Robust Design of Energy Efficient Grass Cutting Robot

Muhammad Tahir Saleem[1], Aisha Akbar Awan[2]

[1,2]Department of Mechatronics Engineering
Wah Engineering College, University of Wah
[1]raotahir629@gmail.com
[2]aisha.akbar@wecuw.edu.pk

ABSTRACT

Regular mowing is necessary to maintain lawns and grassy areas, but this may be a time-consuming and labor-intensive chore. Currently, people cut grass with manually operated tools, electrical lawnmowers, and internal combustion engines, all of which are time-consuming and environmentally unfriendly. This research proposes the idea of a teleoperated solar-powered lawn mowing robot that avoids these disadvantages. Through the use of an android application, an operator may precisely navigate the lawn by controlling the robot's forward, backward, left, and right motions. The grass cutting efficiency is improved by the incorporation of solar panels. By reducing carbon emissions, it lessens reliance on conventional fossil fuel-based energy sources and has a minimal negative effect on the environment. Solar energy is also self-sustaining, so the robot can maintain the grass continuously for long periods of time without having to stop. This design demonstrates how technology may be utilized to minimize human labor while still utilizing renewable energy sources effectively.

Keywords: Teleoperated solar powered grass cutter, Efficient Design, Android Application, Rechargeable solar powered batteries.

1. INTRODUCTION:

Prior to Edwin Budding's creation of the first grass cutter in England more than a century ago, chores involving cutting grass were completed using manual instruments like the scythe [1]. Since then, grass cutter machines have become more and more popular and used in the care of yards and lawns. The conventional design of grass cutters with gasoline engines had several disadvantages, such as the need for frequent maintenance (grease and engine oil), which cost additional money and required labour. They were accountable for the environmental pollution as well. Furthermore, motors driven by fossil fuels have a tendency to freeze and stop working under adverse weather conditions[1]. Environmental consciousness and technology are combining to lessen pollution and its impacts. Customers are searching for methods to play a part in lessening pollution [2]. In light of all of this, the development of an environmentally friendly lawnmower is necessary to assist with green technology initiatives. The purpose of this article is to design and build a solar-powered teleoperated grass cutting machine that will address many issues with conventional lawn mowers by using solar power as an energy source. The mower and an Android phone are connected via Bluetooth thanks to an application. It results in mechanical motions like mowing grass, turning left, turning right, and moving ahead and backward. The Android app controls each of these motions. Thus, customers may utilize an Android application to mow lawns when positioned far away. In the end, the consumer will labour less in their everyday life and contribute more to the environment. The mower may be used to maintain clean, well-kept ground in shopping centres, parks, schools, hospitals, etc.

2. LITERATURE REVIEW:

After reviews and comparisons of the efficacy of gasoline, electric, and solar lawnmowers, it was determined that the solar mowers were quieter, more energy-efficient, and required less maintenance. Since it runs on solar power, there is no air pollution, unlike gasoline mowers that create a lot of noise and have an adverse effect on the environment.[3], [4]

A number of systems were proposed for grass cutting robot and all of them reduced the need of human interruption. but rather than using a smart phone for controlling the robot they used alternative methods like the use of ultrasonic sensor or inputting the dimensions of the plot before the cutting operation.[5]–[10]

A unique concept for a self-sufficient solar-powered device was put forth, which utilizes a Bluetooth module to enable operation via a mobile device. However, they did not create a real physical system—rather, they only ran and examined several simulations using various software.[11]

In order to minimize air pollution, solar-powered remotely operated lawn cutter prototypes were created. These prototypes could operate wirelessly via Bluetooth from a safe distance, using an Android smartphone.[12]–[15]

3. METHODOLOGY:

3.1 Design:

For our design, many parameters should be under consideration, such as selection of components, structure of the main body and position of the components in the main body. The most crucial aspect of our design is the efficiency of the robot, which is highly dependent on the above-mentioned parameters. We start with our project with making sketches and drawing schematic diagrams of our robot so we can better visualize our design.

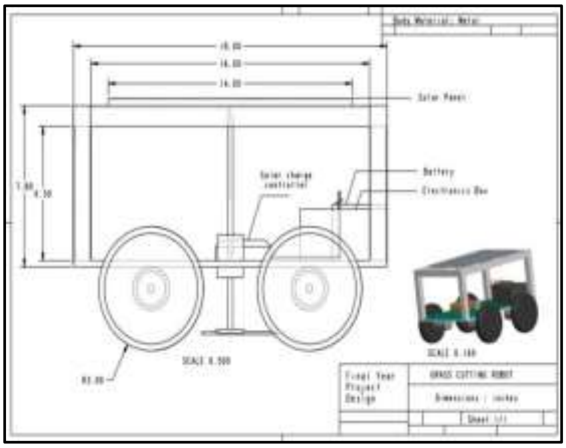

Figure 1: Sketch with Dimensions

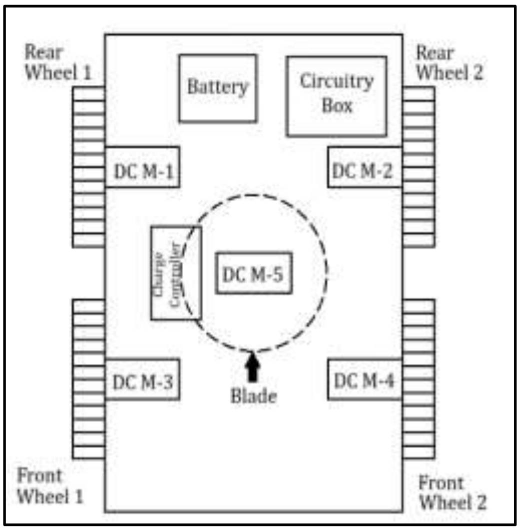

Figure 2: Schematic Diagram of the Robot

In the above schematic diagram, the circuitry box would contain the circuit elements of the robot like the microcontroller, motor driver and wires.

All the four wheels of the robot has its own DC motor for the movement of robot and a motor used at the canter with the blades for cutting mechanism. The charge controller is placed besides the cutter motor and not included in the circuitry box due to its big size.

With the help of the above sketch and schematic diagram 3D model of the robot was made.

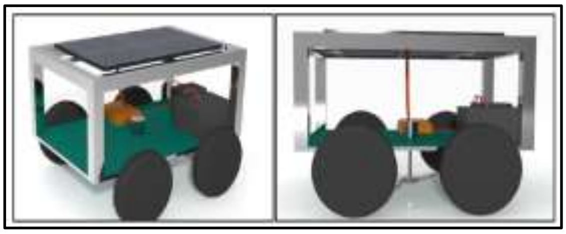

Figure 3: 3D model created in SolidWorks software

3.2 Calculations:

This design is proposed keeping the efficiency of the system in mind. Efficiency is basically the ratio of power input to the power output of the system i.e.

$$\eta = \left(\frac{P_{out}}{P_{in}} \times 100\right)\%$$

The solar panel is of 50watt and we suppose our operation takes 2.5 hrs. so, the input power in our system is 125Wh(watthours). Now for the power output of our system which can be easily found by finding the power used by different components of our system by the formula:

$$P = V \times I$$

we see that the components that are mainly responsible for power consumption are the movement and the cutter motor. For a 2.5hr operation the power that would be consumed by the movement motors and the cutter motor, from the above equation would be 96Wh and 10.2Wh. So, by neglecting the minor power losses, the overall power output of our system would be 106.2Wh.

3.3 Components Selection:

Based on the design calculations we concluded the following components for our project design.

Table 1: Component Details

Component	Specification
Battery	7Ah lead acid battery
Solar Panel	50 watts Monochromatic
Movement Motors (4)	12V DC Motor
Cutter Motor	12V (2400RPM) Motor
Microcontroller	STM32F103C8
Bluetooth Module	HC-05
Motor Driver	L293D
Charge Controller	24V(Max), 10Amp

3.4 Circuitry:

The circuitry of our system includes the components like the microcontroller, the Bluetooth module, battery and charge controller etc. The overall working of the circuitry of our system can be expressed easily by the following block diagram.

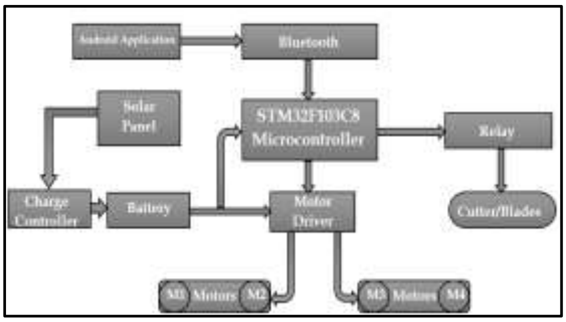

Figure 4: Block Diagram

Where the solar panel, charge controller and the battery would be connected in such a way, as shown.

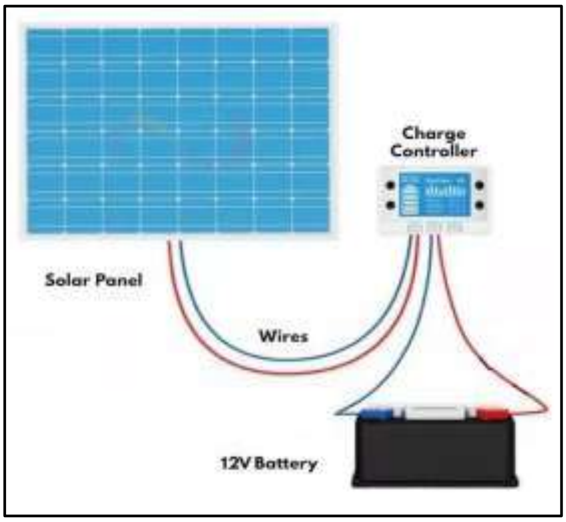

Figure 5: Solar panel-battery connection

3.5 Simulations:

The major parts of our circuitry system are the movement and cutter motors. To avoid any possible damage to the circuit components, first we conduct simulations on software. For that purpose, we have used proteus software. However, some components like the STM microcontroller and the Bluetooth module are not available in the proteus library so, run simulations using logic probes instead of the microcontroller to check the functionality and feasibility of the motors and motor driver.

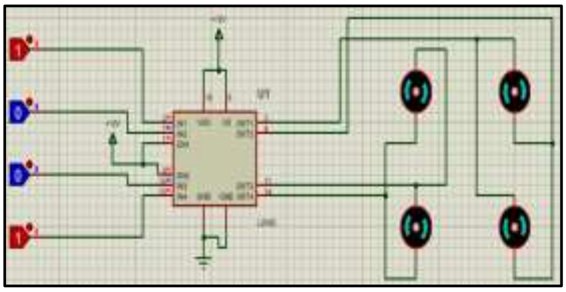

Figure 6: Simulation for the movement motors

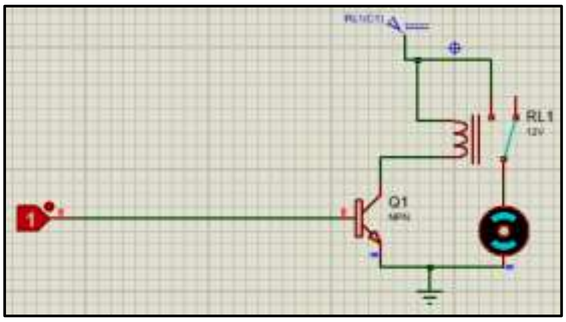

Figure 7: Simulation for the cutter motor

The microcontroller is programmed in such a way to use its USART2 module to receive and transmit data over a serial communication interface. In our case to receive characters from an external device (smart phone) and perform specified actions (movement/cutting) based on the received characters.

4. RESULTS AND DISCUSSION:

This robot's whole system is powered by a DC 12V 7Amp battery supply. A solar panel is attached to this battery. Consequently, this battery gets charged by solar energy. This device contains four DC motors that are attached to four wheels, and the grass-cutting blades are connected to the middle, lower side of the robot. This system requires a connection with an Android smartphone in order to function.

Figure 8: Lawn Mowing Robot

Bluetooth is being used to link the two together. After establishing a successful connection, the user may control the device using an Android app. The figure below shows the flowchart of the system:

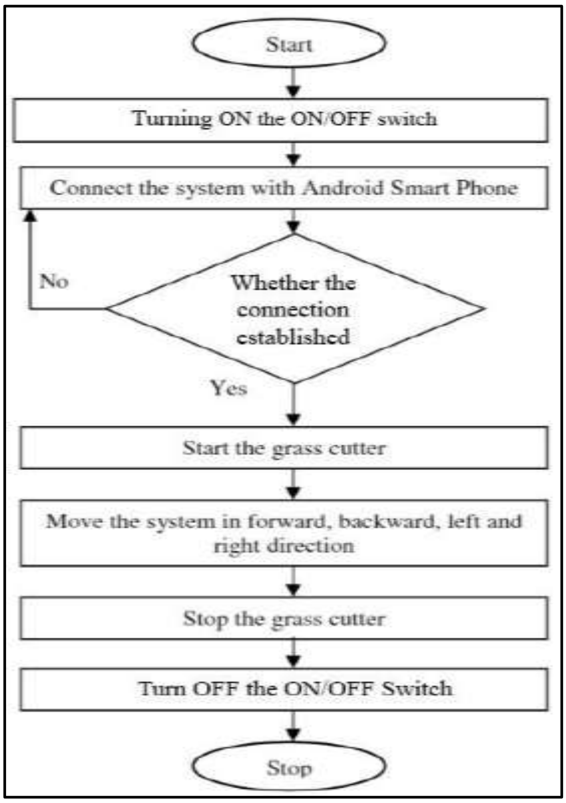

Figure 9: Flowchart of the system

4.1 Design Analysis:

The Efficiency is a factor that discriminates our solar based system from the traditional gasoline-based systems. As it is already discussed and calculated, that the power input of our system is 125Wh and the power output of the system is 106.2Wh. so by using equation 2 we calculate the efficiency that results in 84.96%. In a study on gasoline based engines the efficiency was found to be around 54%-56%[16]. This is due to the huge losses of power in these gasoline-based system. Whereas, in our system, there are little to no losses of power. Hence, it is clear that our lawn mower is a reasonable replacement to the traditional mowers.

4.1.1 Advantages:

- It is cost effective due to low maintenance cost and no fueling cost.
- Light weight
- Can be used in areas where large machineries cannot be used due to its small size.
- It is an easy way to lower greenhouse gas emissions and to create a cleaner environment.
- Remote control of the robot allows users to mow the grass without having to physically strain themselves in hard-to-reach places or on uneven terrain.
- Does not require a skilled person for operation.

4.1.2 Disadvantages:

- If there is no sunlight the system has to be charged traditionally by a charger.
- It cannot be operated during rain.
- Only suitable for small lawns and grounds.

5. CONCLUSION:

This research had the objective to reduce manpower, time consumed and cost in the task of lawn mowing and hence it proposes a way that easily achieves the above-mentioned objectives. We proposed an idea of a smart phone operated grass cutter that would be operatable within a 10-meter range of our smart phone. Another beneficial specification is that it uses a solar panel to charge its batteries, which would surely reduce cost and time. The operator can easily manipulate the robot's horizontal and vertical movements and control the cutting action of the robot with the help of an android application. The main components of our system are a 12V, 7A battery that would power all the circuit components, an STM32F103C8 microcontroller that would act as the brains of our system, 4 12V movement motors, a 12V cutting motor and a 50-watt solar panel which would be mounted on the top of the robot and would be responsible for charging the battery while the system is being used. The best features of our robot are that it is cheaper, durable, robust and more efficient than the traditional methods and equipment used for grass cutting.

Human efforts for grass mowing are also greatly reduced by using this system. Manual lawn mowing can also result in uneven grass size. However, with the use of this technology, grass cutting is consistent, and it can be utilized to trim the grass of any grassy region.

6. REFERENCES:

[1] S. L. Sharma, "Study on Automated Solar Grass Cutter," *GRD Journals-Global Res. Dev. J. Eng.*, vol. 4, no. 10, pp. 49–54, 2019, [Online]. Available: www.grdjournals.com.

[2] R. Sivagurunathan, L. Sivagurunathan, J. Chia, and J. Hao, "Design and fabrication of low cost portable lawn mower," *Hal.Science*, vol. 5, no. SJET, pp. 584–591, 2017, doi: 10.21276/sjet.2017.5.10.9.

[3] Wassell, "Solar Powered Lawnmower," no. 19, pp. 2–5, 1989.

[4] M. Singh, A. Padhan, S. Saurabh, K. Priyesh, M. Rai, and T. Naveen, "A Review and Comparative Analysis of Solar, Electric and Gasoline Lawnmowers: An Extensive Study," *IJISET-International J. Innov. Sci. Eng. Technol.*, vol. 3, no. 4, pp. 370–376, 2016.

[5] D. Athina, D. Kiran Kumar, R. B. Kalyani, and K. Vittal, "Solar Grass Cutter Using Embedded Platform An Experimental Validation," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1057, no. 1, p. 012086, Feb. 2021, doi: 10.1088/1757-899X/1057/1/012086.

[6] A. Hariya Anil Kadachha and D. D. Dethaliya Yashit Tita UG Student Assistant Professor, "Fully Automated Solar Grass Cutter," *IJSTE-International J. Sci. Technol. Eng.* |, vol. 3, no. 09, pp. 104–106, 2017, [Online]. Available: www.ijste.org.

[7] V. Kubendran, S. George Fernandez, K. Vijayakumar, and K. Selvakumar, "A fully automated lawn mower using solar panel," *J. Adv. Res. Dyn. Control Syst.*, vol. 10, no. 7 Special Issue, pp. 977–983, 2018.

[8] V. Bhandare, "Automated Solar Grass Cutter: An Overview," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 6, no. 2, pp. 185–188, 2018, doi: 10.22214/ijraset.2018.2029.

[9] A. D. Shah, S. J. Mujawar, P. R. Sutar, S. R. Prasad, F. Year, and B. Tech, "Solar Powered Intelligent Grass Cutter Robot," *IJSDR2004039 Int. J. Sci. Dev. Res.*, vol. 5, no. 4, pp. 229–234, 2020, [Online]. Available: www.ijsdr.org.

[10] A. Wicaksana and T. Rachman, "済無No Title No Title No Title," *Angew. Chemie Int. Ed. 6(11), 951–952.*, vol. 3, no. 1, pp. 10–27, 2018, [Online]. Available: https://medium.com/@arifwicaksanaa/pengertian-use-case-a7e576e1b6bf.

[11] B. Ibrahim, V. Siva Brahmaiah, and P. Sharma, "Design of smart autonomous remote monitored solar powered lawnmower robot," *Mater. Today Proc.*, vol. 28, no. May, pp. 2338–2344, 2020, doi: 10.1016/j.matpr.2020.04.633.

[12] Ezenwobodo and S. Samuel, "International Journal of Research Publication and Reviews," *Int. J. Res. Publ. Rev.*, vol. 04, no. 01, pp. 1806–1812, 2022, doi:

10.55248/gengpi.2023.4149.

[13] M. W. Jabbar, M. Noman, A. Muneer, A. Abbas, and A. Mazhar, “Solar Powered Grass Cutter for Domestic Utilization †,” *Eng. Proc.*, vol. 12, no. 1, pp. 8–12, 2022, doi: 10.3390/engproc2021012105.

[14] F. B. Ismail, N. F. O. Al-Muhsen, F. A. Fuzi, and A. Zukipli, “Design and Development of Smart Solar Grass Cutter,” *Int. J. Eng. Adv. Technol.*, vol. 9, no. 2, pp. 4137–4141, 2019, doi: 10.35940/ijeat.b4920.129219.

[15] Snehal Popat Jagdale, “Android Controlled Solar based Grass Cutter Robot,” *Int. J. Eng. Res.*, vol. V9, no. 07, pp. 750–753, 2020, doi: 10.17577/ijertv9is070276.

[16] H. B. Vuthaluru, V. K. Pareek, and R. Vuthaluru, “Multiphase flow simulation of a simplified coal pulveriser,” *Fuel Process. Technol.*, vol. 86, no. 11, pp. 1195–1205, Jul. 2005, doi: 10.1016/j.fuproc.2004.12.003.