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IMPLEMENTATION OF DALY BMS AND MODULXHM604 AS A BATTERY PACK FOR ECGO2 ELECTRIC MOTORCYCLES TO IMPROVE SAFETY, CAPACITY AND FAST CHARGING

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Abstrack: This research aims to improve battery performance and safety on the ECGO2 electric motorcycle by re-assembling the battery system using 18650 lithium cells, Daly BMS 13S/7A battery management system, and XH-M604 module. The configuration used is 13S5P (65 cells), resulting in a total voltage of 48.1 V and a capacity of 14 Ah, or equivalent to 673.4 Wh of energy. Compared to the ECGO2 built-in battery that requires 4-7 hours of charging time, this system is able to speed up charging to ±1.6 hours using a 7 A current charger. Test results using an oscilloscope show that the voltage of the assembled battery is more stable under load than that of a single battery, with minimal ripple. The estimated operating time of an 800 W electric motor using a 673.4 Wh battery is about 50 minutes. To achieve 2 hours of operation, the 13S10P configuration or energy-saving mode (400-500 W) can be used. The system is also more cost-effective at Rp2,678 per Wh compared to the manufacturer's version of Rp4,464 per Wh, as well as improved safety against leakage and overheating.

Keywords: daly bms; electric motorcycle; fast charging; 18650 lithium battery.

Abstrak: Penelitian ini bertujuan untuk meningkatkan performa dan keamanan baterai pada sepeda motor listrik ECGO2 dengan merakit ulang sistem baterai menggunakan sel lithium 18650, sistem manajemen baterai Daly BMS 13S/7A, dan modul XH-M604. Konfigurasi yang digunakan adalah 13S5P (65 sel), menghasilkan tegangan total 48,1 V dan kapasitas 14 Ah, atau setara dengan energi 673,4 Wh. Dibandingkan baterai bawaan ECGO2 yang memerlukan waktu pengisian 4–7 jam, sistem ini mampu mempercepat pengisian menjadi ±1,6 jam menggunakan charger arus 7 A. Hasil pengujian menggunakan osiloskop menunjukkan bahwa tegangan baterai rakitan lebih stabil di bawah beban dibandingkan baterai tunggal, dengan ripple minimal. Estimasi lama pengoperasian motor listrik 800 W menggunakan baterai 673,4 Wh adalah sekitar 50 menit. Untuk mencapai 2 jam pengoperasian, dapat digunakan konfigurasi 13S10P atau mode hemat energi (400–500 W). Sistem ini juga lebih hemat biaya dengan efisiensi harga Rp2.678 per Wh dibandingkan Rp4.464 per Wh versi pabrikan, serta meningkatkan keamanan terhadap kebocoran dan panas berlebih.

Kata kunci: baterai lithium 18650; daly bms; sepeda motor listrik; pengisian daya cepat.

INTRODUCTION

Electric motorcycles are one type of vehicle that does not produce CO_2 emissions, making them a viable alternative in response to the rising prices of fuel types such as Pertalite and Pertamax, as well as a solution to reduce air pollution typically caused by fuel-powered motorcycles. In Indonesia, between 2021 and 2022, the number of motorcycles reached approximately 125,305,332 units. Each motorcycle emits about 0.15 kg of CO_2, meaning that in just one day,

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motorcycles in Indonesia generate around 18,795,799.8 kg of CO_2 emissions.

To combat rising air pollution, the Ministry of Transportation promotes electric vehicles, encourages public transportation, and enforces stricter emission standards. Regulations PM No. 44/2020 and PM No. 45/2020 provide the legal basis for electric vehicle operation on public roads [1].

The proposed battery system with Daly BMS (13s/7A) and a custom charger (24V/60A) improves current capacity, charging efficiency, and safety. In contrast, many Indonesian e-motorcycles still use 48V/14A lithium batteries (350W, 0.67 kWh) with only a 50–65 km range, long 4–7 hour charging times, no BMS protection above 20A—making them prone to overheating or fire—and relatively high costs. Therefore, the new design offers enhanced performance, shorter charging duration, and greater safety compared to existing systems. [2][3].

The EC-GO2 electric motorcycle's battery has several weaknesses, including limited capacity, long charging time, low charging input power, susceptibility to leakage, and high cost. These limitations highlight the need for this research, which aims to analyze and enhance the battery performance of the EC-GO2 by applying a Daly BMS module (13s/7A) combined with 18650 lithium batteries [4].

Several studies that discuss electric motorcycle batteries, including. Iman et al (2024) explained that the results of field tests obtained data showing differences in endurance (time), top speed, and distance traveled between 72V 40 Ah and 72V 20 Ah electric vehicles on 3 different road conditions [5]. Muhammad and Eka (2023). Battery efficiency testing at a speed of 40 km/hour showed the most optimal results. With a full voltage of 53.9 V, after traveling 20 km using a motor with a current limiter, the remaining voltage was 45.3 V. Efficiency was recorded as 10.4% better than a motor without a current limiter [6]. Using 20 5V 12Ah dry batteries connected in series and parallel, the voltage produced is 60.3–68.3V. Charging is done with a 60V smart charger that automatically stops when full, taking 2 hours. The adaptive method is more efficient because charging is monitored directly via the LCD.

Tests found that charging a 53.9V battery takes 4.38 hours, while charging a 60.3–68.3V battery only takes 2 hours. A faster process is achieved when using a PLN voltage source [4]. Research found that this electric vehicle was designed with 1,200 W of power and a top speed of 60 km/h, but in field tests, it only achieved 47 km/h. This reduction was due to the motor using only 1,000 W of power, the use of a reduced controller for energy efficiency, and the use of smaller-diameter wheels (20 inches) [7].

The purpose of this research is to conImage battery cells in a series-parallel arrangement and integrate the Daly BMS protection system (13s/7A) to achieve higher current and power output. To enable fast and safe charging, a special charging system is designed using a 10A digital volt module, an XH-M604 charge controller, and a 24V/60A power supply. This configuration not only improves charging speed and safety but also represents a novelty of the study, namely the combination of Daly BMS batteries arranged in series-parallel (13S/7P) with the XH-M604 module.

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METHOD

This research utilizes a laboratory experimental approach by calculating and redesigning the battery system of the ECGO2 electric motorcycle using a lithium 18650 battery configuration equipped with a Battery Management System (BMS) to enhance battery performance and safety. as for the flow diagram of this research :

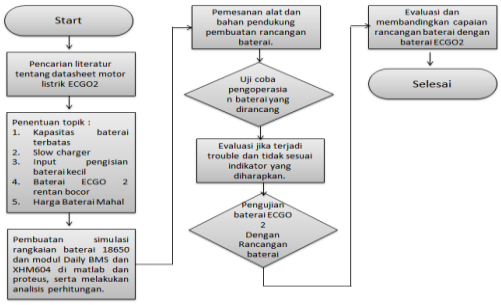

Image 1. Research Flow Diagram

The diagram illustrates the stages of designing a replacement battery for ECGO2, starting from literature review, circuit simulation, material procurement, testing and evaluation, to final performance comparison with the original battery.

The initial literature review of this research was carried out through a comprehensive study of relevant references :

(1) Baterai Capacity

$$C_{total} = C_{sel} x N_{paralel} \quad (1)$$

(2) Battery charger time

$$t_{charge} = \frac{C_{total}}{I_{charge}} xK \quad (2)$$

(3) Battery Operating Duration

$$t_{operasi} = \frac{E_{total}}{P_{beban}} \quad (3)$$

(4) Battery Leakage Current

$$E_{hilang} = E_{total} x \frac{r_{leak}}{100} \quad (4)$$

(5) Battery Cost Estimation and Efficiency.

$$H_{total} = N_{sel} x H_{sel} + H_{BMS} + H_{lainnya} \quad (5)$$

The ECGO2 electric motorcycle battery has a capacity of 48V/14Ah (672Wh), powering a 350W motor for about 1.9 hours or 50–65 km. Standard charging takes 4–8 hours but can be shortened to 1.6 hours with a 10A fast charger. It has a 3% monthly self-discharge (≈20Wh). The factory battery costs IDR 3–3.5 million, while a self-assembled 18650 lithium pack with BMS costs IDR 1.8–2 million, making it more economical at IDR 2,678/Wh versus IDR 4,464/Wh. [6],[8],[9].

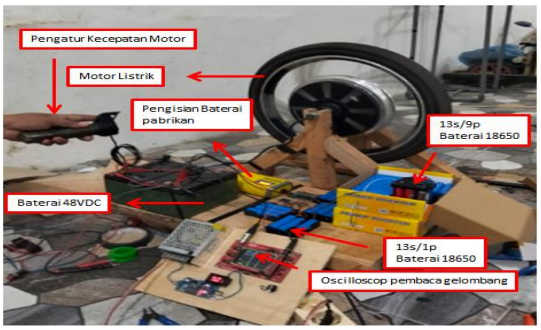

Image 2. Design of Daly BMS and XH-M604 Module with 13Sx10P 18650 Battery Pack (48VDC, 12A/44V).

The image shows the 48 VDC battery test setup for the ECGO-2 electric motorcycle. A 13s×10p pack of 18650 lithium cells provides the voltage and capacity required by the traction motor. A Battery Management System (BMS) monitors each cell's voltage, prevents overcharge and over-discharge, and balances cells to keep operation stable. The pack connects to a control unit and digital display for real-time monitoring of key test parameters during charge and discharge. This testing stage verifies performance and safety before the battery is integrated into the vehicle.

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RESULT AND DISCUSSION

The research findings show that redesigning the ECGO2 electric motorcycle battery with lithium 18650 cells in a 13S4P configuration and integrating a Daly BMS (13s/7A) successfully enhances capacity, shortens charging time to about 1.6 hours, and improves cost efficiency by up to 40% compared to the original battery, while still ensuring safety and operational stability. The detailed test results are as follows:

Battery capacity.

V_{total} = 3.7V x 13 = 48.1V

C_{total} = 2.8Ah x 5 = 14Ah

E = V x Ah atau E = 48.1V x 14Ah = 673.4Wh

The calculation results reveal a performance comparison between the original battery and the newly assembled battery pack.

Table 2. Comparison Performance Battery

Parameter	ECGO-2	18650 modification
V	48v	48.1V
C	14Ah	14Ah
W	672Wh	673.4Wh
Sell	Kering	65 sell (18650)
Tin	4-7 hour	±1.6 jam (Fast Charger)
Protection	LOW	Daly 13 cell/7A
Temperature	Rawan over heat	Stable and safe
Estimation	3-6 million	1.8-2.5 million

The custom 13S5P battery pack built with 18650 cells and a Daly BMS (13s/7A) delivers the same capacity and voltage as the original ECGO2 battery (48V, 14Ah). However, it offers superior performance with a faster charging time of about 1.6 hours and a lower cost of IDR 1.8–2 million. In addition, enhanced current protection ensures greater safety and operational efficiency [10][11]

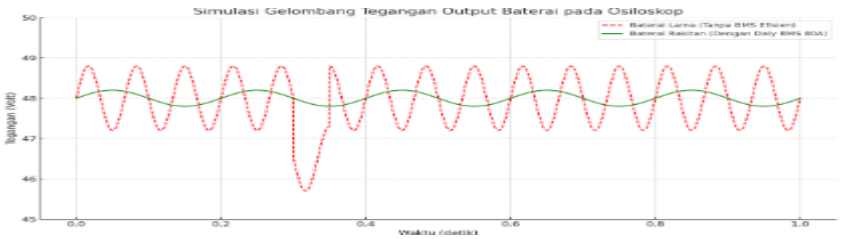

Image 3. Comparison of the operating waveforms of the two batteries.

The oscilloscope image compares the output waveforms of the custom 13S5P battery pack and a single 18650 cell. The single cell shows unstable waveforms with noticeable voltage fluctuations under load, while the assembled pack produces a flatter, more stable waveform. This indicates a steadier voltage supply and stronger performance under high loads, demonstrating the effectiveness of the series-parallel configuration in stabi-

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lizing power delivery and enhancing system efficiency.

Battery Charging and Operating Time

To complete the charging of a 18650 battery pack consisting of 13 cells in series and 5 cells in parallel (total 65 cells) within 2 hours, the charging current must be increased to at least 7A, calculated as follows:

$$I = \frac{12.5A}{2.x.0.9} = 6.9A \text{ or } 7A.$$

Image 4. 13S/20A BMS module for 18650 cells (3.7 V, 6.9 A).

The ECGO2 electric motorcycle uses an 800W motor with chain drive and CVT, powered by a 48–60V lithium battery (up to 26Ah). It offers a 70–80 km range per charge, 4–6 hour charging time, three speed modes, and a top speed of 60 km/h, with 2–3 hours of operation depending on usage condition :

$$t_{operasi} = \frac{673.4Wh}{800H} = 0{,}48\,jam/50menit$$

To extend the ECGO2's operating time to about 2 hours, the battery capacity can be increased from a 13S5P (14Ah) to at least 13S10P (28Ah), or by using higher-capacity cells (3,500 mAh each). An alternative solution is to run the motor in ECO mode, which consumes only 400–500 W, enabling the existing 14Ah battery to last nearly 2 hours without adding more cells [12], [13].

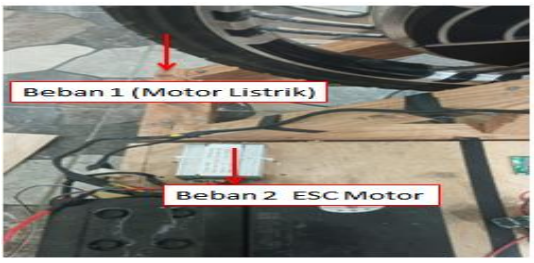

Image 5. Load circuit of the electric motorcycle wheel and the ESC module.

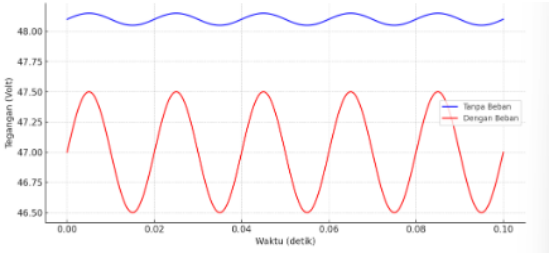

Image 6. Comparison of battery waveforms under no-load and load conditions.

The waveform illustrates battery voltage behavior under no-load and load conditions. In the no-load state (blue line), the voltage is stable at around 48.1 V with minimal ripple, indicating little current draw. Under load (red line), the voltage drops to about 47 V with increased ripple due to the motor's current demand. This is a common phenomenon in electrical systems, where higher loads cause voltage drops and reduced stability.

Battery Leakage, Estimation, and Efficiency

A single cell failure in the 13S5P battery reduces one parallel group's capacity from 14 Ah to 11.2 Ah, lowering the total capacity to about 13.77 Ah. Consequently, the ECGO2's operating time decreases slightly from 50 minutes to around 49.8 minutes. Although this reduction is minimal, the resulting current imbalance can accelerate cell degradation and raise the risk of overheating, ultimately reducing the battery system's efficiency and safety.

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$$t_{baru} = \frac{48.1x13.832}{800} = 0.83.or.49.8\,\text{min}$$

If the leakage current is more severe (e.g., 1 A from a short circuit or damaged cell), the loss of operating time and heat generation can become significant, posing a risk to the entire system. In a 13S5P configuration, failure of a single cell reduces one parallel group's capacity from 14 Ah to 11.2 Ah, lowering the total battery capacity to about 13.77 Ah. This decreases the ECGO2's operating time from 50 minutes to roughly 49.8 minutes. Although the reduction seems minor, the current imbalance accelerates cell degradation and raises the risk of overheating, which over time diminishes efficiency and undermines the battery system's overall safety and reliability.

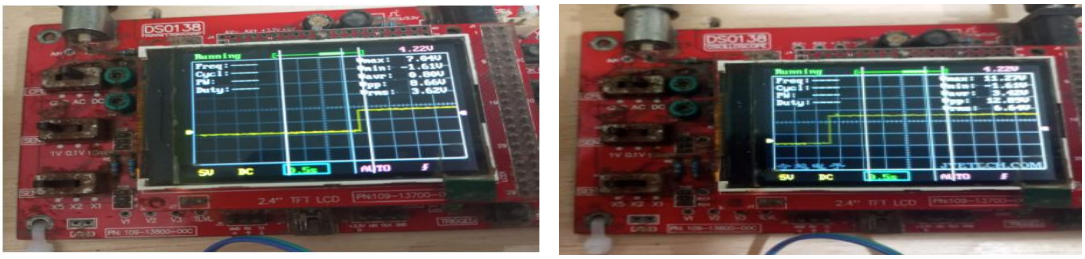

Image 7. Comparison of waveforms with and without leakage.

The 18650 battery has a nominal voltage of 3.7 V and a maximum of 4.2 V. In a 13-series, 5-parallel (13S5P) configuration, the pack produces a nominal voltage of about 48.1 V and a maximum of 54.6 V. With each cell rated at 1,200 mAh (1.2 Ah), the total capacity is 6 Ah, giving an output of roughly 48.1 V × 6 Ah ≈ 289 Wh. [11][12].

The image shows the voltage waveform of a 13S5P battery pack on an oscilloscope. On the right, the normal condition appears with a stable voltage of about 48.1 V and minimal ripple. In contrast, the red line represents a leaking cell, marked by a voltage drop to around 47.8 V and increased ripple from internal current imbalance. This indicates potential performance issues and safety risks if the leakage is not promptly resolved.

CONCLUSION

The 13S5P 18650 battery with a 13S/7A BMS and XH-M604 module improves charging efficiency (≈1.6 hours), stability, safety, and cost-effectiveness compared to the factory battery. This design offers a practical alternative for commercial e-motorcycles, with potential for further development using active cooling or higher-capacity cells to extend range and lifespan.

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