

Design of a Solar-Powered Lawnmower

KESHINRO, AMOS DIMEJI, Engr. Matthew B. OLAJIDE

In partial fulfilment of the requirements for the award of bachelor of science (b.sc.) Degree in electrical and electronics engineering
Department of computer and electrical/electronics engineering college of engineering and environmental studies
olabisi onabanjo university
Ibogun campus ogun state, nigeria

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CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND

The solar-powered lawnmower utilizes the energy from the sun to power the rotation of the blades for mowing of the lawn. Making cutting grass easier over the years, many individuals have added a modification to the mowing machine's actual design speed, efficiency and power to suit particular needs or conveniences. [1]

Nowadays, there are plenty of options starting from the simplest push mower to the most advanced electric grass cutting machine. According to the world energy report, we get around 80% of our energy from conventional fossil fuels like oil (36%), natural gas (21%) and coal (23%). [2] Due to fossil fuels' depleting nature, alternative sources are proffered as a viable solution to avoid an energy crisis soon. The solar-powered lawnmower is an improvement on the cordless electric lawnmower. The sun provides a sustainable amount of energy used for various purposes on earth for the atmospheric system. Every minute the sun radiates about 5.68×10^{26} calories of power, the world intercepts only 2.55×10^{18} calories. [3][4]

The solar-powered lawnmower works on a similar principle to the other early lawnmower inventions. The photovoltaic panel converts the energy from the sun to electrical energy needed to drive the mower. With the use of solar as the energy source, a lawnmower will address several issues that the standard internal combustion engine, such as downtime due to fuel refills and the danger associated with gasoline spillage. The solar-

powered lawnmower eliminates the dangerous emissions generated by the gasoline spillage and the internal combustion engine into the atmosphere. The solar-powered lawnmower will help reduce air pollution and noise pollution produced by other lawnmowers as well as significantly reduce the operational cost. [5][6]

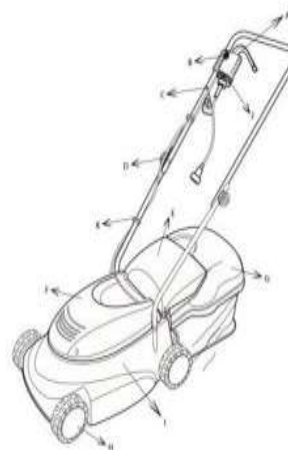


Figure 1.1: Diagram of a typical lawnmower [7]

CHAPTER TWO

DESIGN ANALYSIS

The design comprises four (4) primary sections, which are:

1. Power Supply Unit
2. Charging and Storage Unit
3. Control Unit
4. Load or Output Unit

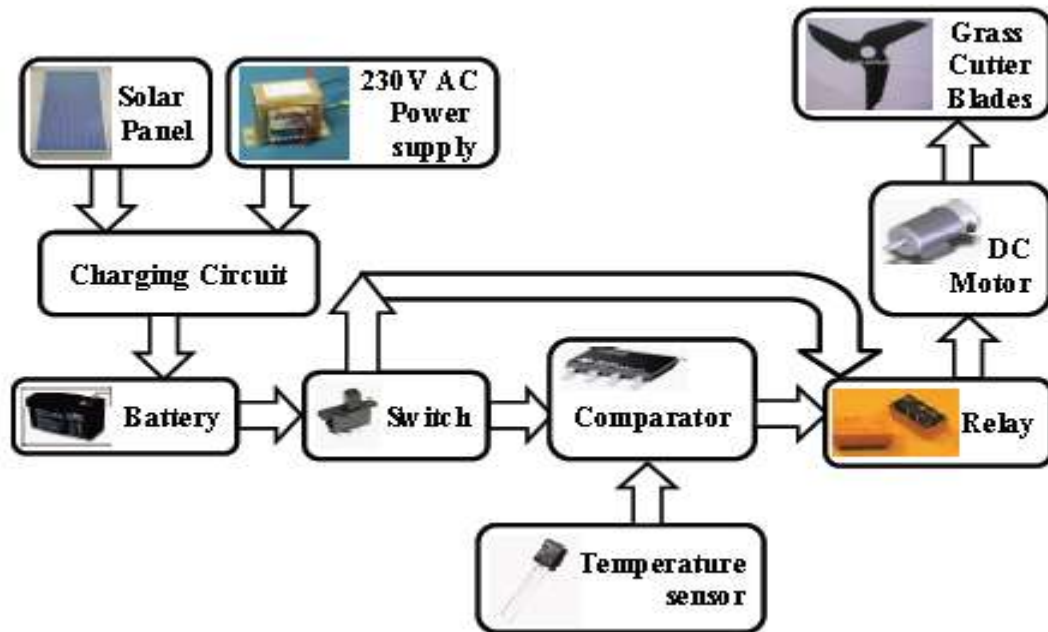


Figure 2.1: Block diagram of the project

2.1. POWER SUPPLY UNIT

The power supply unit comprises the primary and secondary power supply. The main source is a solar panel that produces current from sun rays' absorption. The voltage, in this case, varies as the temperature changes. A voltage regulator (also known as a charge controller) connects to the solar panel's output, producing a steady voltage of 12v.

The secondary power, in this case, is gotten from alternative means like turbine power supply, electromagnetic power supply, and so on, which can produce an alternating current of about 220-240v AC, 50Hz. The output will have two different plugin outlets, which will serve as inputs for the next section.

2.2.1. CHARGE CONTROLLER CALCULATIONS

Maximum power point tracking (MPPT) is used because of its better efficiency and durability.

Solar panel rating = 50W

Solar panel voltage = 12v

$$I = \frac{50}{12} = 4.17A$$

$P = IV$

The most suitable charge controller rating is 5A (MPPT) charge controller.[8]

2.2. CHARGING AND STORAGE UNIT

The charging circuit consists of components that convert the AC power source to DC to charge the battery. The two input sources include;

1. 230VAC supply
2. The solar power dc supply

The circuit (fig2.2) consists of a battery voltage level detector that helps control overcharge and overuse. The positive terminal of the upper comparator of the 555 (pin 5) connects with a reference voltage to turn OFF the charger if the battery charges above 13.8V. The reference voltage combines a Zener diode in series with a resistor. If the battery voltage exceeds 13.8V, the comparator output goes high, and the flip flop is set, turning OFF the transistor and the relay.

If the battery voltage is below the preset voltage (set by us), the lower comparator will reset the flip flop turning ON the transistor, and the relay will switch to charge the battery. The recharge is by varying the variable resistor.

Fig 2.3 shows the circuit for the low battery indicator with the cut-off designed using lm741 comparator IC. The variable resistor and the reference voltage sets the threshold voltage. When the battery voltage drops to a certain level, the voltage at the pin3 (non-inverting input) is lower than the reference voltage at pin2. Hence, the output of the IC becomes HIGH, illuminating the led and powering the transistor, which in turn powers the 6V relay.[9]

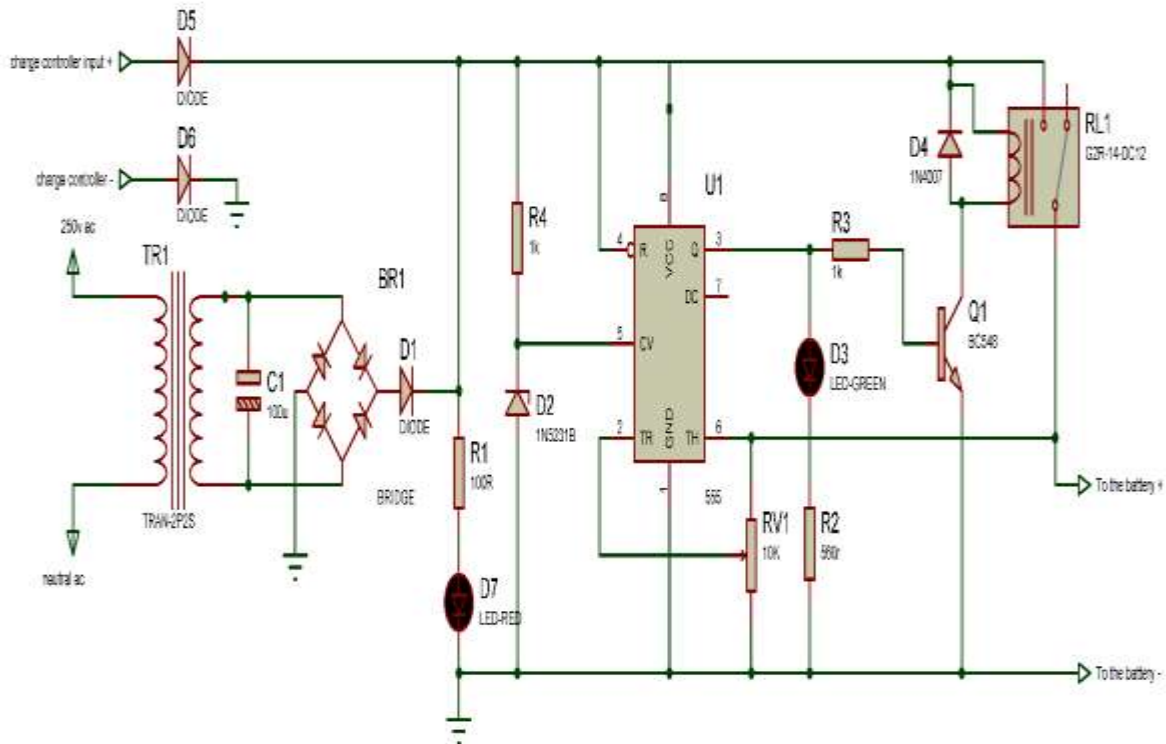


Fig2.2: Charging circuit design with battery level detector

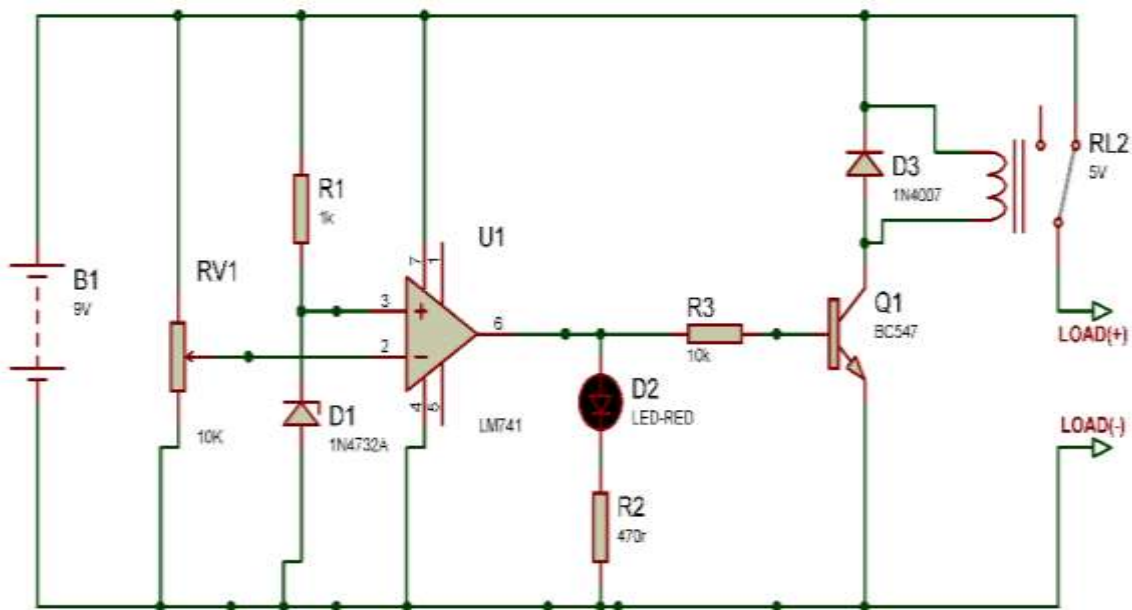


Fig2.3: Low battery indicator with cut-off circuit

3.2.1. CALCULATIONS Operation

$$\text{Operational hours} = \frac{\text{Battery amperage}}{\text{Motor current}} = \frac{34\text{AH}}{20.83\text{A}} \quad (1)$$

$$= 1.63\text{Hours}$$

$$= 97.8\text{min (1hr 37.8mins)}$$

Or

$$\text{Operational hours} = \frac{\text{Battery wattage}}{\text{Motor wattage}} = \frac{34 * 12 \text{ WH}}{250\text{W}} \quad (2)$$

$$= 1.632\text{Hours}$$

$$= 97.8\text{min (1hr 37.8mins)}$$

Charging Period

$$\text{Charging hours} = \frac{\text{Battery wattage}}{\text{Solar rating}} = \frac{34 * 12 \text{ WH}}{50\text{W}} \quad (3)$$

$$= 8.16\text{Hours (8hr 10mins)}$$

[10]

2.3. CONTROL UNIT

The maximum operating temperature of the design motor specification is 120^oc. The motor at no point should be allowed to get to this point. The control unit has been designed in such a way to ensure this.

The control unit consists of the switch, comparator, relay and temperature sensor. This unit is responsible for the regulation and effective regulation of the mower. The level of the switch determines the current flow. The switch is a two-way switch wired to have an ON state and an OFF state. The ON state allows current flow through conductors to the comparator circuit and the relay.

The comparator circuit consisting of an op-amp IC is employed to control the system when needed depending on the temperature level. When the temperature level of the motor is less than 118^oc, it switches to NC as the relay is not energized. When the temperature exceeds 118^oc, the comparator circuit energizes the relay and switches to NO, supplying no current to the motor.

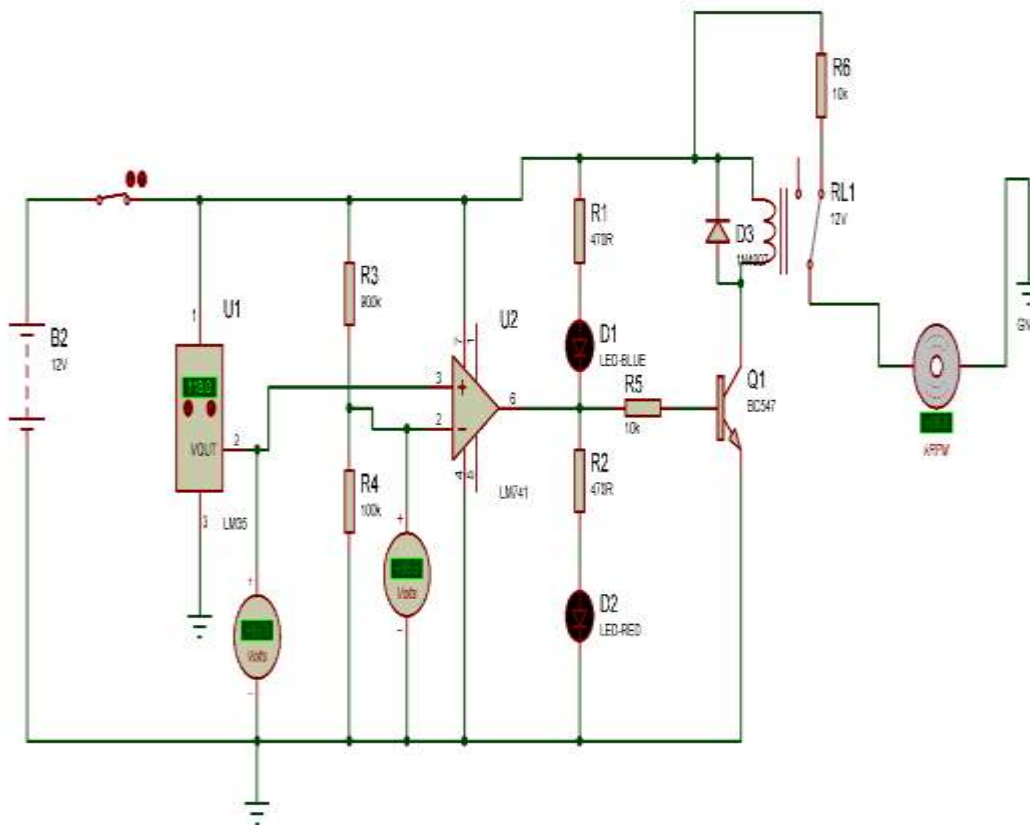


Fig 2.4 Control Unit Circuit

2.4. LOAD OR OUTPUT UNIT

This unit consists of the load, which is, in this case, a DC motor. The specification and analysis of the load are in the table below.

Table 1: Technical specification of the mower

Voltage (volts)	12	Front Wheel size Dia.	8 inches
Blade weight (N)	0.14	Rear Wheel Size Dia.	8 inches
Solar charge time (hours)	8.16	Size of yard	½ -1 Acre
Fuel Type	Rechargeable Battery	Cordless	Yes
Lawnmower Type	Walk Behind	Run Time (min.)	98 min./ fully charged battery
Maximum cutting height (inches)	3.5	Start Type	Electric
Motor Power	250W	Motor Model	12V D.C.
Battery Specification	12V/34Ah (2 * 12V/17Ah)	Battery charging time	8 to 10 hours
Cutting height	3.5"	Solar rating	50W 12V
Motor phase-frequency	Single-50Hz	Max Operating Temperature	120 ⁰ c

2.5. PRINCIPLE OF OPERATION

The dc motor is supplied dc power from the battery, controlled by the manual switch and the comparator. The manual switch controls the current flow from the battery to the relay, while the control unit controls the current flow to the motor.

When the switch is ON, current flows through conductors to energy the motor and hence causes rotation of the blade, leading to the lawn's cutting action. The mower can move in any direction manually to perform the cutting.

When the battery reaches a critical level (9v or whatever threshold set), the battery's supply is automatically disconnected until recharged.

Suppose at a point of usage; there is a massive increase in temperature up to about 120⁰c due to several factors like the environmental factor, long period of use etc.; the control unit sets in play

by sensing the temperature rise, switching the lawnmower OFF to avoid damages.

The mower is then connected to a power source to recharge the battery. When the battery is fully charged (13.8v), The circuit alters the current flow from charging the battery even though the power supply is intact to avoid overcharging and damaging the battery.

CHAPTER THREE RESULT AND DISCUSSION

The report is a detailed sum of a designed project architecture which executes and satisfies the requirement of creating a solar-powered lawnmower. The implemented hardware and computer simulation gives the following specifications.

3.1. SOLAR PANEL DAILY READING

Table 2: Solar Panel Voltage Reading at Sun Hours

Time (hrs)	Voltage(V)
0.00	0.00
7.00	15.00
8.00	16.00
9.00	18.50
10.00	17.00
11.00	15.15
12.00	19.67

13.00	19.72
14.00	20.20
15.00	20.00
16.00	20.56
17.00	18.03
18.00	17.00
19.00	14.00

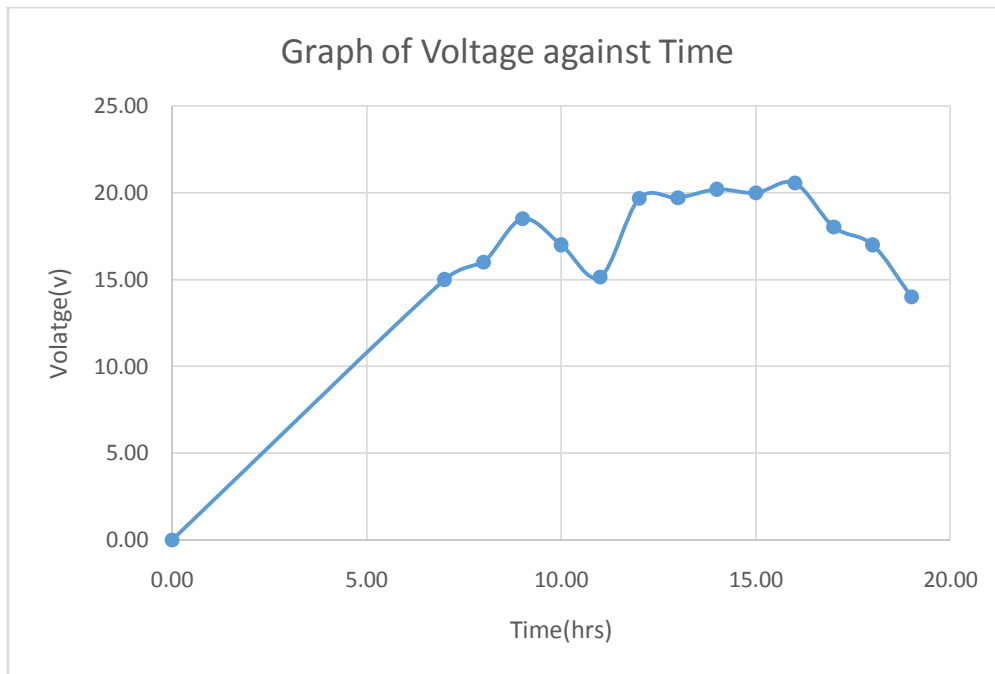


Fig 3.1: Graph of Voltage against Time

Table 3: Battery reading parameter

SG Reading	% of Charge	Measured Voltage
1.277	100	12.73
1.258	90	12.62
1.238	80	12.50
1.217	70	12.37
1.195	60	12.24
1.172	50	12.10
1.148	40	11.96
1.124	30	11.81
1.098	20	11.66
1.073	10	11.51

3.2. DISCUSSIONS

Based on the test results, it is possible to identify some significant conclusions from this work.

These include the following:

1. The area of cut (battery duration) depends on lawn conditions, grass density, moisture content, grass length and height of cut.

2. Switching the product on and off frequently during cutting will also reduce the area of cut (battery duration).
3. The maximum cutting height is 3.5 inches.
4. The run time is 98 min. / fully charged batteries.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1. CONCLUSION

Solar energy is inexhaustible energy from the sun. From the test and observation in chapter 4, we can conclude that as the sun's intensity radiated through the panel increases, the output voltage from the panel also increases, giving rise to the voltage generated.

This project will save cost, minimize noise, and reduce environmental hazards produced by other existing mowing methods. Therefore, solar energy is one of the most available sources of generating power.

4.2. RECOMMENDATION

It is worth noting that no matter how good construction or design might be, there is always room for improvement. The design implementation in this project would undoubtedly have some limitations. A possible area of improvement is incorporating remote sensors into the lawnmower to operate it by the remote control.

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