Low Carbon Footprint Electric Lawn Mower

Functional Description and
Complete System Block Diagram

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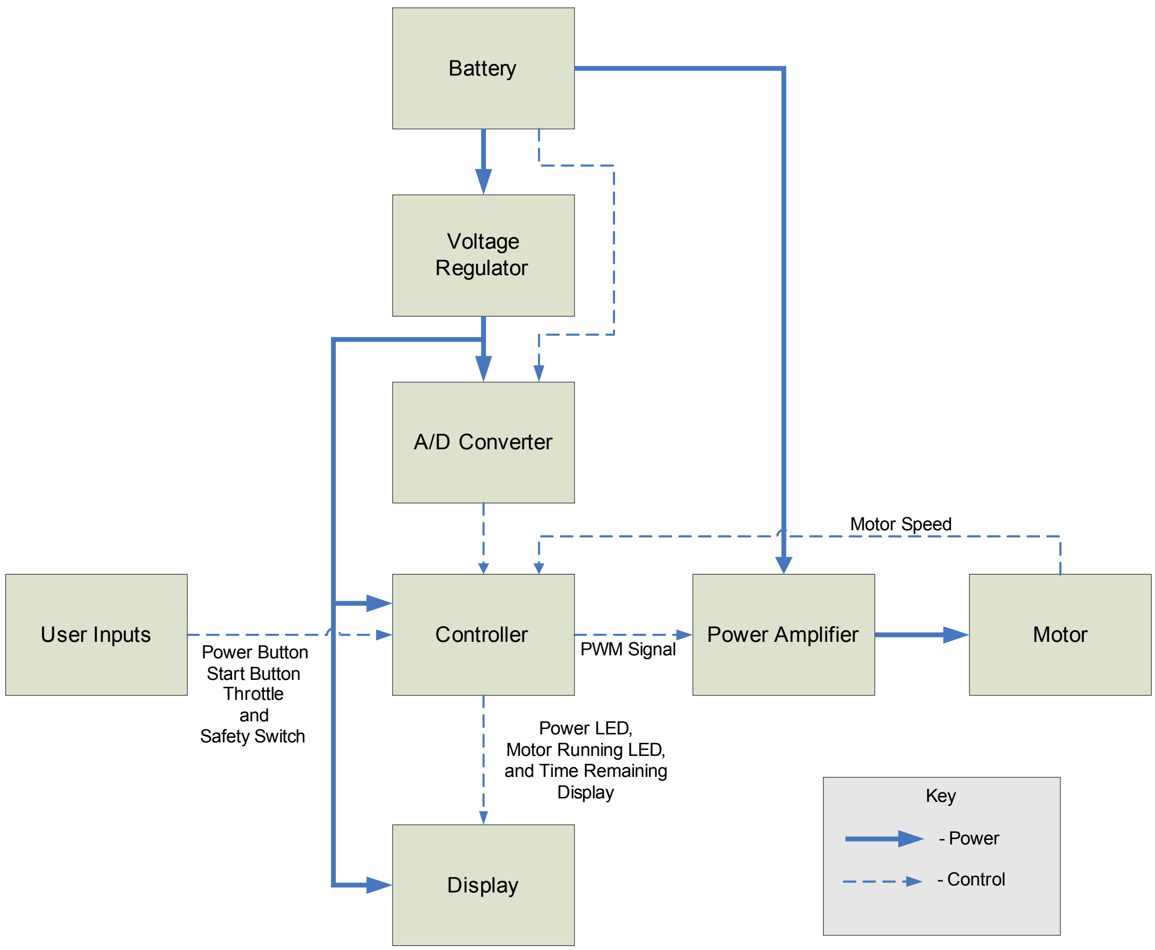
Environmental pollution is becoming more of a problem. A major contributor to this pollution is the use of gasoline-powered lawn mowers[1]. Our overall project goal will be to design a lawn mower that will be a solution to this problem. The project will consist of two separate systems: a battery-powered 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

Battery: The mower will use a rechargeable battery for power. The battery capacity will be chosen to supply enough energy to mow a 10,000 ft^2 yard in one hour with a full charge.

Voltage Regulator: Since the battery voltage varies as it is discharged, a Voltage Regulator will be needed to supply the various components with a constant voltage supply.

A/D Converter: The A/D converter will be used to convert the battery voltage into a digital signal so the controller can determine the charge of the battery.

Controller: The controller will be used to start and stop the motor, control the speed of the motor, and control the display. It will control the speed of the motor by varying the duty cycle of a PWM signal. As long as the frequency of the PWM signal is high enough, the motor will see the average value of the PWM signal voltage.

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

Display: The display will consist of a power LED, an LED to alert the user that the blade is spinning, and a few seven-segment displays to show how much time is left until the battery is dead.

H-Bridge: The H-bridge amplifier will be used to convert the PWM signal from the controller into a PWM signal with a higher voltage that will be used to power the motor.

Motor: The mower will use a dc motor that will be chosen so that it has sufficient power to spin a blade fast enough to cut grass. The motor will feedback its speed to the controller so the blade speed can be increased or decreased depending on the size of the load.

Fig. 2 – Mower Controller Flow Chart

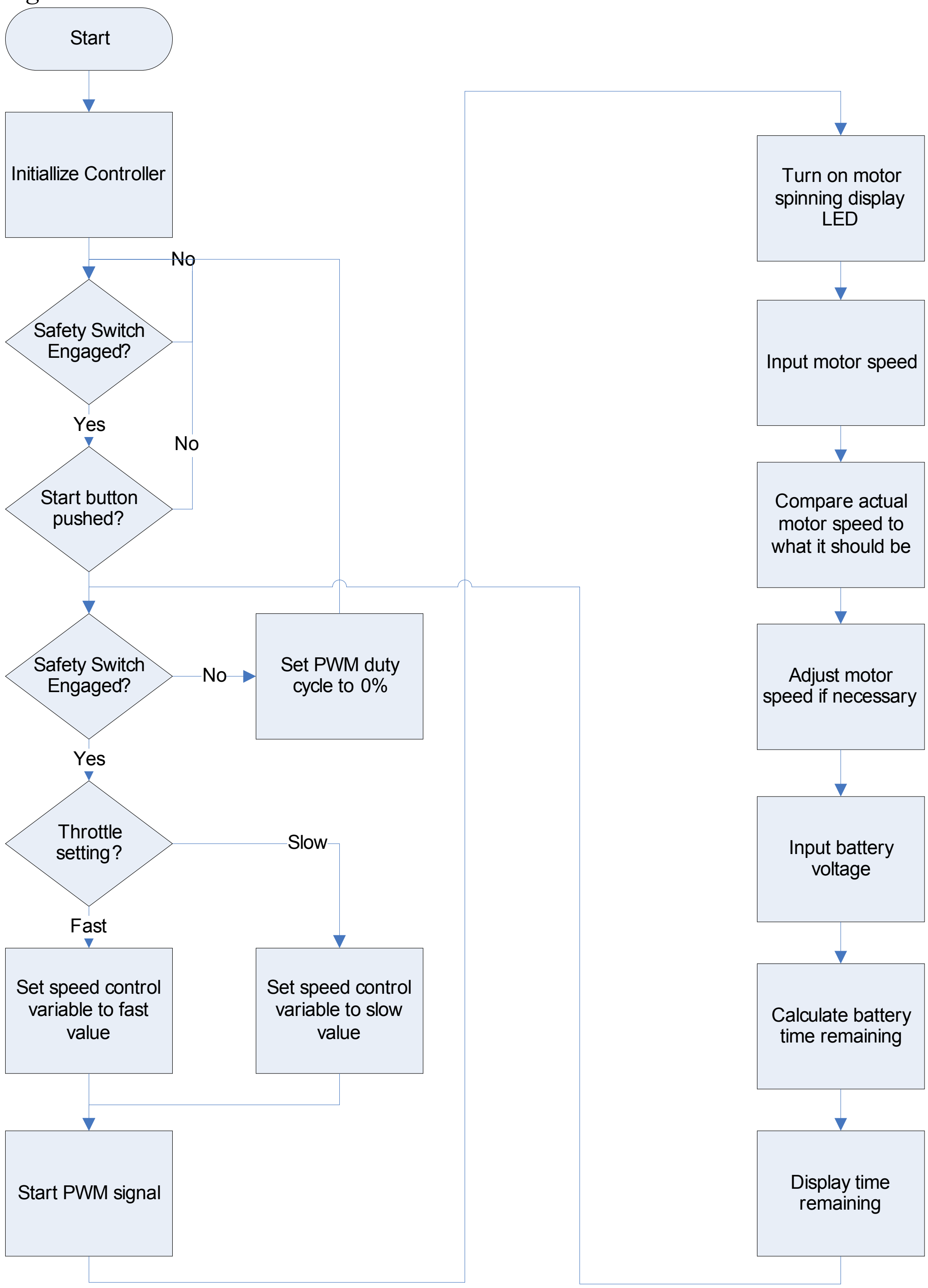
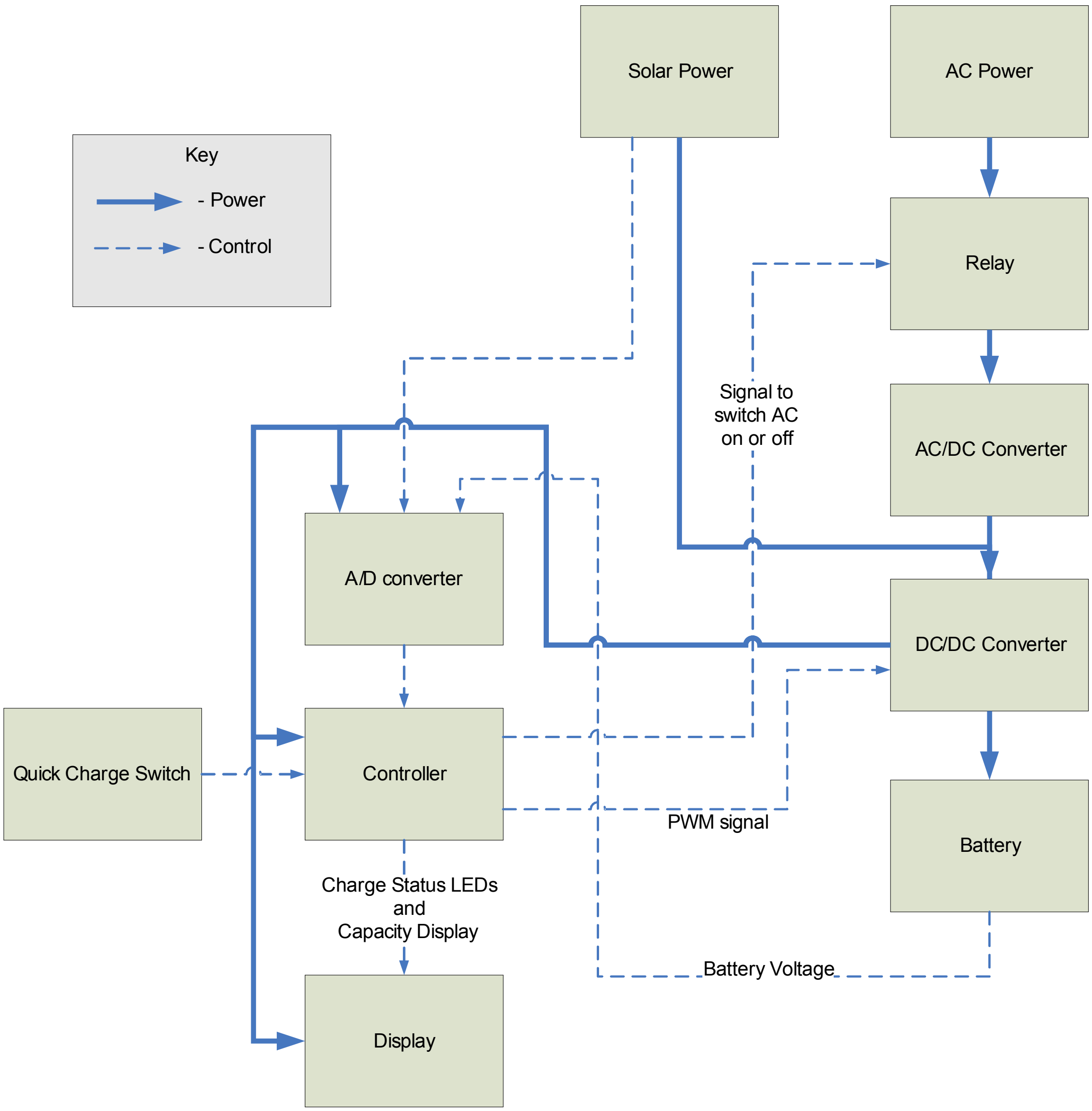


Fig. 3 – Battery Charger Block Diagram



Charger Subsystem Breakdown

AC Power: Standard 110V 60Hz power from the power grid.

Relay: Used to switch the AC power from a wall outlet on/off.

Quick Charge Switch: User input to charger controller to charge in Quick Charge Mode. See Charge algorithm.

AC/DC Converter: Takes AC power then rectifies it and conditions it into DC current.

DC Power Regulator: Regulates the current and voltage supplied to charge the battery.

A/D Converter: Analog to digital converter used by the microcontroller to read the battery terminal voltage.

Solar Power: Photons that hit the PV cells will create a DC current.

Photo Voltaic Cells: The PV cells are sized according to the size of the battery for the lawn mower. Based on the average solar radiation energy that a site will receive per day, the PV cells must be able to fully charge the battery after a complete discharge in at least 5 days of average sunny weather. The cells will be able to supply the minimum voltage and current necessary to the charger subsystem to complete the full charge in five days.

Charger Controller: The charger system will take inputs from either the DC output of the PV cells or an AC backup fed from a standard wall outlet incase of extended periods of inclement weather. The charger conditions the input energy to the proper voltage and current levels needed to charge the battery. The controller will maximize the amount of time using entirely solar energy while attempting to minimize using energy from the wall outlet. The exact conditions of when the controller will switch on the AC reserve will be developed after the charging rates are determined. The digital part of the controller will be implemented on a microprocessor and it will have user inputs and a display. The display will show charge status and capacity. The user will have the option of switching to a high current quick charge from the wall AC if desired. The AC power will be switched on via a relay signaled from the controller and will then be fed into an AC/DC converter. After the AC is converted to DC, it is fed to the DC current/voltage converter which charges the battery. If the system is solely running off the DC solar power, it is fed directly into that voltage/current regulator.

Charging Algorithm: During extended periods of time without use of the lawnmower system, the battery will remain fully charged by using the minimum amount of power needed. According to Battery University.com, this is called the float level and it refers to the minimum voltage and current needed to counteract the rate the battery self discharges. The controller will maintain this level when the battery is fully charged. When the battery has been discharged after the lawn has been mowed, the charger will have at least 5 days to charge the battery completely. Based on the battery size, the proper voltage and current levels to do this will be determined. If the user decides to enter quick mode charge by purely AC utility power, the charge algorithm will be optimized for speed. In the first stage, current is held constant at about 30% of the rated output current of the battery. In the second stage, voltage is held constant while current is minimized, and the third stage maintains the float charge levels.

Fig. 4 – Flow Chart for Charger Controller

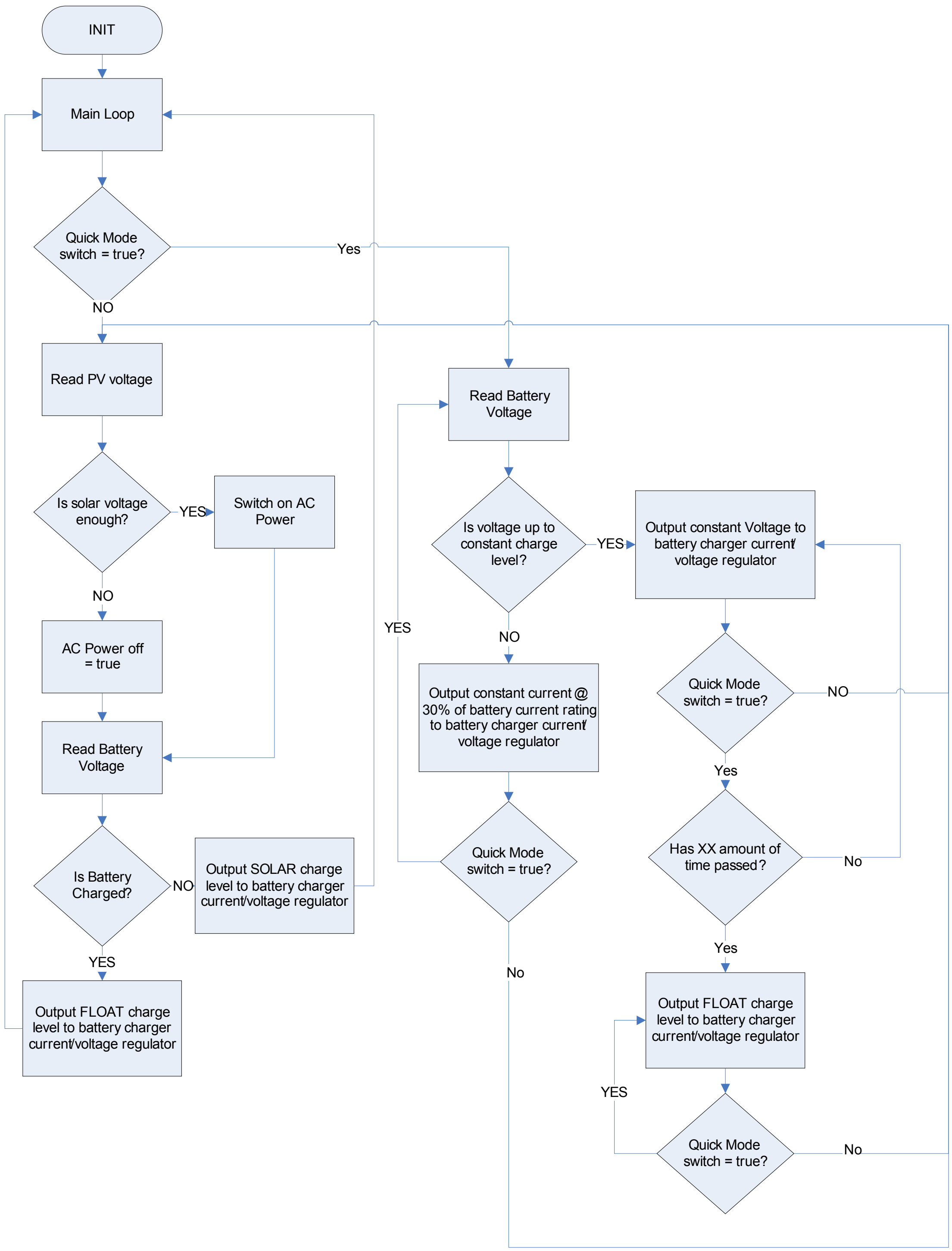
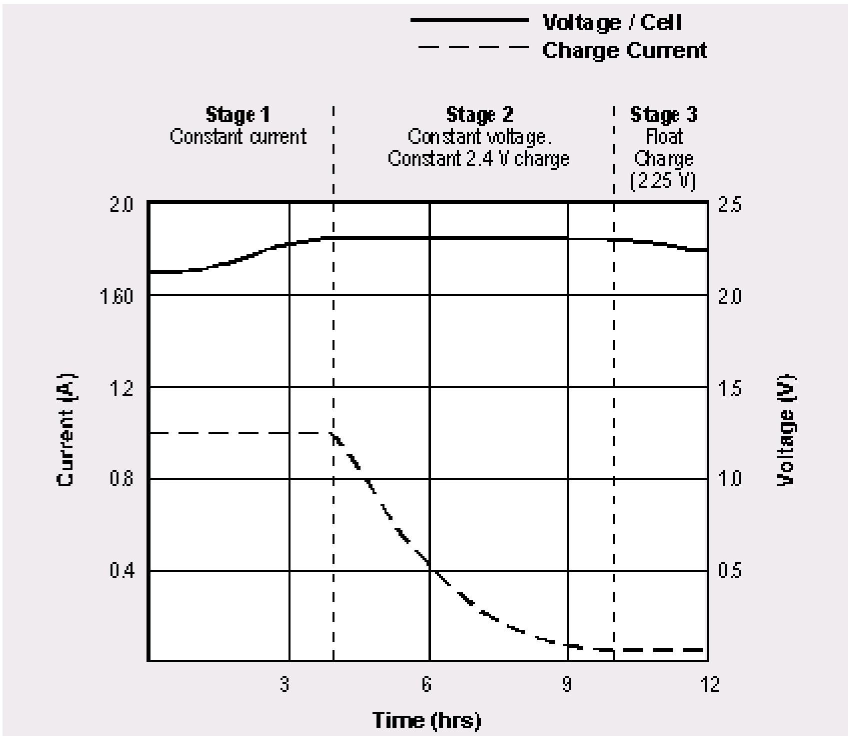


Fig. 4 – Quick Mode Battery Charging Algorithm [2]



References:

1. http://www.mindfully.org/Air/Lawn-Mower-Pollution.htm
2. http://www.batteryuniversity.com/partone-13.htm