

DESIGN AND FABRICATION OF AUTONOMOUS AND MOBILE OPERATED SOLAR GRASS CUTTING ROBOT

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ABSTRACT: Grass gives the beauty to the environment when properly managed. The present technology commonly used for cutting the grass is by using the manually handled device. There are challenges related to time consumption, labour intensiveness and non-renewable energy sources. Hence the need for a system arises which can autonomously perform such tasks. The project aimed at developing an autonomous solar grass cutting robot embedded with obstacle avoidance and path planning mechanisms. The autonomous robot utilizes energy from the sun via photovoltaic panel to charge the battery for continuous performance of the robot. On the other hand, the robot can be controlled using smart phone. In order to attain the objectives an Arduino mega with ultrasonic sensor and Bluetooth module are used.

Key words: Grass Cutter, embedded, path planning mechanisms, Bluetooth, Arduino, photovoltaic panel.

INTRODUCTION: A Grass cutter (also named as mower or lawnmower) is a machine utilizing one or more revolving blades to cut a grass surface to an even height. The height of the cut grass may be fixed by the design of the grass cutter, but generally is adjustable by the operator, typically by a single master lever, or by a lever or nut and bolt on each of the machine's wheels. The blades operated by D.C motor running with electricity from the battery, The most common self-contained power source for Grass cutters is solar power. Smaller cutters often lack any form of propulsion, requiring human power to move over a surface; "walk-behind" mowers are self-propelled, requiring a human only to walk behind and guide them. Larger Grass cutters are usually either self-propelled "walk-behind" types, or more often, are "ride-on" mowers, equipped so the operator can ride on the mower and control it. A robotic Grass cutter is designed to operate either entirely on its own, or less commonly by an operator by remote control. Power plays a great role wherever man lives and works. The living standards and prosperity of a nation vary directly with the increase in the use of power. The electricity requirement of the world is increasing at an alarming rate due to industrial growth, increased and extensive use of electrical gadgets. According to world energy report, we get around 80% our energy from conventional fossil fuels like oil, natural gas and coal ,it is well known that the time is not so far when all these sources will be completely exhausted So alternative sources should be used to avoid energy crisis in the nearby future. The best alternative source is solar energy Two

main styles of blades are used in Grass cutters. Grass cutters employing a single blade that rotates about a single vertical axis are known as rotary mowers, while those employing a cutting bar and multiple blade assembly that rotates about a single horizontal axis are known as cylinder or reel mowers (although in some versions, the cutting bar is the only blade, and the rotating assembly consists of flat metal pieces which force the blades of grass against the sharp cutting bar). There are several types of grass cutting machines, each suited to a particular scale and purpose. The smallest type non-powered push mowers are suitable for small residential lawns and gardens. Electrical or piston engine-powered push-cutters are used for larger residential lawns. Riding grass cutters, which sometimes resemble small tractors, are larger than push mowers and are suitable for large lawns, although commercial riding Grass cutters can be "stand-on" types, and often bear little resemblance to residential lawn tractors, being designed to mow large areas at high speed in the shortest time possible. The largest multi-gang (multi-blade) grass cutters are mounted on tractors and are designed for large expanses of grass such as golf courses and municipal parks, although they are ill-suited for complex terrain.

LITERATURE REVIEW [1] ‘Vicky Jain, Sagar Patil, Prashant Bagane, Prof. Mrs. S. S. Patil ’ Solar Based Wireless Grass Cutter, International Journal of Science Technology and Engineering, Vol. 2, 2016, 576-580. They have prepared wireless grass cutter. They have used solar panel so it is not required to charge battery externally and battery is continuously charged at constant voltage when grass cutter is in working. The battery is getting charged by using day light and we can use it as per our convenience . Because of two DC motor both forward and backward motion of grass cutter can simultaneously possible. [2] ‘Ashish Kumar Chaudhari, Yuvraj Sahu, Prabhat Kumar Dwivedi, Harsh Jain‘ Reference Book:-Experimental Study of Solar Power Grass Cutter Robot, , International Journal of Advance Research and Innovative Ideas in Education, Vol. 2, 2016, 68-73. In this paper author explained that solar plate which is placed above the grass cutter generates solar energy and use this energy for working the grass cutter. Also, using driver circuit for controlling speed of motor as per the requirement. For preventing battery from overcharging and over discharging regulator is placed into the system and it should be placed in series. They have provided LCD display unit which displays voltage generated during solar rays trapping. Due to seasonal conditions if battery is not charged they can provide the power bank to charge the battery instantly. [3] ‘Praful Ulhe, Manish D. Inwate, Fried D.Wankhede, Krushnkumar S. Dhakte’ Modification of Solar Grass Cutting Machine, International Journal for Innovative Research in Science & Technology, Vol. 2, 2016, 711-714 In this paper they have prepared manually operated grass cutter with spiral roller blades due to spiral blades increases the efficiency of cutting. For adjusting the height reel cutter is component placed on grass cutter. The battery can be charged during working

conditions and it also having AC charging. For collection of cut grass a box is placed over grass cutter so the cut grass put outside the lawn. It is having light in weight and compact in design. [4] 'T. Karthick, S. Lingadurai, K. Muthuselvan, M. Muthuvanesh, C. Pravin Tamilselvan' Grass Cutting Machine Using Solar Energy, International Journal of Research in Mechanical, Mechatronics and Automobile Engineering, Vol. 2, 2016, 1-5. In this paper author fabricated grass cutting machine with rotary blades by using solar energy. The solar energy is trapped in the photovoltaic cell to generate electricity. The cells may be grouped in the form of panels or arrays. Solar panel is placed such that to absorb high intensity from sun and it will incline at 45°. The main function of solar charger is increased current during batteries are charging and also disconnect when they are fully charged. By considering ground clearance they can adjust the height of grass. [5] An autonomous lawn mower was also developed by an Israeli researcher [7] which is capable of detecting the edge of an area coverage, with perimeter wire sunk around the lawn acerbity. Comparable to friendly robotic is the Mobot [8], both design for domestic garden type of area 100-200m²/hr.

FABRICATION OF FRAME: Fabrication is a process of joining of two or more components by applying temporary assembly or permanent assembly process like welding, riveted joints and some other joining operations. In the present work arc welding, gas welding and bolts and nuts was preferred to join the various components.

Selection of material

In this project we are using Galvanized iron, because these pipes are cheaper, light weight, and easy to handle. GI pipes are low carbon and zinc protected pipes respectively, used in a variety of industries. To get these extremely useful pipes at affordable prices, generally, a huge amount of carbon is present in iron, which is used for making pipes and other harder materials. GI (Galvanized Iron) pipes are important class of pipes used in a variety of applications as well as industries. Galvanization is a process in which iron or steel is coated with a layer of zinc to protect them from corrosion or rusting. Pure iron is very ductile and contains no carbon. The metal zinc lasts long and helps to increase the life of iron or steel. Galvanized Iron pipes and steel are used in most of the structural applications and come with a layer of zinc to give 100% protection from rusting. These pipes and tubes come in numerous sizes and shapes according to the specific requirements of the customers.

Features of G.I pipes: Some important features of Galvanized Iron pipes have been pointed below-

- Higher life as well as durability
- Easier welding and rigorous fabrication
- Anti-rust coating and superb finish
- Higher resistance to corrosion

- Superb ability to bend and ease of threading
- Easy to cut
- Adhere to the international quality standards

Nominal Bore in mm	Outside Diameter in mm		Thickness in mm	Mass of screwed and <u>socketted</u> tube. (kg/m)
	Maximum	Minimum		
15	21.8	21.0	2.6	1.22
20	27.3	26.5	2.6	1.57
25	34.2	33.3	3.2	2.43
32	42.9	42.0	3.2	3.13
40	48.8	47.90	3.2	3.60
50	60.8	59.7	3.6	5.10
65	76.6	75.3	3.6	6.54
80	89.5	88.0	4.0	8.53
100	115.0	113.10	4.5	12.50
125	140.8	138.5	4.8	16.40
150	166.50	163.90	4.80	19.50

Table.1 Dimensions & Nominal Mass of Medium Quality Steel Tubes as per IS 1239

These pipes are widely used for conveying raw water & distribution of treated water in majority of rural water supply schemes, where the requirement of water is less. Mostly medium quality GI pipes are used. These pipes are cheap, light in weight and easy to handle & transport & easy to join. Their sizes vary from 15mm to 150mm.

Frame making procedure

1. Make two 66 x 18c.m rectangles with (25x25mm) G.I pipes, one for front and other for back side of the robot.
2. 80c.m side bars are welded to those rectangles
3. 65c.m vertical pipes are welded perpendicularly to back side rectangular section, to support solar panel.
4. 40c.m pipes are welded to 65cm pipe and 80c.m pipe at an angle, for supporting the solar panel.
5. 15c.m pipes are welded to the rear side frame, to which the robot supporting and rotating wheels are attached.
6. Two 10c.m pipes with 5mm drilled hole are welded one on either side of the robot, for adjusting the supporting wheels with the help of bolt when ever required.
7. Another two 10c.m pipes along with a round ring to support grass cutting motors welded to front face of the frame.

DESIGN OF GRASS CUTTER

Grass cutting motor: While selecting the grass cutting motors some factors are to be considered like blade weight, blade length and speed of the motor. The speed of the motor lies between 800 to 1200 rpm and the torque of the motor depends on blade weight. Length of the blade should be more For more grass cutting efficiency.

Volume of the blade, $v = l \times b \times t$

$$= 200 \times 18 \times 0.5 = 1800 \text{ mm}^3$$

$$= 1.8 \times 10^{-6} \text{ m}^3$$

Density of the blade (carbon steel), $\rho = 7850 \text{ kg / m}^3$

Mass of blade, $m = \rho \times v$

$$= 7850 \times 1.8 \times 10^{-6} = 0.01413 \text{ kg} = 14.3 \text{ g}$$

Weight of the blade, $W = m \times g = 0.01413 \times 9.81 = 0.1386 \text{ N}$

Blade length, $l = 0.1 \text{ m}$

Torque required to turn the blade $= W \times l = 0.1386 \times 0.1 = 0.014 \text{ N-M}$

Torque required to cut different types of grasses is considered as 0.2 N-m

The blade speed required for grass cutting is 1000 rpm

Power consumed by the grass cutting motor, $P = 2\pi NT / 60$

$$= (2\pi \times 1000 \times 0.2) / 60 \text{ watts}$$

$$= 21 \text{ watts}$$

Required current, $I = P/V = 21 / 12 = 1.75 \text{ A}$ (for one motor)

Where Voltage = 12 V

Robot wheels motor

The selection of the motor depends upon robot weight, torque needed to move the robot, and speed of the robot.

Speed of the robot motor, $N = 35 \text{ rpm}$

Angular velocity of the motor, $\omega = 2\pi N / 60$

$$= (2\pi \times 35) / 60$$

$$= 3.663 \text{ rad/sec}$$

Velocity of the motor $= r \times \omega = 0.0675 \times 3.663 = 0.2 \text{ m/s}$

Total weight of the robot = 32 kg

Weight of the robot on each wheel, $W = 8 \text{ kg} = 78.48 \text{ N}$

Power required to move the robot = weight of the robot $\times$ velocity

$$= 78.48 \times 0.2 = 15.784 \text{ W}$$

Required current, $I = 15.784 / 12 = 1.3 \text{ A}$ (for one motor)

Battery

Battery selection depends upon how much power we needed to run the robot, and how many hours to operate the robot.

- 3.5 amps current is required for grass cutting motor. The robot wheel motor requires 4amps current in order to run the robot. For electronic devices 1amp current is required.
- Therefore approximately 9amps current is required by the robot for its operation. 9AH battery is needed per an hour.
- But in this project 26AH battery is used for continuous working of the robot without any interruption for long time.

Solar panel

The size of solar panel depends upon average shiny hours and required time to recharge the battery.

Battery capacity = 26AH.

Average shiny hours in Eluru = 6 hours.

So 100W solar panel is used to recharge the battery in minimum time.

Current generated from solar panel (I) = $100 / 12 = 8.33A$

i.e. 8AH battery is fully recharged in one hour; our battery capacity is 26AH so by using this 100watt solar panel, our battery is completely recharged approximately in 3 hours.

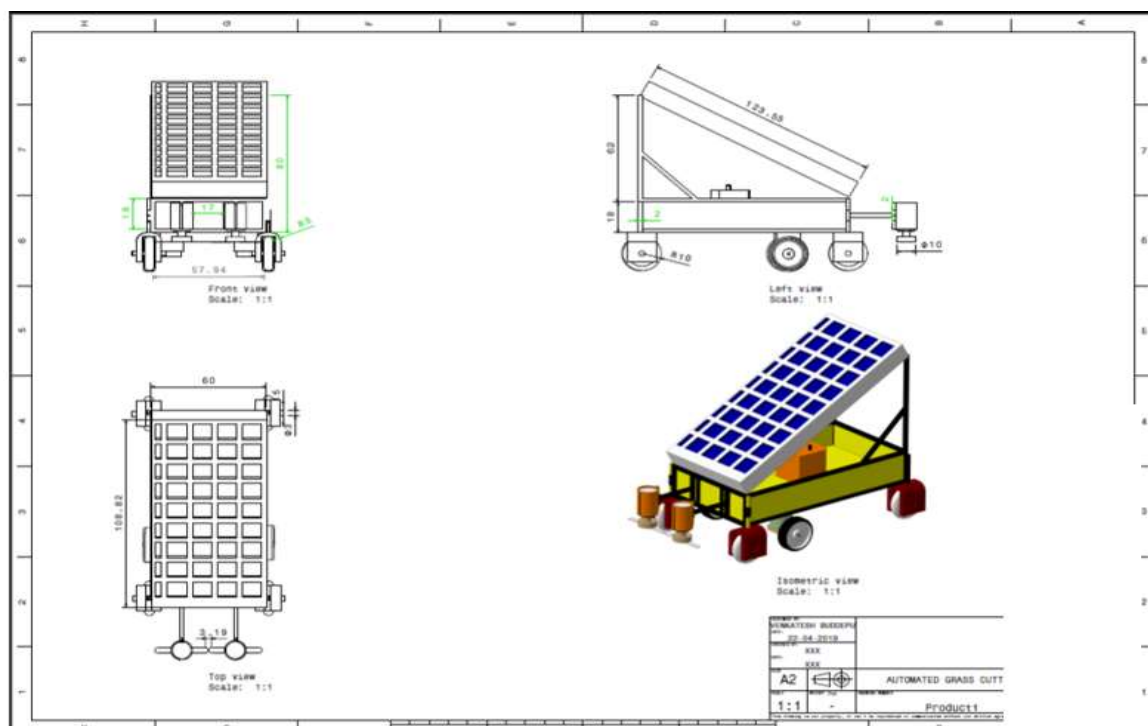


Fig.1 Assembly diagram and isomeric views of the robotic vel



Fig2 Solar grass cutting robot

Specifications of electrical devices

Device name	Model	Quantity
Solar panel	V-Guard 12v,100watt solar panel	1
Battery	Exide 12v-26AH battery	1
charger	Tez tech12v-10A D.c battery charger	1

Solar charge controller	Caldipree 10A pwm solar charge controller	1
change over (or) transfer switch	Havells 10A change over switch	1
Grass cutter motor	895 high speed Johnson D.C motor	2
Wheels motor	12v, 5amps, Wiper motor	2

Table.2 specifications of electrical devices

WORKING PRINCIPLE

It has panel mounted in a particular arrangement at an angle of 50 degrees in such a way that it can receive solar radiation with high intensity easily from the sun. This solar panel convert solar energy into electrical energy as studied earlier. Now this electrical energy is stored in battery using a solar charger. The motor is connected to the battery through motor driver with the help of connecting wires. It starts and stops the working of the motor. From this motor, the power transmits to the wheels there by the robot starts moving. The grass cutting motors connected to the battery rotates at high speed and torque to cut the grass. The microcontroller controls the robot.

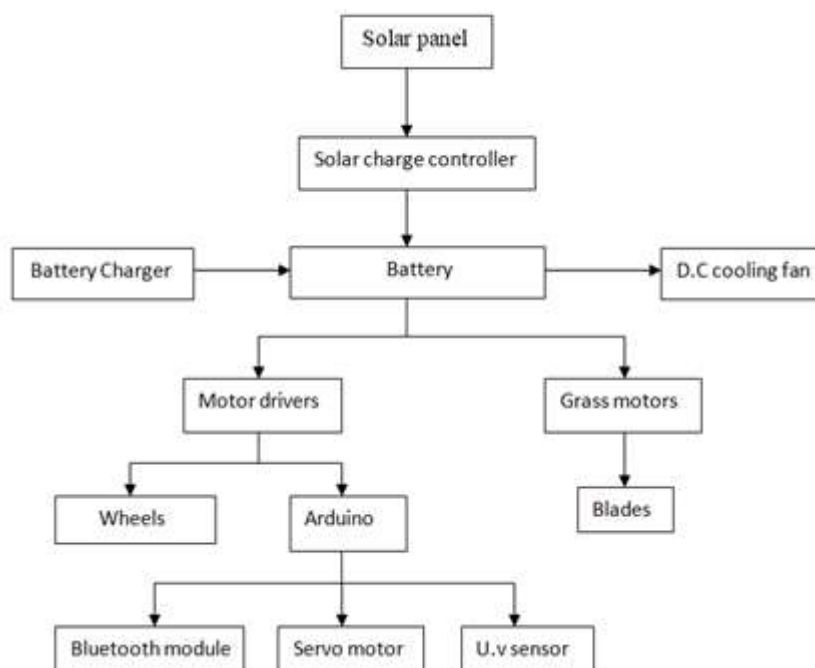


Fig.3 Robot working flow diagram

Obstacle avoidance mechanism

After switch on the robot, the ultrasonic sensor receives power from micro controller, the sensor attaches to the servo motor and rotate about 180degrees. If any obstacle detected within the range, the signals passes to the micro controller from ultrasonic sensor, if the signal is low robot moves forward or the signal is high the robot stops the motion. then the micro controller decides the movement of the robot.

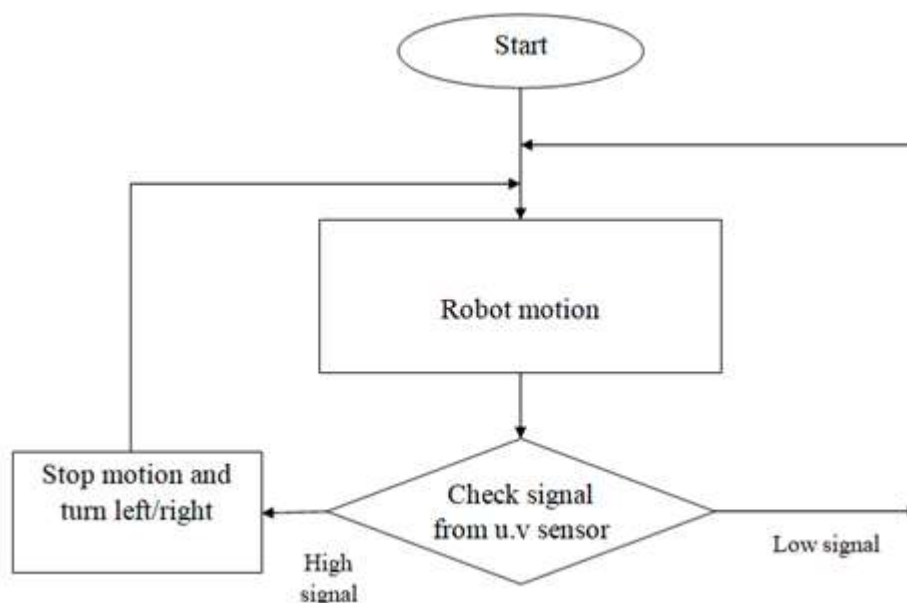


Fig.4 Obstacle avoidance flow diagram

Operating procedure

Install “path finder” app in the Google play store. Switch on the grass cutter, turn on Bluetooth in smart phone, and then connected to the robot Bluetooth module. After connecting the Bluetooth you can operate the grass cutter both automatic mode and manual mode.

RESULTS

The efficiency of the robot depends on the coverage area of the field in turn the area coverage depends on the robot speed and blade width.

Field efficiency

Forward speed of the robot = 0.8m/s

Width of the blade =0.4 m

Theoretical field efficiency = forward speed x width of the blade
=0.8 x 0.4

$$=0.32 \text{ m}^2/\text{s}$$

Area of testing field = 4m x16m

Total area covered =63.1 m²

Time taken =210 seconds

Effective field capacity = total area covered / total time

$$= 63.1 / 210$$

$$= 0.30 \text{ m}^2/\text{sec}$$

Field efficiency = effective field capacity / theoretical field capacity x 100

$$= 0.30 / 0.32 \%$$

$$= 95 \%$$

percentage of Area coverage

At = total area of lawn = 64 m²

Aut = area of un cut = 63.1 m²

Percentage of area coverage = (At – Aut) / At x100

$$= (64-0.9) / 64 \times 100 \%$$

$$= 98.5 \%$$

Conclusions and future scope:

Our project entitled “Design and fabrication of autonomous and mobile operated solar grass cutting robot” is fabricated successfully, after testing, the results obtained are satisfactory.

- Grass cutting robot uses solar energy which is renewable source of energy. It meant to be a green option to the environment.
- Grass cutting robot is free from both environment and noise pollution.
- Solar grass cutting robot is fully automated and with the help of sensors which detects the obstacles in front of it.
- Non skilled person also handles it easily and reduces human effort.

It can be further extended to higher power rating and can be used for agriculture applications such as paddy, wheat and maize crops cutting purpose.

- Design of blades should be done based on types of grass is used to cut.
- Suspension system can be added to the robot.

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