pratiwi[1], Solly Aryza[2], Amani Darma Tarigan[3]
[1,2,3]Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
Email: ranypratiwi1998@gmail.com, sollyaryzalubis@gmail.com, amanidarmatarigan@dosen.pancabudi.ac.id

Article Info

Keywords:
electric wheelchair,
battery performance,
load cell calibration

ABSTRACT

An electric wheelchairs are vital mobility aids for individuals with mobility impairments or special needs. These wheelchairs rely on electric motors powered by batteries to provide the necessary propulsion. The accuracy and reliability of battery power measurement in electric wheelchairs are crucial for maintaining balance, stability, and ensuring a safe and comfortable user experience. One critical component in electric wheelchairs is the load cell, which measures the applied load such as user weight or additional loads. Over time, load cells may experience changes in their characteristics, such as sensitivity alterations or drift, potentially affecting load measurement accuracy. Therefore, calibration of load cell loads in electric wheelchairs becomes essential. Calibration ensures that load measurements remain accurate and consistent over time by comparing the output produced by the load cell with accurately known loads, and then adjusting the scale or resetting load cell parameters to achieve accurate measurements. This research aims to analyze the impact of load cell calibration on the performance of electric wheelchair batteries. The research questions include evaluating the effects of calibration on load measurement accuracy, identifying factors influencing load cell performance, and developing effective calibration methods. The study focuses on assessing how load cell calibration influences the performance of electric wheelchairs, with particular attention to measurement accuracy and stability aspects. The objective of this research is to enhance load measurement accuracy in electric wheelchairs through proper load cell calibration. The benefits include improving safety and comfort for wheelchair users by providing accurate load measurements, ensuring wheelchair balance and stability, and reducing the risk of injury or failure. Additionally, the findings contribute to the development of better electric wheelchair technology and enhance the quality of life for users.

Corresponding Author:
Rani Pratiwi
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
ranypratiwi1998@gmail.com

INTRODUCTION

Electric wheelchairs are crucial mobility aids for individuals with mobility impairments or special needs. They are powered by electric motors that provide the energy to move the wheelchair. The accuracy and reliability of load measurement on electric wheelchairs are

Jurnal Scientia
Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

essential to maintain balance, stability, and ensure a comfortable and safe user experience. One critical component of electric wheelchairs is the load cell, which measures the applied load, such as user weight or additional burdens. However, over time and with continuous use, the load cell may undergo changes in its characteristics, such as sensitivity variations or drift, which can affect load measurement accuracy. Therefore, load cell calibration in electric wheelchairs is crucial. Calibration ensures that load measurements on electric wheelchairs remain accurate and consistent over time. The calibration process involves comparing the output generated by the load cell with accurately known loads, and then adjusting the scale or resetting the load cell parameters to achieve accurate measurements.

This research aims to analyze the impact of load cell calibration on electric wheelchairs. Research problem statements include evaluating the effects of calibration on load measurement accuracy, identifying factors influencing load cell performance, and developing effective calibration methods. The study will focus on the influence of load cell calibration on the performance of electric wheelchairs, with attention to accuracy and measurement stability aspects. The research goal is to enhance load measurement accuracy on electric wheelchairs through proper load cell calibration. The benefits of this research include improving the safety and comfort of electric wheelchair users by ensuring accurate load measurements, maintaining balance and stability of the wheelchair, and reducing the risk of injury or wheelchair failure. Additionally, the findings of this research can contribute to the development of better electric wheelchair technology and enhance the quality of life for users.

Literature Review

Concept Theoretical.

In this literature review, it generally consists of a collection of written reviews of existing sciences to support the author's research activities. The basic theoretical concepts are tailored to the topic of this research both quantitatively and qualitatively. Several points of material that the author elaborates to support this research include implementation, microcontroller-based devices, and electric wheelchairs. Implementation is the application or execution of a carefully prepared and detailed plan. Therefore, implementation does not stand alone but is influenced by the following object.

Microcontroller-based devices are electronic devices/components applied with a microcontroller as their central controller. Fundamentally, these electronic devices have their own operational systems and functions according to the designed circuit, but their utility can be enhanced when applied through a microcontroller. The primary goal is to create devices that facilitate daily human activities. For example, an ultrasonic distance sensor that initially detects distance can be utilized to calculate the height of an object based on software algorithms programmed into the microcontroller.

Electric Wheelchair

An electric wheelchair is a wheelchair powered by electricity using a motor with a battery as its power source. This device is operated by moving a joystick, typically positioned in front of the armrest, providing comfort and ease of use when maneuvering. The innovation of electric wheelchairs has transformed the functionality of manual

Jurnal Scientia
Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

wheelchairs. This innovation has impacted various aspects of life, including health. Wheelchairs that were once designed simply and operated manually by hand have now been modernized into types that can be controlled using a joystick.

1) Handle Gas (Throttle Potentiometer)
2) Brake
3) Battery and Controller Compartment
4) Seat
5) Linear Actuator Button
6) Caster Wheel
7) Linear Actuator
8) Hoverboard Wheel
9) Footrest
10) Actuator

Main Components

Microcontroller

A microcontroller is a functional computer system integrated into a single chip. It is built from similar basic elements. Simply put, this computer produces specific outputs based on the input received and the program executed. Today, there are various shapes and types of Arduino boards tailored to their intended purposes. The Arduino Mega 2560, for instance, has gained trust in large-scale projects such as in the field of robotics.

Ultrasonic Sensor

An ultrasonic sensor functions by converting physical quantities (sound) into electrical quantities and vice versa [9]. The HC-SR04 Ultrasonic Sensor is a ready-to-use device that serves as a transmitter, receiver, and controller of ultrasonic waves. This device can measure distances from 2 cm to 400 cm. The HC-SR04 Ultrasonic Sensor has 4 pins:

a. Vcc pin is used for positive voltage (+),
b. Trigger pin is used to send signals from the sensor,
c. Echo pin receives signal reflections from objects,
d. Gnd pin is used for negative voltage (-).

Figure 2. HC-SR04 Ultrasonic Sensor

The strain gauge in a load cell is used to measure changes in strain as electrical signals, because effective changes occur in the load resistor wire. The strain gauge is a crucial component of a load cell, functioning to detect the magnitude of dimensional changes caused by a force element.

Jurnal Scientia
Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

Figure 3. HX711 Module

HX711 Module:

The HX711 is a weighing module that operates on the principle of converting measured changes in resistance into voltage changes through its circuitry.

Figure 4. HX711 Board with Pin Comb

Based on Figure 4, there are 6 pins (E+, E-, A-, A+, B-, and B+) provided to connect the load cell sensor cables, but only 4 pins are used. The red cable connects to E+, the black cable to E-, the white cable to A-, and the green cable to A+. As for the microcontroller, the connected pins include GND and VCC for the HX711 power pins, each connected to Ground and 5V respectively. Additionally, the DT (Data) and SCK (Serial Clock Sync) pins are connected to the microcontroller's analog pins.

Voltage sensor

A voltage sensor is used to detect the remaining voltage (voltage level) from a voltage source such as a battery. The circuit of this sensor typically includes two resistors as a voltage divider, terminals for connection to the voltage source, and pins for managing the voltage value. According to the diagram, the voltage sensor has 2 terminal ports and pins connected to the microcontroller:

Figure 5. Voltage Sensor

a. GND Port: Used for connecting the negative (-) electrical terminal of the voltage source.
b. VCC Port: Used for connecting the positive (+) electrical terminal of the voltage source.
c. S Pin: Used to provide analog voltage value to the microcontroller.
d. + Pin: Used for connecting positive (+) voltage to the microcontroller.
e. Pin: Used for connecting negative (-) voltage to the microcontroller.

This setup allows the voltage sensor to accurately measure and transmit voltage information to the microcontroller for further processing.

METHOD

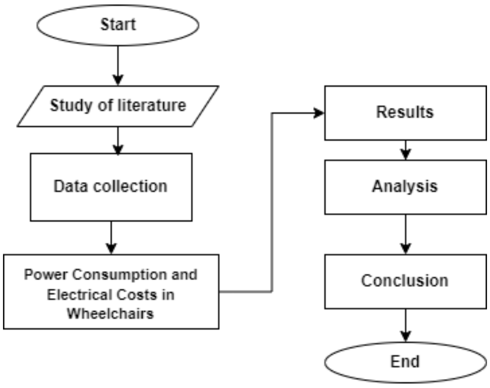

Figure 6. Flowchart

This study aimed to analyze the performance of electric wheelchair batteries under different operational conditions to evaluate their efficiency, longevity, and reliability. The following steps outline the methodology used:

Battery Selection:

Three types of commonly used electric wheelchair batteries were selected for this study:

a. Sealed Lead-Acid (SLA) battery
b. Lithium-Ion (Li-Ion) battery
c. Nickel-Metal Hydride (NiMH) battery

The batteries were sourced from reputable manufacturers, and all had similar capacities and specifications to ensure comparability.

Operational Conditions:

The batteries were tested under varying operational conditions to simulate real-world usage. These conditions included:

a. Load Variations: Testing with different user weights (50 kg, 70 kg, and 90 kg) to assess the impact of load on battery performance.
b. Terrain Conditions: Testing on three types of terrains:
    1. Flat, smooth surface (indoor)
    2. Rough, uneven surface (outdoor gravel)
    3. Inclined surface (ramps at 5°, 10°, and 15° inclines)
c. Temperature Variations: Batteries were tested in a controlled environment with temperatures of 10°C, 25°C, and 40°C to evaluate performance under different thermal conditions.

Testing Procedures:

1. Cycle Testing: Each battery underwent charge and discharge cycles to measure capacity retention over time. The batteries were fully charged, discharged to a pre-

determined cutoff voltage, and then recharged. This cycle was repeated 100 times to evaluate long-term performance.

a. Energy Efficiency Measurement: The input energy required to fully charge the batteries and the output energy during discharge were measured to calculate energy efficiency under each operational condition.
b. Range Testing: The wheelchair was driven continuously on each terrain until the battery was depleted. The distance traveled was recorded to assess the range provided by each battery under different conditions.

Data Collection and Analysis:

a. Voltage, Current, and Power Measurements: During each test, the voltage, current, and power output of the batteries were continuously monitored using a data acquisition system (DAQ).
b. Temperature Monitoring: Battery surface temperatures were measured using thermocouples placed on the battery casing to assess the impact of external temperature on battery performance.
c. Statistical Analysis: The collected data were analyzed using statistical tools to determine the effects of load, terrain, and temperature on the battery performance indicators, such as energy efficiency, range, and cycle life.

2. Safety Protocols:
Safety precautions were taken during all tests to avoid overheating, overcharging, or deep discharging, which could damage the batteries. Each test was conducted under close supervision, and the batteries were inspected regularly for signs of wear or damage.

RESULTS AND DISCUSSION

Analysis and Discussion of Speed vs. Distance Graph

From the results of the speed vs. distance graph tests, it is evident that the speed of the wheelchair is influenced by the weight it carries. Observations show consistent patterns between speed and distance in the context of different weights:

High Speed with Light Load (50 kg)

At a distance of 100 meters with a 50 kg load, the wheelchair reaches a speed of 8.48 km/h. This indicates that the wheelchair can move faster when carrying a lighter load. A lighter load reduces resistance and the energy required to move the wheelchair, thereby increasing speed.

Moderate Speed with Medium Load (70 kg)

For a distance of 100 meters with a 70 kg load, the wheelchair's speed drops to 5.44 km/h. This decrease indicates that additional weight significantly affects the wheelchair's speed. Although still in the moderate range, the added weight causes a noticeable reduction in speed.

Slow Speed with Heavy Load (90 kg)

With a 90 kg load, the wheelchair moves at a speed of 3.79 km/h for a distance of 100 meters. This is the slowest speed observed, showing that a heavier load greatly affects the wheelchair's ability to maintain high speed. Heavier loads increase resistance and require more power to move, thereby reducing speed.

From the data, it can be concluded that body weight has a significant impact on the speed of the wheelchair. There is an inverse relationship between the weight of the load and the speed of the wheelchair: the heavier the user, the slower the wheelchair. Conversely, the lighter the user, the faster the wheelchair moves.

Other Factors Affecting Speed

In addition to body weight, several other factors can influence the speed of the wheelchair:

a. Surface Condition: Smooth and even surfaces allow the wheelchair to move faster compared to rough or uneven surfaces.
b. Technical Condition of the Wheelchair: The condition of the battery, motor, and mechanical systems of the wheelchair also affect speed. Wheelchairs with better and more efficient components tend to perform better.
c. Physical Condition of the User: The physical strength and health of the user can also have an impact, especially with manual wheelchairs where the user's hand strength is crucial for speed.
d. Environment: Weather conditions, such as wind or rain, can also affect the speed of the wheelchair.
e. Considering all these factors, it is important to choose a wheelchair that suits the user's needs and conditions to ensure maximum comfort and efficiency in daily use.

Table 1. Recapitulation of Power Consumption Results and Electricity Costs

Test	Parameter	100 meters	150 meters	200 meters
P1	Weight	50 kg	50 kg	50 kg
	Speed	8.48 km/h	9.82 km/h	11.84 km/h
	Power	1.38 Wh	1.45 Wh	1.54 Wh
	Time	27 seconds	33.6 seconds	62.4 seconds
	Distance	100 meters	150 meters	200 meters
	V0	39.75 Volts	39.75 Volts	39.75 Volts
	V1	38.74 Volts	38.30 Volts	37.88 Volts
	ΔV	1.01	1.45	1.87
	Electricity Cost	Rp. 1,993	Rp. 2,094	Rp. 2,224
P2	Weight	60 kg	60 kg	60 kg
	Speed	6.94 km/h	7.73 km/h	8.23 km/h
	Power	1.41 Wh	1.48 Wh	1.57 Wh
	Time	34.2 seconds	69 seconds	76.8 seconds
	Distance	100 meters	150 meters	200 meters
	V0	39.84 Volts	39.84 Volts	39.84 Volts
	V1	38.74 Volts	38.30 Volts	37.88 Volts
	ΔV	1.10	1.54	1.96
	Electricity Cost	Rp. 2,037	Rp. 2,138	Rp. 2,268
P3	Weight	70 kg	70 kg	70 kg
	Speed	5.44 km/h	6.01 km/h	7.22 km/h

	Power	1.44 Wh	1.51 Wh	1.60 Wh
	Time	64.2 seconds	78 seconds	86.4 seconds
	Distance	100 meters	150 meters	200 meters
	V0	40.01 Volts	40.01 Volts	40.01 Volts
	V1	38.74 Volts	38.30 Volts	37.88 Volts
	ΔV	1.27	1.71	2.13
	Electricity Cost	Rp. 2,080	Rp. 2,181	Rp. 2,311
P4	Weight	80 kg	80 kg	80 kg
	Speed	4.07 km/h	5.28 km/h	6.19 km/h
	Power	1.47 Wh	1.54 Wh	1.63 Wh
	Time	79.2 seconds	85.2 seconds	120 seconds
	Distance	100 meters	150 meters	200 meters
	V0	40.03 Volts	40.03 Volts	40.03 Volts
	V1	38.74 Volts	38.30 Volts	37.88 Volts
	ΔV	1.29	1.73	2.15
	Electricity Cost	Rp. 2,123	Rp. 2,224	Rp. 2,354

Table 2. Testing Patient Weight and Distance on Power Consumption

Power (Wh) Patient Weight	Distance		
	100 Meters	150 Meters	200 Meters
50 Kg	1.38 Wh	1.45 Wh	1.54 Wh
60 Kg	1.41 Wh	1.48 Wh	1.57 Wh
70 Kg	1.44 Wh	1.51 Wh	1.60 Wh
80 Kg	1.47 Wh	1.54 Wh	1.63 Wh
90 Kg	1.50 Wh	1.58 Wh	1.66 Wh

Analysis and Discussion of Power vs. Distance Graph

From the results of the power vs. distance graph tests, it is observed that the power consumption of the wheelchair varies with the distance traveled and the weight of the load. Here are the key findings based on the provided data:

High Power Consumption with Heavy Load (90 kg)

At a distance of 100 meters, the wheelchair carrying a 90 kg load consumes 1.5 Wh of power. This indicates that heavier loads require more energy to move over the same distance compared to lighter loads. The higher power consumption reflects the increased effort needed to overcome resistance and move the wheelchair.

Lower Power Consumption with Lighter Load (50 kg)

Conversely, at the same distance of 100 meters, the wheelchair carrying a 50 kg load consumes 1.35 Wh of power. This lower power consumption demonstrates that lighter loads require less energy to achieve the same distance. The reduced power usage indicates less resistance and easier movement for the wheelchair.

Linear Actuator Testing Phase

During the linear actuator testing phase with a 50 kg load, the initial height of the wheelchair seat was 48 cm. The actuator was tested to ascend, reaching a maximum height of 68 cm in 17 seconds. This indicates a vertical rise of 20 cm over the test period.

Subsequently, the actuator was tested to descend from 68 cm back to 48 cm, achieving this in 14 seconds. This testing phase demonstrates the actuator's ability to smoothly adjust the seat height, both ascending and descending, which is crucial for user comfort and accessibility. The analysis highlights the relationship between power consumption, load weight, and distance traveled in wheelchair performance. Heavier loads necessitate greater power consumption to achieve movement over the same distance compared to lighter loads. Additionally, the linear actuator testing phase underscores the actuator's efficiency in adjusting seat height, crucial for meeting user needs effectively. These findings emphasize the importance of optimizing wheelchair design and components to enhance efficiency and user experience.

Table 3. Testing patient weight with rise and fall time on the linear actuator

Patient Weight (kg)	Height Testing Distance (Δh = 20 cm)	Time Ascending (seconds)	Time Descending (seconds)
50	20 cm	17 seconds	14 seconds
60	20 cm	20 seconds	16 seconds
70	20 cm	23 seconds	18 seconds
80	20 cm	25 seconds	20 seconds
90	20 cm	30 seconds	25 seconds

Analysis and Discussion of Time vs. Distance Graph

The analysis of the time vs. distance graph for the linear actuator, using a load of 50 kg and a height difference (Δh) of 20 cm, reveals significant insights into the performance differences based on weight:

Faster Performance with Lighter Load (50 kg)

During the linear actuator testing:

a. Ascending: The actuator took 17 seconds to ascend the height (Δh) of 20 cm.
b. Descending: It took 14 seconds to descend the same distance.

Slower Performance with Heavier Load (90 kg)

In contrast, with a load of 90 kg:

a. Ascending: The actuator required 30 seconds to ascend the height of 20 cm.
b. Descending: It took 25 seconds to descend the same distance.

From the analysis, it can be concluded that the weight of the load significantly impacts the time taken by the linear actuator to adjust height:

a. Lighter Load (50 kg): Demonstrates quicker response times, both ascending and descending, which indicates smoother and faster adjustments.
b. Heavier Load (90 kg): Shows longer times for both ascending and descending movements, highlighting the increased effort and time required to lift and lower the heavier load.

This conclusion underscores the importance of considering load weight when designing or selecting linear actuators for wheelchair systems, aiming to optimize performance and user experience based on operational efficiency and speed of adjustment.

CONCLUSION

When using a 50 kg load, the time required for the linear actuator to go up (17 seconds) and down (14 seconds) is shorter than when using a 90 kg load, which takes 30 seconds to go up and 25 seconds to go down. From this data, it can be concluded that a lighter load (50 kg) produces faster up and down speeds compared to a heavier load (90 kg). This shows that the speed performance of the linear actuator on an electric wheelchair is greatly influenced by the user's weight. Users with a lighter weight will experience faster and more responsive movements in using an electric wheelchair, while users with a larger weight will experience slower movements.

ACKNOWLEDGEMENTS

We express our heartfelt thanks for the invaluable support and contributions to this research. With the assistance and encouragement from various parties, we have conducted this study with dedication and precision. We extend our gratitude to everyone involved for providing resources, guidance, and exceptional moral support. This research would not have been possible without the solid teamwork and tireless enthusiasm of all those involved. Every contribution, whether large or small, has been significant for the advancement of science and technology. We thank our families and friends for their unwavering support, and we are grateful to the institutions and scientific communities that have provided the space and facilities for our research.

REFERENCES

Adiyasa, I. W. (2022). Improvisasi Torsi Dan Efisiensi Pada Redesain Motor Brushless DC Hoverboard Berdaya Dasar 350W. Jurnal Pendidika Vokasi Otomotif, 5(1), 27-42.

Aryza, S., Efendi, S., & Sihombing, P. (2024). A ROBUST OPTIMIZATION TO DYNAMIC SUPPLIER DECISIONS AND SUPPLY ALLOCATION PROBLEMS IN THE MULTI-RETAIL INDUSTRY. *Eastern-European Journal of Enterprise Technologies*, (3).

Ac, M. N. (2022). Rancang Bangun Controller BLDC Berbasis Mikrokontroler STM32 Blue Pill Pada Kendaraan Listrik Urban Agnijaya Weimana. Jurnal Spektrum, 9(3).

Annirohman, S. (2023). Rancangan Kursi Roda Elektrik Dengan Remot Dan Tuas. Jurnal Teknik, 12(1).

Chigondo, M., & Chigondo, F. (2016). Recent Natural Corrosion Inhibitors for Mild Steel: An Overview. J. Chem, 1–7. https://doi.org/10.1155/2016/6208937

Elmer, T. J. (2021). Kontrol Himpunan Panel Surya dengan Penyesuaian Diri Otomatis Menggunakan Aktuator dengan Dua Derajat Kebebasan. Jurnal Teknik ITS, 10(2), B177- B182.

Jurnal Scientia
Volume 13, Number 04, 2024, DOI 10.58471/ scientia.v13i04
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

Ferdiansyah, D., & Susanto, A. (2020). Rancang Bangun Prototype Kursi Roda Menggunakan Arduino R3 Berbasis Android. GATOTKACA Journal (Teknik Sipil, Informatika, Mesin Dan Arsitektur), 1(2).

Ikhsan, M. W. (2022). Pengaruh Pembebanan Dan Pengaturan Kecepatan Motor BLDC 1 kW Pada Sepeda Motor Listrik. Jurnal Edukasi Elektro, 6(2), 149-156.

Mawardi, M., & Lianda, J. (2018, November). Rancang Bangun Kursi Roda Elektrik Menggunakan Joystick. In Seminar Nasional Industri dan Teknologi (pp. 67-74).

Nursab, T. H. (2020). Rancang Bangun Kursi Roda Dengan Head Motion Control Menggunakan Sensor Gyroscope Untuk Penyandang Disabilitas.

Ramadeanto, L. H. (2018). Performansi EDFA Di Setiap Bit Rate Yang Dikirimkan Dari Transmitter Ke Receiver Pada Jarak 50 Km Pada Sistem. eProceedings of Engineering, 5(3).

Risdiyono, E. (2020). Perancangan dan Pengembangan Desain Kursi Roda Elektrik dengan Fitur Berdiri untuk Penyandang Disabilitas.

Z. Lubis. Aryza. S. & Alam, H. (2023). Analisis Hybrid PLTA dan PLTS Sebagai Energi Listrik Alternatif Pengganti Energi PLN. *JET (Journal of Electrical Technology)*, *8*(3), 119-127.