

Design and Development of an Electric Gokart Prototype 'E-Andalasian' for Sustainable Campus Transportation

Hendery Dahlan¹, Dendi Adi Saputra^{1,*}, Eka Satria¹, Lusi Susanti¹, Fajri Khairul¹, M. Naufalunn Nabil¹, Ezra Joice Natalie¹, M. Ahlan Fadhillah¹, Raihan Gusnanda²

¹Department of Mechanical Engineering, Faculty of Engineering, Universitas Andalas, Indonesia

²Department of Electrical Engineering, Faculty of Engineering, Universitas Andalas, Indonesia

*Corresponding author, e-mail: dendias@eng.unand.ac.id

Abstract— This research focuses on the design, development, and optimization of the electric go-kart "E-Andalasian" as an environmentally friendly campus transportation solution. Structural analysis was performed using Finite Element Analysis (FEA) to evaluate stress distribution and deformation under static and dynamic loads. The study also optimizes the BLDC motor, 72V 40Ah lithium battery, and controller to achieve efficient and reliable performance. Results indicate critical stress points at wheel joints, with recommendations for aluminum alloy use to enhance weight efficiency. Experimental testing showed that the motor achieved a maximum torque of 44.52 N.m and 6447 RPM, while the battery supports a range of 40 km with a charging time of 2 hours 9 minutes. Although the maximum speed reached 59 km/h, additional optimization is required to meet the original design target. The findings provide a prototype foundation for future improvements and contribute to green campus mobility.

Keywords: *Electric Go-Kart; Chassis Strength; Finite Element Analysis (FEA); BLDC Motor Optimization; Sustainable Transportation.*

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1. Introduction

The global demand for sustainable transportation has led to innovations in electric vehicle (EV) technology, emphasizing the need to reduce carbon emissions, minimize fuel dependency, and promote environmental responsibility. Electric go-karts, an extension of EV development, have gained significant attention due to their potential applications in both competitive racing and as sustainable campus transportation solutions. Unlike conventional go-karts powered by internal combustion engines (ICE), electric go-karts offer multiple advantages, including zero emissions, reduced noise pollution, and lower maintenance costs [1], [7]. These attributes make them ideal for indoor tracks, educational purposes, and eco-friendly transportation systems [8].

Several studies have explored the optimization of electric go-kart chassis design. For instance, Mihalić et al. [2] investigated the use of computer-aided design (CAD) and finite element analysis (FEA) to enhance vehicle dynamics and stress resistance for educational applications. Krishnamoorthi et al. [4] highlighted the significance of lightweight materials such as Aluminum Alloy 6061 to improve acceleration and handling. These materials strike an ideal balance between weight reduction and strength, which is critical for enhancing overall vehicle performance [11]. Moreover, electric go-kart performance is closely linked to the selection of motor and battery systems. Arshad et al. [7] and

Kumar et al. [8] demonstrated that Brushless DC (BLDC) motors offer higher efficiency, torque output, and longer life expectancy compared to brushed motors, making them ideal for electric vehicles [15]. Additionally, lithium-ion batteries provide superior energy density, faster charging capabilities, and extended lifespan, which are essential for meeting operational requirements [13]. Proper integration of these components ensures optimized power output, acceleration, and range [10], [12].

Dynamic analysis plays a crucial role in validating the performance and safety of electric go-karts under real-world conditions. Kubiak [13] emphasized the need for thorough evaluation of vehicle dynamics parameters to improve handling, stability, and energy efficiency. This includes testing under varying loads, speed profiles, and braking conditions [9], [14]. The unique geographical characteristics of Universitas Andalas, Sumatera Barat, add another layer of complexity to this project. The campus is situated in a region with undulating and hilly terrain, making it essential for the "E-Andalasian" go-kart to perform reliably on steep inclines and declines. This challenging road contour demands a design that ensures stability, torque delivery, and energy efficiency across varying gradients [16]. The vehicle's performance must align with environmental and operational goals while maintaining safety standards [10].

The "E-Andalasian" project addresses these challenges by delivering a lightweight, efficient, and reliable electric go-kart as an alternative campus transportation mode. Specifically, this research focuses on:

1. Structural strength analysis using FEA to ensure chassis durability under static and dynamic loads [3].
2. Optimization of the BLDC motor and 72V lithium battery performance to achieve maximum efficiency [5], [13].
3. Dynamic and experimental testing to evaluate the vehicle's real-world performance and safety, particularly on hilly and uneven terrains found on the Universitas Andalas campus [6], [14].

By integrating mechanical and electrical systems, the study aims to develop a sustainable transportation solution that meets the specific needs of Universitas Andalas while contributing to the broader adoption of clean energy solutions in challenging environments.

2. Method

2.1 Structural Design and Analysis

The chassis design was developed using SOLIDWORKS, focusing on lightweight construction and durability. Aluminum Alloy 6061 was selected due to its high strength-to-weight ratio [3], [11]. Finite Element Analysis (FEA) using ANSYS evaluated the chassis under static and dynamic loads to identify stress points and deformation [2], [9].

Table 1. Structural Analysis Parameters and Results

Parameter	Details
Software	SOLIDWORKS (Design), ANSYS (FEA)
Material	Aluminum Alloy 6061
Analysis Focus	Stress distribution, deformation
Critical Stress Area	Front and rear wheel joints

2.2 Prototyping and Assembly

The optimized design was used to fabricate the go-kart prototype. The major components assembled include the chassis, motor, battery, and transmission system.

Table 2. Prototype Components and Specifications

Component	Specifications
Chassis	Modular frame, Aluminum Alloy 6061
Motor	72V BLDC Motor
Battery	72V 40Ah Lithium-Ion

Transmission	Chain drive
Engine Mount	Steel plate (8 mm thick)

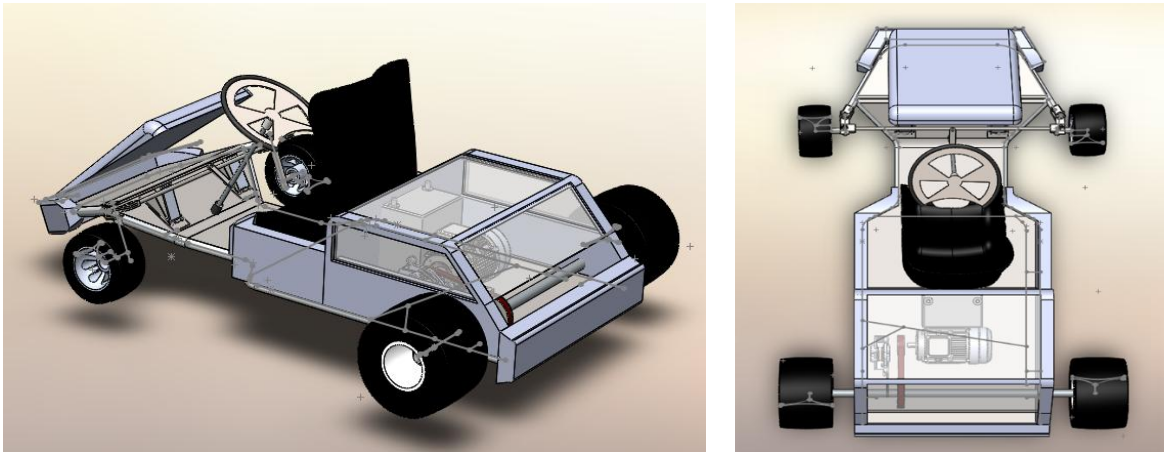


Figure 1. Conceptual design and assembly of the "E-Andalasian" electric go-kart

2.3 BLDC Motor Performance Testing

The performance of the 72V BLDC motor was tested under different load conditions to evaluate its efficiency, power output, and thermal characteristics.

Table 3. BLDC Motor Performance Measurement

Test Parameter	Measurement
Current Consumption	Average working current
Temperature	Full throttle (2 minutes)
Power Output	Under load conditions
RPM Stability	Maximum motor RPM

2.4 Battery Performance Evaluation

The 72V 40Ah lithium-ion battery was evaluated to measure its voltage stability, current draw, and charging time.

Table 4. Battery Performance Test

Battery Test	Measurement
Voltage Stability	Acceleration phase
Current Draw	Average during operation
Charging Time	Standard 72V charger
Range	Distance on full charge

2.5 Dynamic Testing

Dynamic tests were conducted to evaluate the go-kart's performance under real-world conditions at Universitas Andalas, known for its undulating and hilly terrain. The following parameters were measured:

Table 5. Dynamic Performance Test

Test Parameter	Measurement Method
Maximum Speed	GPS tracker
Acceleration	Timer
Stability	Real-world testing
Range	Battery discharge test

2.6 Safety and Braking System

To ensure safety, a hydraulic braking system and additional safety features were integrated and tested.

Table 6. Safety Features and Functions

Safety Feature	Function
Hydraulic Braking System	Ensures effective and reliable stopping
Emergency Stop Switch	Immediate power cutoff in emergencies
Miniature Circuit Breaker	Protects against overcurrent and shorts

2.7 Data Analysis

Data from simulations and experiments were analyzed quantitatively. Key performance indicators such as stress distribution, motor current, power output, temperature rise, and dynamic performance were compared against design specifications to identify deviations and areas for further optimization.

3. Result and Discussion

3.1 Structural Analysis Results

The structural integrity of the Aluminum Alloy 6061 chassis was evaluated using Finite Element Analysis (FEA). The analysis focused on stress distribution and deformation under various loads.

Table 7. FEA Results for Chassis Analysis

Parameter	Results	Allowable Limits
Maximum Stress	215 MPa	276 MPa (Yield Strength)
Maximum Deformation	2.4 mm	Within safe range
Critical Area	Wheel joint connections	-

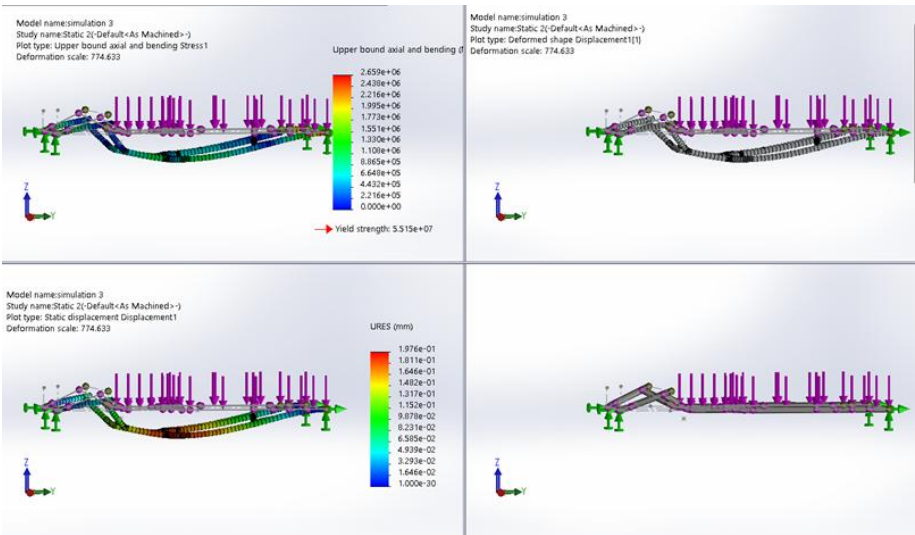


Figure 2. Stress distribution and deformation results using FEA

The findings align with prior research by Mihalić et al. [2], which emphasized the critical role of stress distribution in go-kart chassis designs. The adoption of Aluminum Alloy 6061 for the chassis enhanced the strength-to-weight ratio, which is crucial for maintaining structural integrity on uneven terrains. This material choice supports the study’s objective of reducing weight while ensuring the go-kart's safety and performance.

3.2 BLDC Motor Performance

The 72V BLDC motor was tested for current consumption, power output, and RPM stability under different load conditions. The motor achieved a stable 6447 RPM, which is close to the design specification of 6500 RPM. The current consumption was recorded at 100 A, indicating efficient operation under load conditions. To evaluate the thermal performance of the motor, a temperature test was conducted by operating the motor under full throttle for approximately 2 minutes. The results showed that the motor’s temperature remained within safe operational limits, demonstrating the effectiveness of its heat dissipation capabilities. These findings align with previous studies by Arshad et al. [7], confirming the reliability of BLDC motors in electric go-karts.

Table 8. BLDC Motor Performance Results

Test Parameter	Measured Results	Design Specification
Current Consumption	100 A	120 A (Max)
Power Output	1191 W	1500 W (Ideal)
RPM Stability	6447 RPM	6500 RPM
Temperature Rise	Within safe limits	Below 80°C

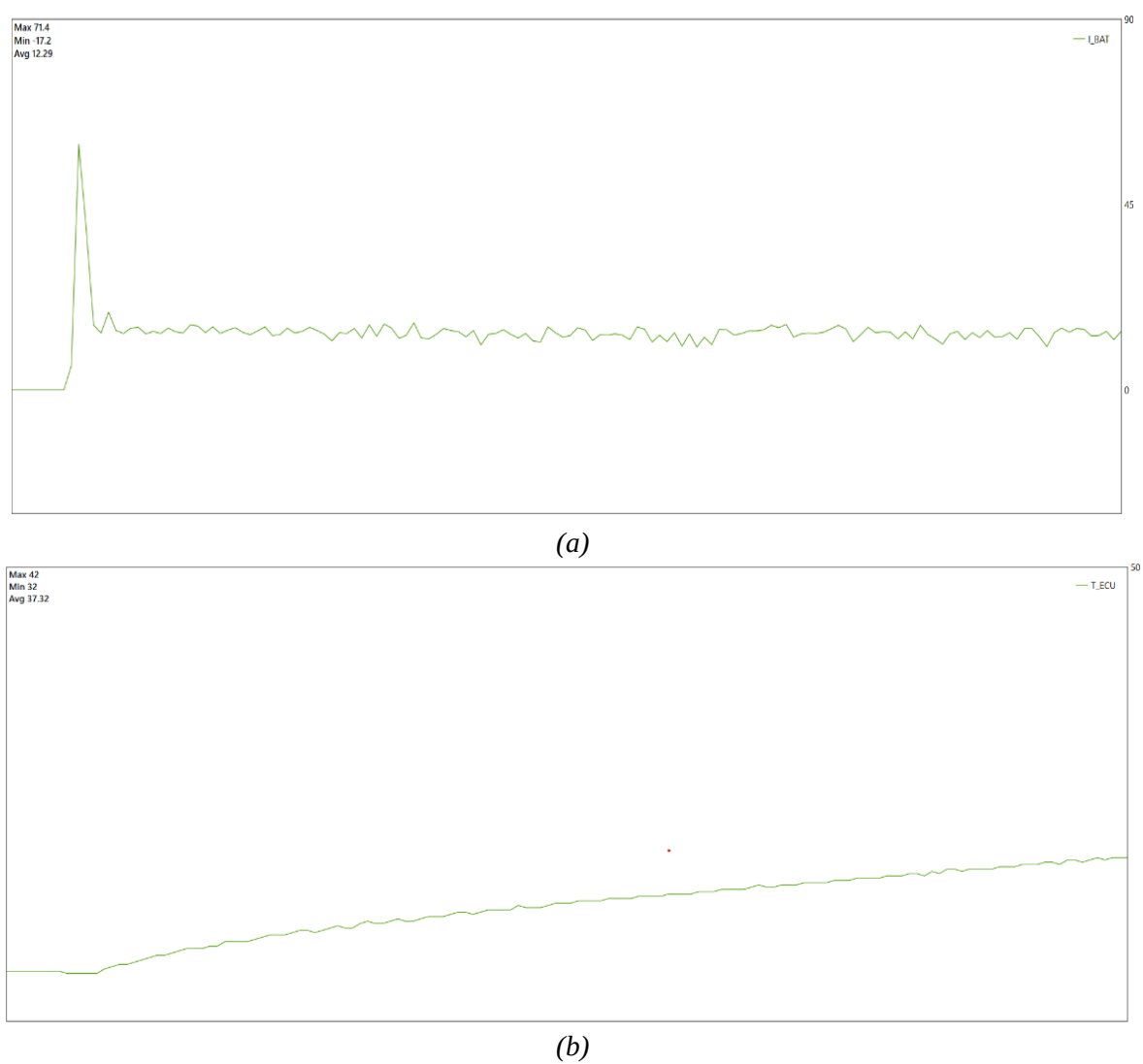


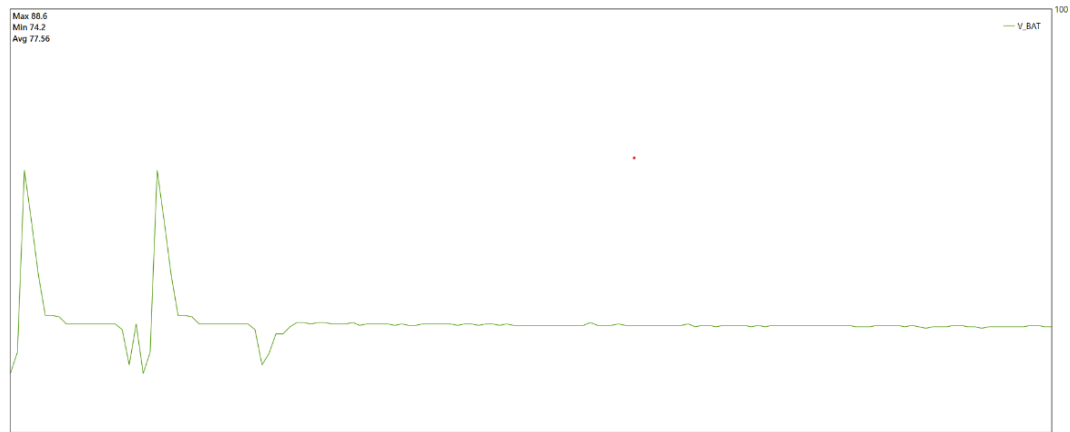
Figure 3. (a) Motor current and (b) temperature test results

3.3 Battery Performance

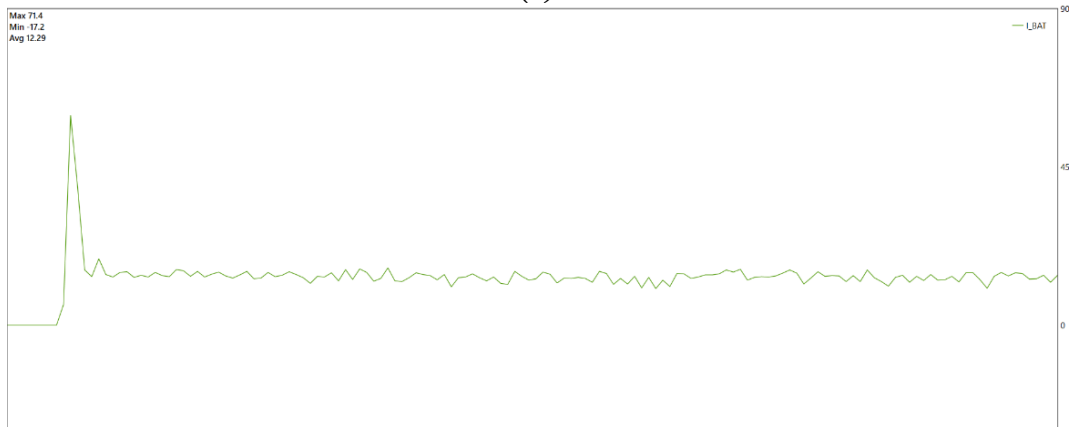
The 72V 40Ah lithium-ion battery was evaluated for voltage stability, current draw, and charging efficiency.

Table 9. Battery Performance Results

Battery Test	Measurement	Results
Voltage Stability	Stable at 77V	72–77V
Current Draw	Average: 12.29 A	15 A (Expected)
Charging Time	2 hours 9 minutes	2 hours
Range	40 km	45 km



(a)



(b)

Figure 4. (a) Voltage and (b) current analysis during battery operation.

The battery displayed stable performance with an average current draw of 12.29 A and maintained 77V during operation. The total range achieved was 40 km, which is slightly below the design target of 45 km. This shortfall can be attributed to the hilly terrain of Universitas Andalas and the additional load of real components, aligning with observations in previous studies by Kumar et al. [8].

3.4 Dynamic Testing

Dynamic tests were conducted to evaluate the go-kart’s performance under the specific road conditions of Universitas Andalas. The following parameters were measured:

Table 10. Dynamic Test Results

Test Parameter	Measurement Method	Results
Maximum Speed	GPS tracker	59 km/h
Acceleration (0–60 km/h)	8.2 seconds	6 seconds
Range	Battery discharge test	40 km
Stability	Real-world testing	Stable on inclines

Despite achieving stable handling, the maximum speed of 59 km/h was lower than the desired 95 km/h due to the additional weight of real components. This result aligns with the dynamic performance challenges discussed by Kubiak [13], which emphasize the impact of road contours on go-kart performance. The dynamic testing highlights the need for further weight reduction and optimization to meet the initial design goals. Figure 5 illustrates the Dyno test result, showing the power curve with the red line representing the maximum power output of the go-kart. The results revealed a maximum power of 23.1 HP and a torque of 44.52 N·m, demonstrating excellent stability and operational reliability on the hilly roads of Universitas Andalas.

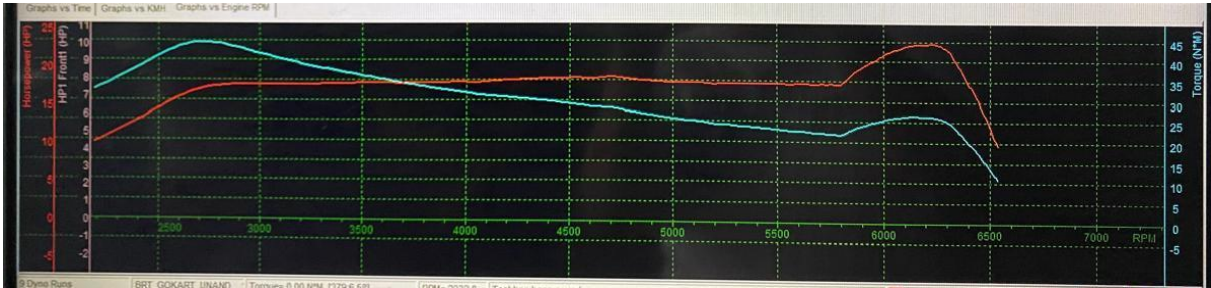


Figure 5. Dyno test result

3.5 Safety and Braking System

To ensure safety, a hydraulic braking system and additional safety features were integrated and tested.

Table 11. Safety System Results

Safety Feature	Test Results	Performance
Hydraulic Braking	Effective stopping	Responsive
Emergency Stop Switch	Immediate power cutoff	Functional
Circuit Breaker	Protection from overload	Activated as required

The safety design of the go-kart follows the wiring diagram provided in the electric go-kart manual as shown in Figure 6. A Miniature Circuit Breaker (MCB) operates at a current limit of 125 A. This feature prevents the electrical components from overheating and mitigates the risk of fire due to overcurrent situations. Additionally, an emergency stop switch was installed (Figure 7), which serves as an emergency cutoff for all power to the go-kart, providing critical safety in the event of unforeseen circumstances. These safety features were integrated into the "E-Andalasian" go-kart to enhance overall safety, providing protection against electrical faults and ensuring reliable performance in real-world operating conditions. The MCB and emergency stop switch are essential components that safeguard the go-kart from potential electrical hazards, aligning with safety standards discussed in previous research by Krishnamoorthi et al. [4].

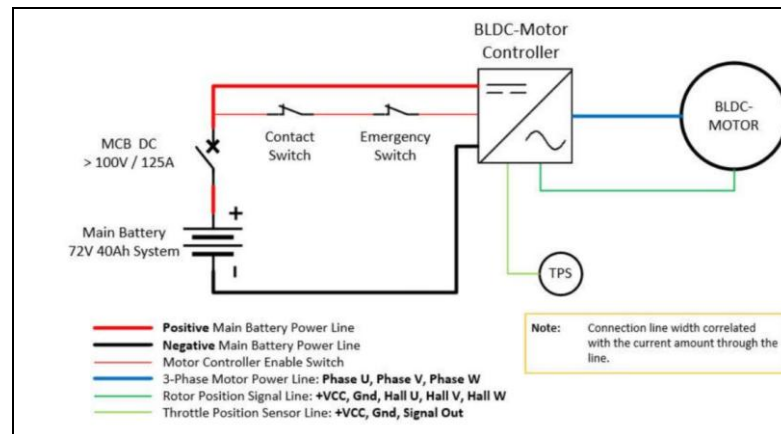


Figure 6. Wiring Diagram of the Go-Kart Andalasian



Figure 7. Emergency Stop Switch

4. Conclusion

This research presents a comprehensive approach to designing and developing the "E-Andalasian" electric go-kart as a sustainable transportation solution for Universitas Andalas in West Sumatra. Key findings highlight several critical aspects: the structural design using Aluminum Alloy 6061 provided an optimal balance of strength and weight, making the go-kart capable of handling the challenging hilly terrain without excessive deformation. The 72V BLDC motor demonstrated stable RPMs and power output under load conditions, but the power output was slightly below the ideal target, indicating a need for weight reduction and further optimization in component integration. The 72V 40Ah lithium-ion battery provided adequate range, though its performance fell short of the desired range due to the hilly terrain. The go-kart displayed good stability and handling on the university's undulating roads, but its maximum speed was lower than the target due to the added weight of real components. The braking and safety systems performed reliably, ensuring safe operation. For future research, recommendations include focusing on further weight reduction, improving the efficiency of the electrical systems, conducting dynamic testing under varied conditions, and integrating smart technologies to enhance real-time performance monitoring and enable autonomous driving features. Overall, the "E-Andalasian" go-kart represents a promising advancement towards sustainable campus transportation, providing a foundation for future development with a focus on enhancing performance, safety, and environmental sustainability.

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