

# Solar Lawn Mower with Solar tracker

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**Abstract:** Most lawn mowers available in the market today are powered by either a battery, a plug-in motor, carbon based fuel or man power even while there is an abundance of renewable resources available. Solar energy is one such renewable resource, and by use of the same, we can reduce our carbon footprint on this planet. This lawn mower comes with a solar panel which charges a lithium-ion battery pack, it also features a HR04 ultrasonic rangefinder and a phototransistor working with an algorithm to find the most efficient charging position and obstacle avoidance. In addition to this, it has the necessary hardware on-board to determine the best time to mow the lawn, and the best time to charge itself. This allows the robot to be autonomous making it a one-time-set-up-and-forget device.

## 1. Introduction

Mowing a lawn can be a very tedious and time consuming task, especially when the area to mow is very large. On average, it takes 30 minutes to mow a lawn of 10,000sqft, people find it very difficult to make time in their busy schedules for something as trivial, and this results in overgrowth of their lawn, and thus makes the once beautiful lawn declass the house. A lawn mower is a machine used to cut or trim the grass to a desirable height by adjusting the blades of the mower. The first known lawn mower was invented by Edwin Budding in 1830 in Thrupp in Gloucestershire, England. Budding's mower was basically designed to cut the grass on sports grounds and extensive gardens alternative to the scythe. It was a mower which required human's effort to push it from behind. This technology has come a long way since Budding's model. Today, lawn mowers are available in many forms to suit the many different user needs. Small mowers lack self-propulsion, and require man power behind it to function. Robotic lawn mowers have also been developed to operate either entirely on its own, or by user interaction through a remote. The mowers powered by electricity or piston engine-powered push-mowers are used for larger residential lawns. Riding mowers are suitable for large lawns, being designed to mow large areas at high speed in the shortest time possible. The largest mowers are mounted on tractors and are designed for very large areas of grass such as in golf courses, cricket grounds and municipal parks. [2]

The mowers are usually powered by a fuel such as gasoline or electricity. Internal combustion engines used with lawn mowers have a single cylinder. The power required usually ranges from 1.5 to 6.75 kW. The engines have a carburetor and require a manual pull crank to start them. Combustion in engine cause a lot of pollution and their engines require periodic maintenance such as cleaning or replacement of the spark plug and air filter, also the engine oil should be changed frequently. The gasoline lawn mowers produce up to 95 decibels or more of noise. [2]

Electric lawn mowers are divided into corded and cordless. Both are usually noise free producing less than 75 decibels. There is a very big disadvantage with the corded mowers of accidentally mowing over the cord or the cable which spoils the mower and puts the user in a huge risk of shock. Cordless electric mowers are powered by 12-volt rechargeable batteries. More the number of batteries, there is more run time and more power. If batteries are on the outside, the depleted batteries should quickly be exchanged with recharged batteries. Cordless mowers are more expensive than the gasoline and the corded mowers. The eventual disposal of worn-out batteries is problematic and the motors in cordless mowers are less powerful than gasoline motors of the same total weight. A study conducted in 2001 showed that few mowers cause the same amount of pollution in one hour which is equal to the pollution produced by driving a 1992 model vehicle for 650 miles. In 2011, the United States Environmental Protection Agency set standards for lawn equipment emissions and they expect a reduction of pollution by at least 35 percent. Mowers also create a large amount of noise pollution and could cause damage to hearing if used without hearing protection. [2][5]

All these problems led to the invention of a solar powered lawn mower. Solar energy is radiant light and heat from the Sun. Solar energy is captured and used for many applications such as solar heating, solar thermal energy, solar architecture and artificial photosynthesis. It is an important source of renewable energy. The great amount of solar energy available makes it a highly appealing source of electricity. In an assessment conducted in 2000 by the United Nations Development Program, found that the annual capacity of solar energy was 1,575–49,837 exajoules (EJ). This is way too larger

than the total world energy consumption, which was 559.8 EJ in 2012. [3][8]

Solar tracking is a system which orients the device towards the direction of the sun. These devices change their orientation according to the movement of the sun to capture more amount of solar energy i.e. Maximum output from the sun. It adds cost and maintenance to the system. But the solar lawn mower which we designed makes use of inexpensive solar tracking system, consists of a servo motor and a light detecting diode. [7]

## 2. Solar Lawn Mower

Solar lawn mower operates on the similar principles as the older versions. The major difference being that it uses solar energy to charge its on-board battery pack so that there is no need of external charging. It operates in three modes: charging, cutting, and stand-by. It automatically enters the charging mode when battery capacity drops below 20% of full capacity. It uses photovoltaic cell in form of solar panel mounted on the top of a robot to convert solar energy into electrical energy which is utilized to charge a rechargeable battery which in turn is used to power the entire device. It makes use of a HR04 ultrasonic sensor which can detect the any obstacle in its path and take a diversion to avoid it. In charging mode, to achieve sufficient amount of sun's UV radiations, it uses a cheap and efficient solar tracking system. This solar tracking system consist of a light detecting diode mounted on top of a servo motor which rotates in all 360 degree direction, taking readings at every 20 degree intervals. These readings are analyzed and compared to determine the most optimal charging position using an algorithm. The robot moves in the direction where maximum intensity is obtained hence, ensuring that the photovoltaic cells receive maximum radiation in order to charge at a faster rate.

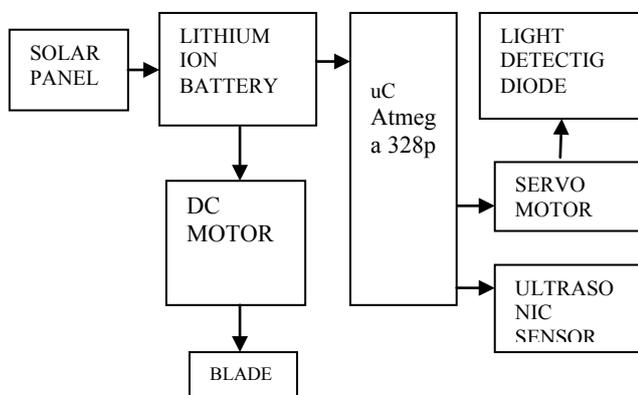


Figure 1. Block diagram of a solar powered lawn mower

Mowing is always stressful on the grass, to reduce the stress put on the grass, and to maintain proper health of the lawn, it is recommended that:

- The lawn must be mowed early in the morning or the evening as mowing during the heat of the day can cause the plant to go into shock.
- Mow when the grass is dry to increase mower efficiency and reduce likelihood of disease spreading from one plant to another.
- Cutting your lawn too short creates an environment for both weed and disease infestation.

Keeping all these factors in mind, the robot utilizes an algorithm to calculate the best time to mow the lawn based on daily statistics as seen in its environment. It uses a DHT-11 digital temperature and humidity sensor to check and measure the temperature and humidity throughout the day. It also uses soil moisture sensor to check the moisture content in the soil.

In reference to the above block diagram in Fig.1, the blocks are explained as follows:

### 2.1 Robotic body

The robotic body consists of 4 wheels and a chassis driven by four 360 degree continuous servo motors producing a torque of 9.4kg/cm each and requires 4.8v to operate. The power supply to these servo motors are provided by the rechargeable battery charged by solar panel.

### 2.2 Dc motor

A 5v dc motor is mounted on the top of the robot's chassis which is used to rotate blades for cutting grass. The height of the axle of motor can be adjusted to facilitate desired trim level. This dc motor is powered by from the same rechargeable battery.

### 2.3 Solar panel

The solar panel uses photovoltaic cells to generate solar energy which is the main source of power. Solar panel is capable of generating a peek voltage of 5v and 1A. This is used to charge Lithium-ion battery cells.

### 2.4 Ultra-sonic sensor (HR04)

The HR04 ultrasonic range sensor offers 2cm-400cm contactless range measurement with 3mm accuracy. The modules includes ultrasonic transmitters, receiver and control circuit. The sensor

comes with 4 I/O pins, the trigger, echo, VCC (5v) and ground. Its working voltage is 5v, working current 15mA and working frequency of 40Hz.

The ultra-sonic sensor helps in detecting the obstacles which will obstruct the movement of the mower and also might cause damage to the mower and thus helps it in changing the path or the direction in which the mower is moving. These sensors facilitate automating the mower without using any human interaction.

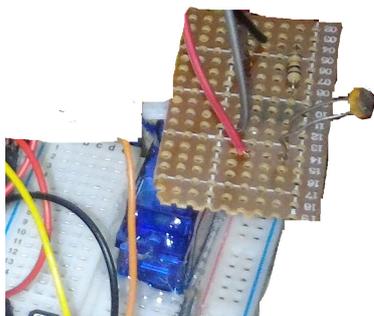
### 2.5 Temperature and Humidity sensor (DHT11)

The DHT-11 is a temperature and humidity sensor that will be used by the robot to access the environmental conditions around it. As mowing the lawn in the heat of the sun or in moist conditions is not healthy for the plant life, it can make smart decisions as to when the optimal time would be to mow the lawn. The DHT-11 has a temperature measurement range of 0-50°C with accuracy up to  $\pm 2^\circ\text{C}$ , and humidity measurement range of 20-90%RH with accuracy up to  $\pm 5\%RH$ .

### 2.6 Solar tracking device

The solar tracking devices are used to increase the energy captured by the photovoltaic cells. They direct the solar panels towards sun. Axial solar trackers rotate on one axis moving back and forth in a single direction. These solar tracking devices are very expensive and may cost more than 6000USD. Thus this mower makes use of very cheap solar tracking system. It consists of a light detecting diode mounted on top of a servo motor. The servo motor rotates the light detecting diode in all direction with 60° turns. The readings thus obtain from all the direction is compared and analyzed to obtain maximum intensity angle and it causes mower to move in that direction.

Thus even in a dark room when there is a very low source of light the mower would move towards the maximum intensity light source in an attempt to charge itself.

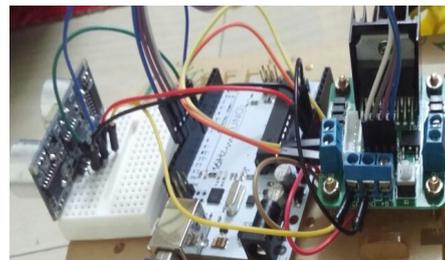


### 2.7 Rechargeable batteries

The robot is powered by 12,000mAh lithium-ion battery that can supply 5V, 2.1A to the device. Its input voltage required to charge is 5V, 1A, which is supplied by the solar cells on-board the robot. Assuming we have a 20% efficient loss during charging, the battery will require 14.4hours to reach maximum charge from complete discharge state. In order to ensure that it is in the optimal charge position, the robot wakes up every hour during its charging state to check its position.

### 2.8 Arduino Uno

The Arduino Uno is used to interface all the various sensors and other components of the robot; it essentially acts as the brain of the robot. The Arduino Uno uses an Atmega328P microcontroller, and requires an operating voltage of 5V, input voltage of 7-12V, and provides 20mA per each of its 26 I/O pins.



## 3. Working

The solar powered lawn mower operates in three modes:

### 3.1 Charging mode

In charging mode the servo motor rotates the light detecting diode to obtain readings from all the direction. On the basis of these readings the mower can move around looking for maximum light source to get charged. The ultrasonic sensor prevents the mower from colliding with obstacles and any other damage by scanning the area for obstacle and changing the direction of the mower. As soon as the battery is charged the mower will automatically enters a stand-by mode, and wakes up when it determines that the lawn needs to be mowed again. The robot automatically enters the charging mode when battery level drops below 20% to ensure its survival.

### 3.2 Cutting mode:

In this mode the charged battery is used to rotate the dc motor which is connected to blades cutting grass. The ultrasonic sensor in this case also prevents the

mower from and kind of obstacles on the way. The movement of the robot is through the 4 servo motors.

### 3.3 Stand-by mode:

In the stand-by mode, the mower calculates the time and date when the lawn needs to be mowed next using an algorithm. It creates its own local database using the temperature and humidity readings it obtains throughout the week to predict the best time the lawn can be mowed to improve the lawn's health. The mower cuts the grass automatically by placing obstacle at each corner of the lawn. On detecting these obstacles the mower takes a turn hence covering the full area. The mower can cut the grass depending upon the position of these obstacles. Hence the user can obtain different and desired patterns.



In present generation when we look forward on automating every other devices at home for user convenience why not consider automating lawn mower too. As mowing lawn is the most strenuous task, nobody would want to manually operate a lawn mower. This lawn mower focuses on providing all the comfort to user and in the same time does the job of the human. It operates automatically on the basis of mobile interface technology. The user can now turn on their mower sitting inside the house using their phone.

## 4. Advantages

1. The cost of maintenance is low.
2. It does not use any of fossil fuels hence cause very less pollution.
3. The solar cells can last longer time and hence helps conserve energy.
4. It has a cost effective solar tracking device.
5. It has an ultrasonic sensor as an obstacle detector and thus avoids damage to the vehicle.

## 5. Conclusion

The Earth receives 174,000 terawatts of incoming solar radiation at the upper atmosphere. The amount of solar energy reaching the surface of the earth is so huge that in one year it is about twice as much as the energy obtained from the non-renewable resources of coal, oil, natural gas, and mined uranium combined over a period of centuries. Hence this enormous amount of energy can be utilized and other

nonrenewable resources can be saved. A lawnmower with solar energy will be easier to use as it eliminates the time going to the gas station for refilling of fuel and also eliminates the danger associated with gasoline spillage. The solar powered lawnmower will help to reduce air pollution as well as noise pollution produced by other types of lawnmowers which otherwise may impair human health irreversibly. In addition, it will help to reduce the cost of using and maintaining a lawnmower. Thus a solar powered lawn mower is very efficient.

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