Low Carbon Footprint Electric Lawn Mower

Functional Requirements List and Performance Specifications

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Environmental pollution is becoming more of a problem. A major contributor to this pollution is the use of gasoline-powered lawn mowers. Our overall project goal will be to design a lawn mower that will be a solution to this problem. The project will consist of two separate systems: a battery-powered lawn mower and a photovoltaic system to charge the battery. Both systems will be microcontroller based. The mower will use a microcontroller to control the speed of the cutting blade and display the charge status of the battery. The charger will use a microcontroller to control the charging algorithm for the battery. In addition to this, the charger will include an AC backup in case of an extended period of cloudy weather.

Fig. 1 – Lawn Mower Block Diagram

Lawnmower Subsystem Breakdown

The lawnmower shall be a push-type mower and shall have an 18 inch cutting blade.

Battery: The battery powering the mower shall be two 12 volt batteries connected in a series configuration. The capacity of each battery shall be chosen so that the mower is able to mow a 10000 sq. ft. yard in one hour. The batteries shall be able to be removed from the lawnmower.
**Voltage Regulator:** The voltage regulator shall have an input voltage of 24VDC and an output voltage that shall meet the requirements to power the various components (to be determined).

**A/D Converter:** The A/D converter shall have 8-bit resolution and have a range of at least 0-24 volts.

**Controller:** The controller shall be used to start and stop the motor, control the speed of the motor, and control the display. The controller shall utilize closed-loop methods to keep the speed of the motor shaft relatively constant. The signal that is output to the H-bridge shall be a PWM signal with a frequency of at least 20 kHz, but less than 100 kHz. The controller shall also monitor the current draw of the motor for over-current protection. The maximum current is to be determined.

**User Inputs:** The user inputs shall consist of a power button to turn the controller on/off, a start button to start the mower, a throttle switch to vary the speed of the mower blade, and a safety switch to stop the mower. The motor shall only spin if the safety switch is engaged.

**Display:** The display shall consist of one power LED, an LED to alert the user that the blade is spinning and at least two seven-segment displays to show how much time is left until the battery is fully discharged. It shall also consist of a voltmeter to display the battery voltage and an ammeter to show the current draw of the motor. The range and accuracy of these two meters will be determined later.

**H-Bridge:** The H-bridge amplifier shall have the capabilities to power the motor (to be determined). It shall have a maximum output voltage of 24VDC.

**Motor:** The motor driving the blade shall have an input voltage of 24V DC and have enough power to spin an 18 inch blade at a speed that will cut grass (to be determined).
Fig. 2 – Mower Controller Flow Chart

1. Start
2. Initialize Controller
3. Safety Switch Engaged?
   - Yes: Set PWM duty cycle to 0%
   - No: Start button pushed?
     - Yes: Throttle setting?
       - Yes: Set speed control variable to fast value
       - No: Set speed control variable to slow value
     - No: Safety Switch Engaged?
       - Yes: Set PWM signal
       - No: Input motor speed
4. Compare actual motor speed to what it should be
5. Adjust motor speed if necessary
6. Input battery voltage
7. Calculate battery time remaining
8. Display time remaining
9. Turn on motor spinning display LED
**Charger Subsystem Breakdown**

**AC Power**: The AC power shall be standard 110VAC from a power outlet.

**Relay**: The relay shall have a control voltage that matches the output voltage of the controller (to be determined) and shall be able to switch 110VAC at a certain current (to be determined).

**AC/DC Converter**: Shall convert 110VAC to a DC voltage (to be determined).
**DC/DC Converter:** Shall regulate the DC power. Shall be able to power components as well as charge the battery.

**Solar Power:** Shall have a power rating that is sufficient to charge two discharged 12V batteries (wired in parallel) to full capacity over a period of five days.

**Quick Charge Switch:** Shall be a two position switch to switch charging mode.

**A/D Converter:** The A/D converter shall have 8-bit resolution and have a range of at least 0-12 volts.

**Charger Controller:** The controller shall be used to control the charge algorithms for the batteries as well as calculate and display information about the state of charge of the batteries.

**Display:** The display shall be made up of at least two seven-segment displays and other LEDs that display the charge state of the batteries.

**Battery:** The battery block shall consist of two 12V batteries (as discussed in the lawnmower subsystem breakdown) that shall be wired in parallel for charging.
**Fig. 4 – Flow Chart for Charger Controller**

INIT

Main Loop

Quick Mode switch = true?

Read PV voltage

Is solar voltage enough?

Yes

NO

Switch on AC Power

AC Power off = true

Read Battery Voltage

Is Battery Charged?

Yes

NO

Output FLOAT charge level to battery charger current/voltage regulator

Output SOLAR charge level to battery charger current/voltage regulator

Read Battery Voltage

Is voltage up to constant charge level?

YES

NO

Output constant Voltage to battery charger current/voltage regulator

Quick Mode switch = true?

Has XX amount of time passed?

Yes

NO

Output constant current @ 30% of battery current rating to battery charger current/voltage regulator

Quick Mode switch = true?

Yes

NO

References

1. http://www.mindfully.org/Air/Lawn-Mower-Pollution.htm