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Intelligent Energy Harvester Solar System for Lawn Mower Application

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ABSTRACT

Energy harvesters are a very fast Engineering field that comes with different combinations of technology that reduces human effort and gives maximum output. Hybrid means it can work both in sun and rain weather. Nowadays, lots of energy and human effort is being wasted on mowing the lawn in different parts of the world. The aim is to develop an all-weather intelligent energy harvester lawn mower that will mow the lawn in all season, with no human effort, no pollution in terms of noise, air, and less energy consumption. More to these, the system has sensors to prevent or divert obstacles, making it operate independently. The concept of this work is to utilize renewable energy, reduce power conversion efficiency, and provide a good selfless and easy environment for grass cutting no matter the weather condition. In this work, a lawn mower is developed and a smart control system for the prevention of obstacles. The hybrid solar panel and graphene were developed to accommodate the output of weather conditions. The sun and rain droplet stays on them and is converted to electricity, it goes through a DC-DC boost converter, passes through a stabilizer, and then to the battery for storing. The Direct current (DC) gear optimizes the directions. A motor driver was developed to drive the DC gears and a MOSFET driver for the blades and the rear tires. The rotating wheel rotates the direction, for each rear tire, is a motor. The solar panel was also used for charging the 12V battery, which is the engine brain of the system, it is controlled by 5V RPS. The RF receiver system receives and interprets commands for the remote control to the microcontroller. The solar panels supply energy to the battery and are controlled by the solar charge controller, which protects the battery from overcharging and maintains the battery's performance. The sensor senses an obstacle and sends it to the RF receiver for change in direction, and the second sensor is for motion detection, motor driver, and Bluetooth unit. The entire design is economical and fit with the objectives.

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1. INTRODUCTION

Energy sources are scattered and available in different forms and shapes on this earth and their use is different from each other. All these energies can be converted from one source to another form of energy These energies include the following: sunlight (Raghunathan. 2005), and heat energy (Proto.A et al., (2018), mechanical vibration, (Gilbert JM and Balouchi. F 2008) etc. The energy sources in a harvesting energy utilization we termed to use are sunlight and raindrops.

A. Energy from the sun

Sun energy is generally known as solar from this part of the worl, Nigeria. That is the origin of energy for everything that breaths on planet. It can be used to cook food, heat water, and generate electricity. It is a source of renewable energy that alternates fossil fuel. It is directly gotten from the sun, others are wind, hydro, etc. Photovoltaic solar panel receives energy from the sun and transforms it to electricity. The solar panels contain solar cells made from two silicon layers, doped, and boron Dimi A.M & Lacho P.M

(2015). The doped has a small amount of phosphorus, negative type (n-type) and the other is positive (p-type). The doping part goes to the negative layer and creates electrons and holes in the positive layer also, its essence is to change the way the atoms are bonded together and share their electrons. If sunlight hits the solar cell, it promotes the electrons to a higher state in the negative type layer and it travels to the positive type layer and back to the negative layer through the wires connecting them to a device as electric energy.

B. Energy from raindrops

Raindrops produce electricity through a material called piezoelectric. Piezoelectric are materials that produce an electric current when put to stress. Vibration from water droplets when it hits piezoelectric material produces electricity as solar panel generates electricity. The kinetic energy gotten from raindrops is effectively turned into electrical energy when transparent polymer layers called grapheme are attached at the top of the cell of a solar photovoltaic (PV) and raindrops fall on the grapheme, rolls off, the friction then generates an electricity charge that is static, which is transferred to the device. University of Yunnan Normal and the China Ocean created model that is one layered. It mesmerized grapheme saturated on the solar cells which split the raindrops ions into positive and negative. It produces electricity when there is an interaction with the oppositely charged ions. Unfortunately, this model is in the design phase and hasn't gone far. Based on increased research, hopefully, it could be a second option.

1.1. HARVESTING OF ENERGY

This is a system of harvesting energy from environmental sources of renewable energy, example solar, kinetic energy from raindrops, wind, and thermal and electromagnetic waves. It is the process where mechanical load, light, and temperature gradients are scavenged and converted to electricity. The Internet of Things (IoT) developed different devices of an ecosystem and establishes broad communications in smart devices, simple actuators and sensors (Lee I.2015). Harvesting of energy from vibrations from ambient which provide sufficient energy for different devices serves as a solution to improve on the device lifetime and eliminate need of batteries to be used as energy source (Shirvanimoghaddam. M et.al 2015). The purpose of harvesting energy is to charge rechargeable batteries used to power devices. In the case of this paper, the energy is harvested and used to power the battery for the lawn mower. Energy harvesting solar panels capture some of this wasted energy, convert it to electricity, and put it to work. It collects instant quantities of energy from piezoelectric/solar sources using the energy harvester process. A piezoelectric material manages a wide range of input frequencies and forces allowing for energy harvesting occurring. They convert mechanical strain from rain into an electrical charge or voltage when it is electrically polarized, this is the piezoelectric effect. It is hoped that in the future, the energy harvesting process that is around us can replace devices whose resources use batteries because it can damage the environment later (Zhang W et.al 2018). At this point, harvested energy supports many systems operated by electricity, example, wireless sensor networks (Nguyen M.T, 2020) devices that consume less power, robots, unmanned aerial vehicles (Vu. V.T, et.al 2020), and even wheelchairs (Nguyen C.V 2020) in order to prolong the operation time. EH technologies are been mixed so to chunk energy from many sources and also from different ambient sources (hybrid), to provide enough power for applications. Chowdhury S.A and Aziz. S,(2012).

1.2. ENERGY HARVESTING MODULE

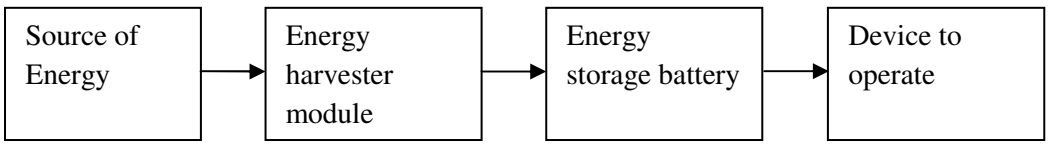

Fig 1: Energy Harvesting Module

This consists of an energy source that can be used for energy harvesting (Fig 1). In this paper, sun and raindrops are used. The energy harvesting module converts ambient energy into electricity which can be stored in energy storage devices like batteries and capacitors. For example, converting mechanical stress into an electrical signal, temperature difference into electric voltage, etc

1.3. HYBRID SOLAR PANEL

The hybrid solar panel, used in this proposed project generate electricity from the sunlight and raindrops. It is the combination of thermal and photovoltaic technologies in a single module. These panels are installed on a rooftop or a high height to get sun energy during the day, when there are rain drops, the solar panel generates electricity from the force from the rain droplets landing on the graphene which is on the surface of the panel. During rainy season, when the sunlight is reduced, the solar panels produces electricity as in the sun season. Hybrid solar panels surmounts this downside of standard solar panels with

the help of turboelectric nanogenerators (TN). This transforms rain energy into electricity.

1.4. GRAPHENE

Graphene is two-dimensional carbon with bonded atoms put in a honeycomb organization. It can be achieved by the exfoliation, oxidation, and reduction of graphite. Electronic properties of grphene depicts it.. Graphene conducts electricity using electrons that moves side by side the whole layer. When grapheme is in an aqueous solution, it binds positively charged ions with its electrons, this is known as Lewis acid-base interaction. The attribute is basically used in graphene-based processes in removing ions from lead and organic dyes from solutions.

1.5. INTELLIGENT LAWN MOWER

Artificial intelligence (AI) has critically influenced everyday life, with the advancement of technology. The business has embraced robots as a result and consumer interactions have become conventional. In recent times, daily lives have been changed because of robot. There is also a big interest in using robots in the scenario of automation (Mark. L, 2020). The intelligent lawn mower is a robotic machine that may not resemble a human but replaces human effort. A lawn mower is a machine cutting grass or other unwanted plants in the field. This is developed to scrap the manually controlled mowing machine. It works with better accuracy than the manual cutter, and reduces wastage of time and materials. This has adverse impact on the relied jobs of people, this lowers cost of manufacturing, improves productivity, and enhances economic health. The system saves humans from performing dangerous tasks and can work in hazardous conditions and poor weather conditions (rain, snow, etc), poor lighting, toxic chemicals, or tight spaces. It is environmentally friendly because of the reduction in noise and air pollution compared to mowers with internal combustion engines, it charges as it is being used and can work for over three hours with no human assistance. The normal manual handling mower is common in Nigeria, however, it is used manually and produces air pollution which causes havoc to workers' health directly and the entire surroundings. It causes vibrations to the ground and on the machine itself. If handled for a long time by a worker, it is health challenging and could cause reduced hand sensation, dexterity, white finger, etc (Raphul. G and Naresh E. 2016). To abate these issues, a new machine that will entirely remove the aforementioned demerits is proposed, and it is the All-weather Intelligent energy harvesting solar system for lawn mower application. This is simply a grass cutter robot that will be energized by converting solar energy and raindrops into electrical energy through the solar cells.

1.6. THE OBJECTIVES OF THE STUDY

- To model an all-weather intelligent lawn mower system for the automatic cutting of grasses.
- To develop a hybrid solar panel and graphene system, that converts solar and kinetic energy into electrical energy which will charge the 12V battery controlled by 5V RPS (Regulated Power Supply).
- To develop an RF receiver system that will send, receive and interpret commands for the remote control to the microcontroller and develop a DC (Direct Current) gear system that will optimize the direction control.
- To develop a smart control system to detect and avoid obstacles.
- To develop a motor driver that will drive the DC gears and a MOSFET driver that will drive a high-speed motor for the grass cutting.

1.7. STATEMENT OF THE PROBLEM

The conventional manual grass-cutting machine is being recorded to be widely used in the agricultural industries. They are dangerous machines that should be operated carefully to avoid accident. They are made of large, fast-moving blades which can catch debris and also can cause injury to humans. However, it consumes lots of energy because it uses fuel and thereby emitting gas, and causing air pollution. It also produces a lot of noise leading to noise pollution as well. This causes havoc to both the environment and the worker making use of it. Its vibration is to a very increased extent as it works and causes ill health such as decreased hand sensation, grip strength, dexterity, carpal tunnel, white finger, etc. Because of the condition of the nation, and newer technology emerging, payment of workers is quite high. In response to these problems, a smart solar-powered robot will be developed. The device will be fuelled by renewable energy, it will have an autonomous capability that is user-friendly (Karthick. T 2016).

1.8. SIGNIFICANCE OF ALL-WEATHER INTELLIGENT ENERGY HARVESTER SOLAR SYSTEM FOR LAWN MOWER APPLICATION.

1. The hybrid lawn mower system is an all-weather machine that works both in sunny and rainy seasons.
2. Its source of energy is natural, with no need for fuel so, it is cost-effective.

3. It is safer and harmless compared to the conventional mower.
4. It has very low maintenance.
5. It is more environmentally friendly because it reduces noise and air pollution.
6. Maintenance is cheaper when compared to a ride on a current lawn mower.
7. There is no need to charge batteries, energy harvester lawns mowers take themselves back to charge automatically in all season, whether in use or not.

1.9. Scope of the study

This research is centered on the energy harvester solar panel, and the intelligent lawn mower used in all season.

2. LITERATURE REVIEW

2.1. THEORY AND WORKING PRINCIPLES OF SOLAR CELLS

Solar cells are devices that works when the light energy inside the photons is turned into electric current if the photons hits a semiconductor device. Usually, Photons from sunlight touch the solar panel and is imbued by semiconducting substance. Electrons that are charged negatively are let go from their atoms as they are stimulated. The material and its type of the nature of its structure, electrons move in a single direction. Due to the structure of the electronic materials, it enables the process to work perfectly, and the silicon that has little amounts of boron and phosphorus is being used in several layers. Finally, arrays of solar cells arranges turns solar energy to direct current (DC).

Anytime a photon touches a semiconductor, one of three things happen:

1. Photon passes direct through the silicon material, only for lower energy photons.
2. The photon can also reverberate the surface.
3. Photon is imbued by the silicon when the photon energy is advanced than the silicon band gap value. Depending on the band structure, it will generate an electron-hole pair and heat.

During absorption of the photon, energy in the crystal lattice gains electron. Unremarkably, this electron is usually seen in the band of the valence. The electron gets the exited by the photon and energizes it to the conduction band there, will move freely thro and fro the semiconductor material. Covalent bonds network which involves the electron also, has only one fewer electron, called a hole. Existence of a disappeared covalent bond allows the bonded electrons by near atoms to move into the hole, this abandon a hole behind, thereby passing on holes in all the lattice. The semiconductor is absorbed by the photon, creating electron-hole pairs. Photon needs energy bigger than the band gap to energize an electron in the valence band inside, the conduction band. Even so, the solar frequency spectrum resemble a black body spectrum about 5,800 K, much of the solar radiation reaching the earth made of photons with energies bigger than the band gap of silicon (1.12eV), which is close to the ideal value for a terrestrial solar cell (1.4eV). The bigger energy photons gets by a silicon solar cell, but the divergence in energy between these photons and the silicon band gap is turned into heat through lattice vibrations called phonons instead of into usable electrical energy.

Output current = current source minus current which flows through the diode, minus current which flows through the shunt resistor:

$$I = I_L - I_D - T_{SH}$$

where

- I = actual current (A)
- I_L = photo generated current (A)
- I_D = current of the diode (A)
- I_{SH} = current of the shunt (A).

The current through these elements is governed by the voltage across them:

$$V_J = V + IR_S$$

Where,

- V_j = the voltage across the diode and resistor R_{SH} (volt)
- V = the voltage across output terminals (volt)
- I = actual current (ampere)
- R_S = series resistance (Ω).

2.2. SUMMARY OF RELATED WORKS

Previous technology of grass cutting was manually operated, using hand devices like cutlass, knives, and scissors, this involves human effort and time required to accomplish the grass cutting process. This leads to no uniformity of the grass. Secondly, because of the engine-powered machines used, leads to air and noise pollution. It is equally expensive. Also, machines that use gasoline or fuel create pollution of both noise and air because of combustion of the engine, consequence upon that, these engines require regular maintenance of change of engine oil, spark plug or filter. A system that can work in rain and sun, which uses less or no human power and can work for a long time more than humans, cheap to obtain and maintain is needed to carry out better functions of lawn mowing, that is why the propose of all-weather energy harvester solar system for lawn mower application.

3. RESEARCH METHODOLOGY

This project has to do with the expert system methodology. It comprises of the user, inference engine, knowledge base and hardware base, as stated in figure 1.

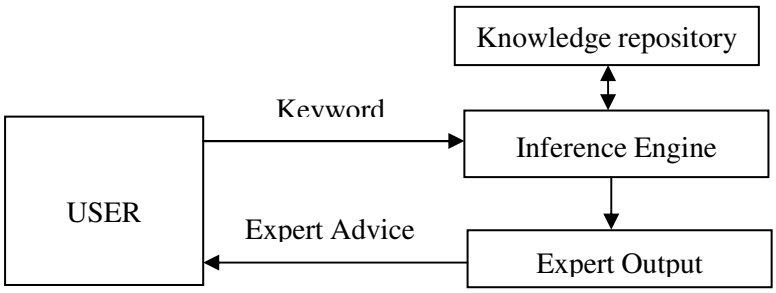

Fig 2: Expert System Methodology (Nwobodo L.O & Inyiama H.C 2017)

User Query = Keywords depending on what the user wants
Inference Engine = locates the keyword in the repository
= Searches for the keyword
= Outputs the keyword

The expert system methodology was used in this research (Fig 2). It requires that the user (someone that wants to mow the lawn) sends a keyword by pressing the remote control device, to the knowledge repository. From the bulk of instructions saved in the repository bank, the inference engine moves through the knowledge repository, looking for the exact match of the keyword, and outputs the result back to the user. Here, the information stored in the knowledge repository is all the work process of the mower machine. The result makes the machine do one thing or another, which could be either to move, mow or stop, etc.

3.1. FLOWCHART OF THE PROPOSED SYSTEM

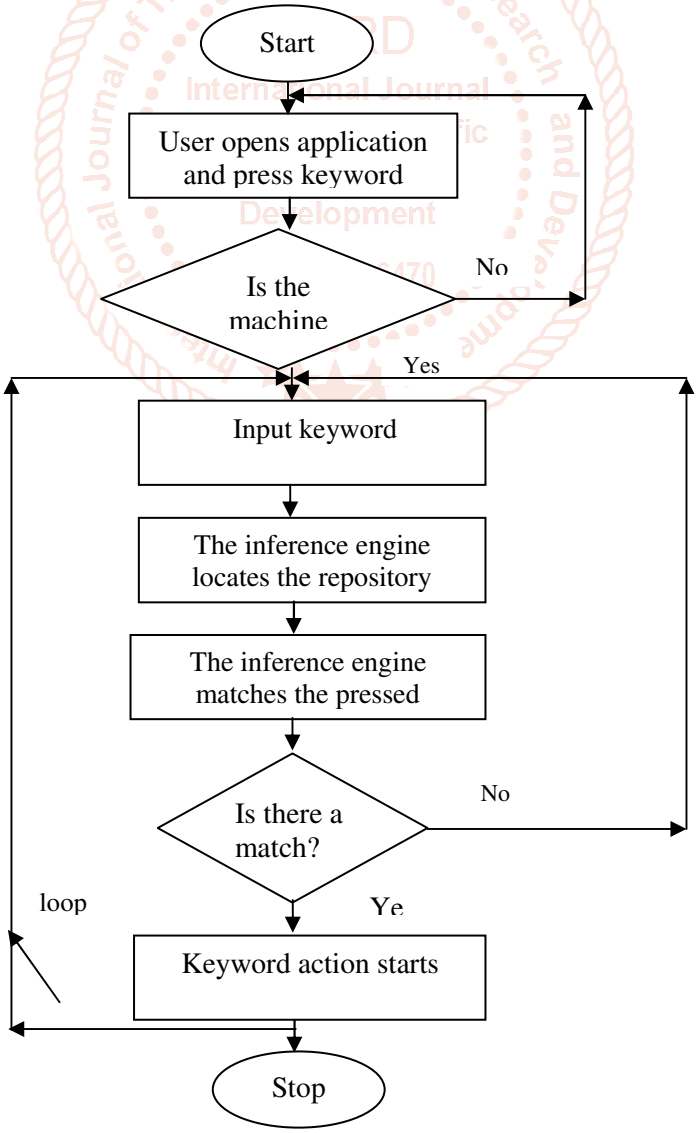

Fig 3: Flowchart of the proposed system

The user opens the application on the remote control (Fig 3). If the machine is ready, the keyword is inputted (move, stop, etc). If not, it goes to the initial stage of start. The inference engine locates the repository, sifting through the repository in search of a matching keyword. If there is a matching keyword, it ignites an action, else it returns back to the input keyword'. There is a continuous loop, checking when a new keyword will be inputted and taking action.

4. MODEL OF THE PROPOSED DESIGN

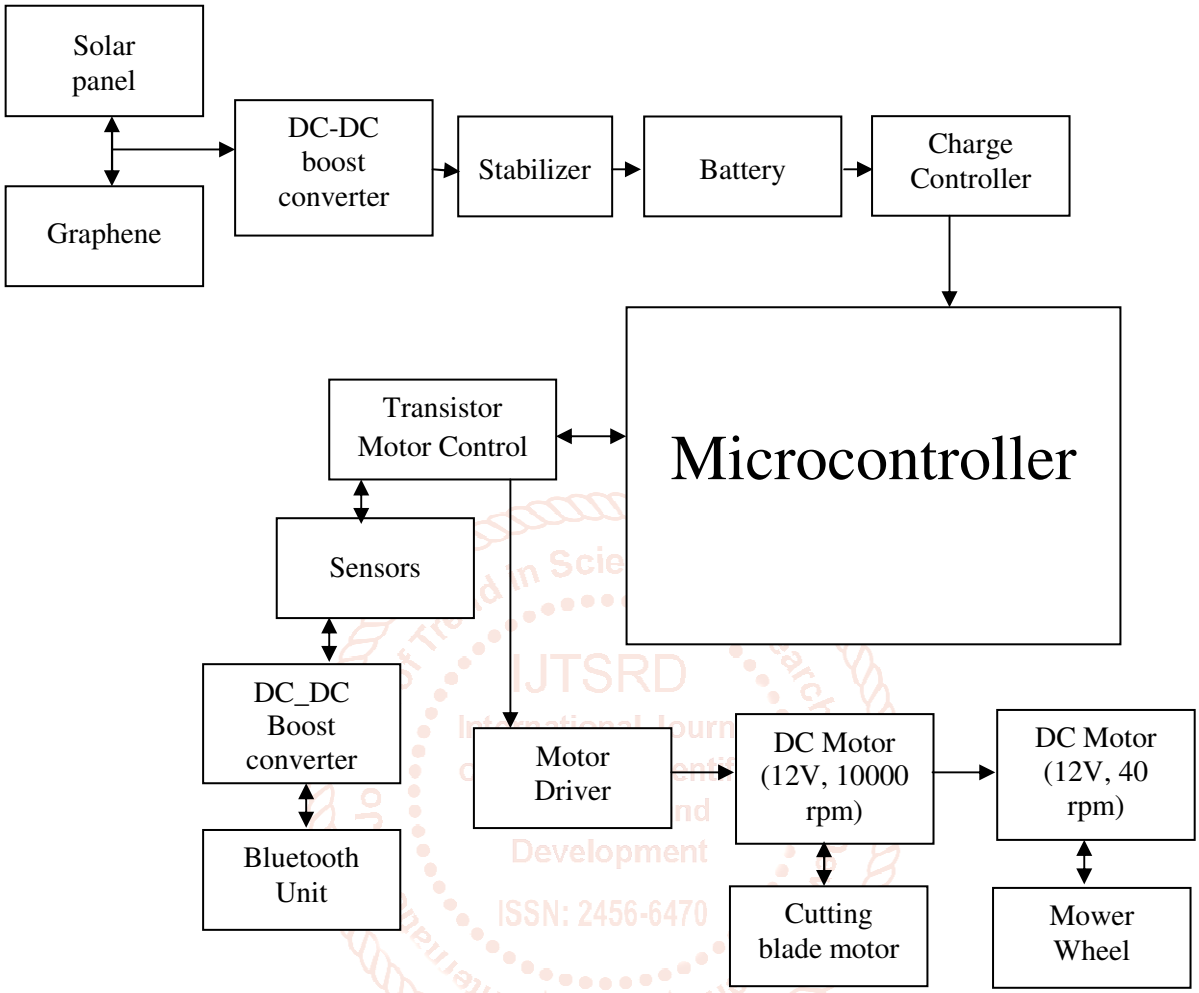

Fig 4: The model of the proposed system

4.1. WORKING PRINCIPLES OF THE PROJECT

Fig. 4 depicts the model of project. Firstly, solar panel and graphene generate electricity from sunlight and raindrops. Sunlight and raindrops are masses on a photovoltaic cell, which sends unoccupied electrons and turns the electrons to solar power. The generated solar power is accumulated in the battery as chemical energy while raindrops are stored in form of kinetic energy. The voltage is regulated by a voltage regulator in the solar panel and collected in the battery before it passes in the microcontroller. The charge controller controls the electricity going into the battery from the solar panel. It helps the battery from overcharging and over-discharging by separating the battery from the load especially in the night period to prevent the display of the battery, and by using a transistor to shunt the charging circuit. This helps to increase the life span of the battery. The battery, 12V, 26Ah used in this project is a storage device that stores sun energy in the form of chemical energy. The energy stored is turned to electrical energy and supplied to the load. Microcontroller which is the heart of the system and houses the program that drives the lawn mower produces the output that switches the transistor on high voltage output to the motors attached. The Bluetooth connects to the microcontroller which drives the unit through remote control. The DC motor of 12V, 10000 rpm is used for grass cutting, the second motor, 12V, 40 rpm is for powering the wheel to rotate in a wanted speed and path. The Bluetooth module drives the sensors through DC-DC Converter. The motor driver acts is the convergence betwixt the two wheels motors and controls the direction and the speed of lawn mower, by using a low-current control signal and turning it to a larger-current signal that drives a motor.

4.2. RESULTS

Force (F) = Mass * Acceleration

The force of cutting blade: F = T * R (1)
T = Torgue
R = blade radius
T = P/2πN (2)

Where, P = I * V (3)
Torgue, P = 2πNT/60 (4)
T = (P * 60)/2πN (5)

Amp hour = Total voltage of load * working time/total voltage =52.8 * 5/ 12 = 22Ah

The battery used is 26AH

Wh (battery) = amp hour * total voltage. Where Wh (battery) is the Wattage hour of the battery.
26 * 12 = 312 Whr

Time required for charging = Whr/panel wattage
=312 Whr/40w = 7.8hr

The time required for a full charge of 100% using 40W solar panel is almost 8hours.

5. PROGRAM CODE FOR THE MICROCONTROLLER

```
// rotate mower to 0
constrain (currentspeed, -255, 255);
for (i=existingspeed: i> i--)
{
 analogWrite (PWMA_pin, i);
 analogWrite (PWMB_pin, i);
 delay (accelerateTime);
}
existingSpeed=0;
    if (currentSpeed<0)
    {
     digitalWrite(DIRA_pin, HIGH);
     digitalWrite(DIRB_pin, LOW);
     newSpeed=-newSpeed:
    }
    else
    {
     digitalWrite(DIRA_pin, LOW);
     digitalWrite(DIRB_pin, HIGH);
    }
    for (i=0; i<=newSpeed; i++)
    {
     analogWrite(PWMA_pin, i);
     analogWrite(PWMB_pin, i);
 delay(accelerateTime);

 }

 existingSpeed=newSpeed;

 }
```

6. COMPARISON OF RESEARCH FINDINGS

Table 1: Comparison of different lawn mowers

S/N	Parameters Comparison	Intelligent Enegy harvester lawn mower (2022) Nwobodo L.O	Yardcutter (Edwin. B 1830	Automatic grasscutter machine. Gaikwd (2017)	Grass trimmer machine. Kumar D.N (2018)	Remote controlled grass cutter	Solar powered grass cutter by Philip B.P
1	Convenient	Yes	No	Yes	No	Yes	Yes
2	Fast	Yes	No	Yes	No	Yes	Yes
3	Safe	Yes	No	Yes	No	Yes	Yes
4	Low maintenance	Yes	No	Yes	No	No	No
5	Environmental friendly	Yes	Very noisy	Yes	No	No	No
6	Cheap	Relatively cheap	Relatively cheap	No	No	No	No
7	Fuel	Nil	Very high	High	No	Yes	No
8	Natural disaster like rain	No	Cannot work inrain	No	No	No	Yes
9	Heavyweight	No	Yes	Yes	No	No	Very heavy
10	Heat generation	No	Yes	Heats at intervals	Yes	Yes	Yes

Table 1 explains the few different mowers in existence, compared using some parameters. It shows that All-weather intelligent energy harvester solar system for lawn mowing applications performed best in them all.

7. SUMMARY

An all-weather intelligent energy harvester solar system for lawn mowing applications has been designed and implemented. The study looked at the different lawn mowers existing and was able to tackle their demerits in terms of energy consumption, heat generation, maintenance, being environmentally friendly, etc. The research underlined the importance of the All-weather intelligent energy harvester solar system for lawn mower application. It is a system that works using the remote control. It has zero human effort and is environmentally friendly in terms of noise and air pollution. Because of the increase in electrical bills, solar panel and graphene were used to power it and also charges it as it performs. A comparison of the existing systems was done and the all-weather intelligent energy harvester solar system for lawn mower application in terms of convenience, safe, fast, fuel consumption, low maintenance, environmentally friendly, weight, heat generation, etc.

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