JRAEE

Journal of Robotics, Automation, and Electronics Engineering
Vol. 3, No. 1, 2025, pp. 136-142
e-ISSN 3025-3780
https://journal.uny.ac.id/v3/jraee

Electrical System Design for the UG-22 Car for the Energy Efficient Car Competition

Muhammad Naufal Muafi[a,1], Sa'adilah Rosyadi[b,2,*]

[a, b]Dept. of Electrical and Electronic Engineering, Vocational Faculty, Universitas Negeri Yogyakarta
[1]muhammad0049ft.2020@student.uny.ac.id; [2]s.rosyadi@uny.ac.id
[*] Corresponding Author

ARTICLE INFO

Article History
Received 25 Oct 2024
Revised 29 Aug 2026
Accepted 31 Aug 2026

Keywords
Car;
Electrical System;
Efficient;
Grounding;
Resistance

ABSTRACT

This research examines the design and construction of the electrical system for the UG-22 car, the reduction of resistance in its electrical system, and the impact of these improvements on the car's results in the Energy Efficient Car Competition. The study describes the stages involved in designing and building the electrical system for the competition, as well as in optimizing the existing system, using the UG-22 car's electrical system as the object of study. Two optimization steps were taken: first, replacing the cable material with a type that has lower resistance; second, adding a grounding system to the car. The system design had to comply with the competition regulations, and the results show that optimizing the electrical system reduced electricity consumption in the UG-22 car. Cable resistance was reduced to 2.2 ohms, a decrease of 48.3%, and adding the grounding system reduced the voltage drop by 2 volts. As a result, electricity consumption was reduced by 49.71%, from 60 joules to 30.5 joules.

ABSTRAK

Penelitian ini bertujuan menguji rancang bangun sistem kelistrikan pada mobil UG-22, pengurangan resistansi pada sistem kelistrikan, dan dampak perbaikan sistem kelistrikan terhadap pencapaian dalam Kompetisi Mobil Hemat Energi. Penelitian ini mendeskripsikan tahapan dalam proses perancangan sistem kelistrikan mobil UG-22 untuk kompetisi mobil hemat energi, serta optimalisasi sistem dengan objek penelitian sistem kelistrikan mobil UG-22. Langkah yang diambil untuk mengoptimalkan sistem kelistrikan dengan mengganti material kabel dengan jenis yang memiliki resistansi rendah dan dengan menambahkan sistem *grounding* (pentanahan) pada mobil. Desain sistem kelistrikan harus memenuhi regulasi kompetisi, dan hasil penelitian menunjukkan bahwa optimalisasi sistem kelistrikan mampu mengurangi konsumsi listrik pada mobil UG-22. Resistansi pada kabel berkurang menjadi 2,2 ohm sebesar 48,3%, dan dampak penerapan *grounding* menunjukkan bahwa hal tersebut mengurangi penurunan tegangan (*voltage drop*) sebesar 2 volt. Selain itu, konsumsi listrik dapat ditekan sebesar 49,71% dari 60 joule menjadi 30,5 joule

1. Introduction

Vehicles rely on a complex network of systems that must work together optimally, with the electrical system being one of the most critical. Electricity plays an essential role in modern motor vehicles, which depend heavily on electrical current for many of their features. Vehicles are equipped with various vital electronic devices, for example, headlights are crucial for safety as they illuminate the road for drivers at night. Therefore, the placement and integration of these electronic components within the car must be both strategic and efficient.

The Energy Efficient Car Competition (*Kontes Mobil Hemat Energi, KMHE*) challenges teams to design, build, test, and drive vehicles that meet safety requirements while travelling the greatest possible distance on minimal energy. The competition is held in Indonesia by the Ministry of Energy and Mineral Resources and is included in the Puspresnas (National Achievement Center) agenda. It is intended to inspire students across Indonesia to innovate in response to future energy challenges. Vehicles entered in the 2022 competition were required to pass detailed technical inspections, for example checking that all bolts were properly tightened and that the doors locked correctly, before being allowed to continue to the race.

A poor-quality electrical system can reduce the responsiveness of sensors and other components, particularly in the ignition system, which depends heavily on the electric spark used for combustion. The effectiveness of a vehicle's ignition system is strongly influenced by its electricity supply. Ignition occurs when the spark plug produces a spark that ignites the compressed air–fuel mixture; it is measured in crankshaft degrees, both before and after Top Dead Center (TDC). The quality of the ignition timing must match the engine's specifications to achieve optimal performance, stronger ignition improves vehicle efficiency [1].

The electrical system of an energy-efficient car covers several circuits, broadly grouped into lighting and warning systems. The lighting system includes the headlights and daytime running lights, while the warning system includes the brake lights, turn signals, the horn, and the indicator and instrument lights. The electrical system plays a very important role in the vehicle, particularly as the main source of illumination when driving at night; it also signals other drivers when the car is turning or braking, and sounds the horn, all important elements of overall vehicle safety [1]. In the Energy Efficient Car Competition, teams must find ways to make both fuel consumption and electricity consumption as efficient as possible. This depends on selecting good-quality raw materials and using more advanced production techniques to create high-quality components. Vehicle weight is another factor that affects fuel consumption [3]: the heavier the car, the more power it requires. It is therefore important to identify the causes of high electricity consumption in the UG-22 car. One such cause is the quality of the cables used, a car's electrical system is the electronic circuit that manages every aspect of electricity in the vehicle. In other words, every component that uses electrical energy is part of the car's electrical system, and this system has a significant impact on fuel efficiency [2]. Because the Energy Efficient Car Competition is held every year, the Garuda UNY team must continually improve and re-evaluate its design. Problems have arisen from constraints in component and cable selection, and any redesign or rebuilding of the electrical system must comply with the rules and regulations issued for the 2022 competition.

2. Literature Review

2.1 The Energy-Efficient Car Competition (*Kontes Mobil Hemat Energi/KMHE*)

KMHE is a competition organized by the Ministry of Energy and Mineral Resources (ESDM) of the Republic of Indonesia, held since 2010 [4]. Its main objective is to encourage the advancement of energy-efficient car technology in Indonesia. In recent years, demand for energy-efficient cars has grown alongside increasing awareness of the importance of efficient, environmentally friendly energy use.

2.2 Basic Concepts of Electricity

Electricity is an essential component of any system used to produce an electric current that can serve as a power source. It can therefore be considered fundamental, for example an electric motorcycle cannot run without it. The following is a brief overview of the basic concepts of an electrical system [5]. This definition is not far removed from the one used in physics: the ability to do work. In everyday life, the energy used by machines and electronic devices is not the same as the energy needed by living things. Machines and electronic devices both require energy to function, but machines draw their energy from fuels such as gasoline, whereas electronic devices require energy in the form of electricity.

2.3 Cable Network

A cable network is a collection of individually insulated cables that connect the various components of a

ISSN 3025-3780 (online)
ISSN 3025-4590 (printed)

circuit. These cables are combined into a single unit to facilitate connections between the electrical components of a vehicle. Cables are the primary components of an electrical installation, channeling electrical energy to the equipment that uses it; they are also the most vulnerable component from the standpoint of electrical installation safety [6].

3. Research Method

This research is Research and Development (R&D), a method that produces a design or a product in a given field and evaluates its effectiveness. The study takes a quantitative approach, using numerical data obtained from measurements with a joule meter to determine how much electricity is consumed. This chapter describes the stages involved in designing and building the electrical system of the UG-22 car for the energy-efficient car competition. The stages used in the design process are shown in Fig. 1.

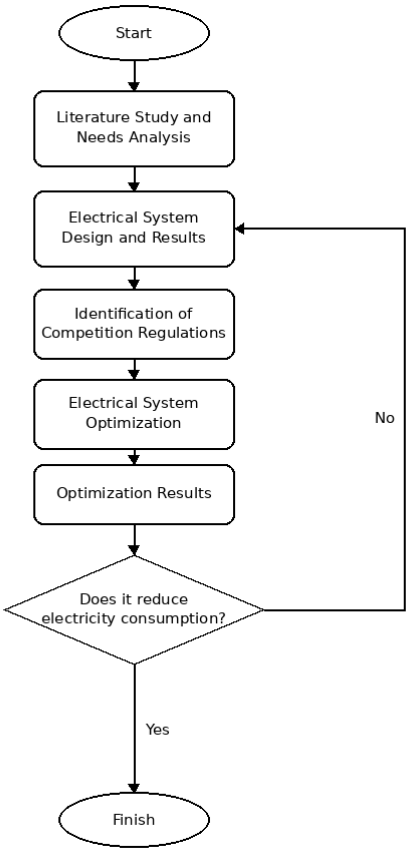

Fig.1 System flowchart design

3.1 Place and Time of Research

The research was conducted at the Faculty of Engineering, Yogyakarta State University (Universitas Negeri Yogyakarta), Karangmalang Campus, Yogyakarta. Its objective was the electrical system of the UG-22 car, with the goal of making it more efficient and achieving better results than in the previous year. The optimization was based on the team's 2021 competition data, which showed that the car's electrical system was still wasteful, particularly because of its cabling. The optimization work was carried out from January to September 2022 and then tested directly in the KMHE competition in October. During the project, the author had the opportunity to rebuild the UG-22's wiring in its entirety. Data gathered during vehicle testing and during the competition itself were used to develop this final thesis.

3.2 Research Procedures and Stages

- Requirement Analysis

Needs analysis is the initial stage carried out to determine the various requirements before designing the UG-22's electrical system. This analysis is based on the problems identified in the field and is carried out through a literature study.

- System Design

Once the needs analysis is complete, the next step is to design the system. This stage produces a design that guides construction, ensuring that the system meets the desired specifications [8], and helps minimize errors during manufacturing. The design process includes planning the wiring layout and confirming that the system will function as expected once built.

System Flowchart: the first step in designing a car's electrical system is to map out the workflow of the system to be built. This is done by creating a system flowchart that describes the process and the sequence of steps needed to operate the system. The flowchart of the UG-22's electrical system for the energy-efficient car competition is shown in Fig. 2.

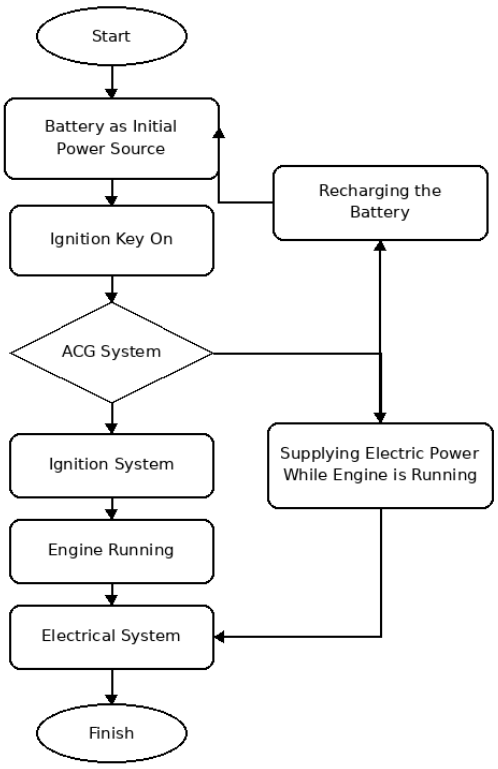

Fig.2 System flowchart design

- Electrical System Optimization

At this stage, the team addressed problems in the UG-22's electrical system by replacing its cables and adding a grounding system. These changes were intended to improve the efficiency of electricity consumption during the KMHE race and to ensure that the electrical system functioned properly and reliably, supporting the car's overall performance.

3.3 Data Collection Techniques

This report draws on several data collection methods, as follows:

- Observation

Direct observation was used to collect the data needed for the study, such as cable resistance values measured with an avometer (multimeter). This method allowed data to be recorded in detail and with accuracy through direct observation.

- Testing

This study used a testing method based on measurements from a monitoring system adapted from Abdillah [6], designed to record data in real time and give an accurate picture of the parameters relevant to the study, especially those related to electrical energy consumption. This allowed the researchers to observe and analyze electricity-usage patterns in more detail and systematically. A central focus of this testing was

ISSN 3025-3780 (online)
ISSN 3025-4590 (printed)

measuring electricity consumption during the race, carried out with a joule meter, which precisely calculates the amount of electrical energy used over a given period. The results were then analyzed to assess the efficiency of energy use and to identify potential savings or further optimizations for similar situations in the future.

- Documentation

The documentation method is similar to direct observation, but the data collected takes the form of electronic documents (photographs) used to support and reinforce the research. This is consistent with documentation studies, a data-collection technique based on written and electronic documents [7].

- Data Analysis Technique

The data analysis technique used in this final project involved analyzing the electric current, voltage, and resistance measured in the circuit in order to determine the electric power used in the UG-22's electrical system. Data analysis techniques are the set of procedures used to process, interpret, and draw conclusions from data in a systematic way [6].

4. Result and Discussion

4.1 Design and Results of Electrical System Manufacturing

The electrical system design for the UG-22 in the Energy Efficient Car Competition had to prioritize efficiency, intelligent power management, and safety throughout its operation. It needed to be designed around the principles of energy efficiency, reliability, and safety. The design and its implementation in the car are shown in Fig. 3.

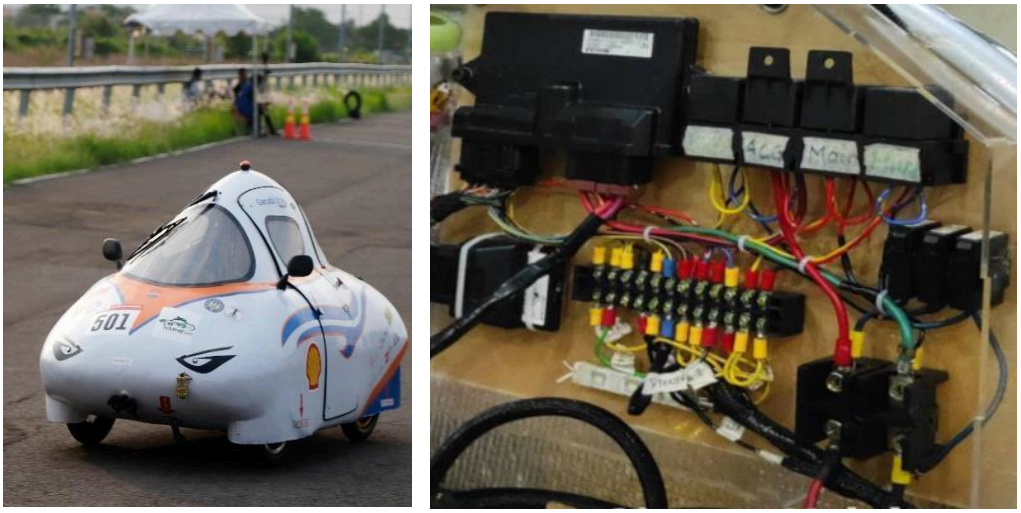

Fig.3 Implementation in the car

4.2 Analysis of Electrical System Results

Every electrical component has a significant effect on the car's electrical system and, in turn, on its energy consumption. In this case, the main problem with the electrical system was the high resistance found in the car during the previous year's competition. The researchers therefore sought to improve energy-consumption efficiency by reducing the resistance in the UG-22 car's electrical system.

Table 1. Electrical System Optimization Calculation

Condition	Cable / Material	Data Source	Voltage (V)	Voltage Drop (V)*	Resistance (Ω)	Energy Use (J)
Cable – before implementation	AVSS BF	2021 results	30	–	5.544×10^{4}	60
Cable – after deployment	AVSS	2022 results	30	–	5.412×10^{4}	30.3
Grounding – before application	–	2021 results	30	2.3	–	60
Grounding – after application	Silicone wire	2022 results	30	0.3	–	38.3

** Reported in the source data under the "Resistance" column heading for the grounding rows; retained here as originally presented.*

4.3 Optimization of the Electrical System Results

Reducing the resistance in the electrical system does not only improve electrical energy efficiency; it also has a positive effect on fuel consumption. With electrical energy used more efficiently, the UG-22 is better able to make use of its fuel, extending its range and improving its overall performance. This effect is especially valuable in competition, where every improvement in energy and fuel efficiency provides a competitive advantage. Optimizing the UG-22's electrical system therefore improves not only the car's technical performance but also its overall competitiveness.

Table 2. Calculation of Resistance Reduction

Parameter	Cable Length (m)	Resistance (Ω)	Energy Consumption (J)
Before implementation	92.4	5.544×10^{4}	60
After implementation	90.2	5.412×10^{4}	28.3
Reduction (impact)	2.2	1,320	21.7

4.4 Addition of the Grounding System

Adding a grounding system helps reduce resistance in the engine circuit. Resistance in the engine should be kept as low as possible, since it affects the responsiveness of the engine's sensors and, in turn, engine performance.

Table 3. Grounding Application Results

Parameter	Voltage Drop (V)	Energy Consumption (J)
Before implementation	3.3	60
After implementation	1.3	38.3
Reduction (impact)	2	31.78*

5. Conclusion

Based on the results and discussion presented above, this study concludes that resistance in the UG-22's electrical system can be reduced by replacing the cables with a lower-resistance type and by shortening the cable runs.

The voltage drop in the UG-22's electrical system can be reduced by adding a grounding system to the vehicle. Doing so reduced the voltage drop by 2 volts, which in turn reduced the amount of electrical energy consumed. Overall, optimizing the electrical system reduced the UG-22's electricity consumption from an initial 50 joules to 28.3 joules after optimization, a total reduction of 43.4%.

Author Contribution:

All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Funding:

This research received no external funding.

Acknowledgment:

The author would like to express gratitude to Universitas Negeri Yogyakarta for providing research facilities and support.

Conflicts of Interest:

The authors declare no conflict of interest.

References

[1] D. Linden and T. B. Reddy, Eds., Handbook of Batteries, 3rd ed. New York, NY, USA: McGraw-Hill, 2002.

[2] R. Afriwan, D. S. Putra, and Martias, "Pengaruh penggunaan voltage stabilizer terhadap konsumsi

ISSN 3025-3780 (online)
ISSN 3025-4590 (printed)

bahan bakar dan kandungan emisi gas buang pada sepeda motor Honda Vario 110 CC tahun 2009," Automotive Engineering Education Journals, vol. 6, no. 4, 2017.

[3] H. Abdi, B. Mohammadi-Ivatloo, S. Javadi, A. R. Khodaei, and E. Dehnavi, "Energy storage systems," in Distributed Generation Systems: Design, Operation and Grid Integration, G. B. Gharehpetian and S. M. Mousavi Agah, Eds. Oxford, U.K.: Butterworth-Heinemann, 2017, pp. 333–368, doi: 10.1016/B978-0-12-804208-3.00007-8.

[4] F. Ardiansyah, "Fungsi isolator pada kabel beserta bahan dan jenis isolator kabel," Pendidikan Elektronika, 2021.

[5] M. I. Fakhri and T. Sukarnoto, "Analisis chassis mobil hemat energi untuk Kontes KMHE tipe prototype Team HMM Usakti," Jurnal Penelitian dan Karya Ilmiah Lembaga Penelitian Universitas Trisakti, vol. 8, no. 2, pp. 330–336, 2023, doi: 10.25105/pdk.v8i2.15812.

[6] T. Ginting, "Pengaruh jenis busi terhadap konsumsi bahan bakar motor bakar 4 tak," Jurnal Informatika Kaputama (JIK), vol. 5, no. 1, pp. 89–98, 2021, doi: 10.59697/jik.v5i1.306.

[7] Nicolaus, G. S. Lubis, and M. Ivanto, "Studi pengaruh dan optimasi sistem transmisi pada kendaraan prototype kelas motor listrik Kontes Mobil Hemat Energi (KMHE) menggunakan metode Taguchi," JTRAIN: Jurnal Teknologi Rekayasa Teknik Mesin, vol. 5, no. 1, pp. 22–28, 2024.

[8] Balai Pengembangan Talenta Indonesia, Pedoman Kontes Mobil Hemat Energi Tahun 2023. Jakarta, Indonesia: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2023.

[9] J. V. Hutagaol, D. Setiawan, and H. Eteruddin, "Perancangan sistem monitoring kendaraan listrik," Jurnal Teknik, vol. 16, no. 1, pp. 96–102, 2022, doi: 10.31849/teknik.v16i1.9640.