Low Carbon Footprint Hybrid Battery Charger

Functional Description and Complete Block Diagram

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1. Introduction

The aim of the Low Carbon Footprint Hybrid Battery Charger (LCC) project is to charge a battery for vehicular applications using the renewable energy resources of photovoltaic arrays and a wind turbine. The project will emphasize efficient energy collection and usage by developing algorithms to maximize renewable energy use and minimize utility A.C. energy use. In addition, the user will have the ability to choose three different modes based on how they want to charge the battery. The modes of operation are: maximum battery life, minimum charge time, and emergency charge. The completed system will require:

1. using photovoltaic arrays and a wind turbine as renewable energy sources
2. a power control system to optimize use of renewable energy
3. a microcontroller based user interface
4. charging systems for the stationary and mobile battery

2. High Level Block Diagram

Figure 2.1 depicts the high level system block diagram. This flow chart shows primary objectives in white and extended objectives shaded. If time permits the shaded blocks will be implemented, but are not necessary for basic functionality. In Figure 2.1, the dotted lines represent control signals and the solid lines represent power flow. The control signals will be used to control the flow of power and transmit data for the user interface. Power flow is the path the power will follow through the charging process to reach the mobile battery.

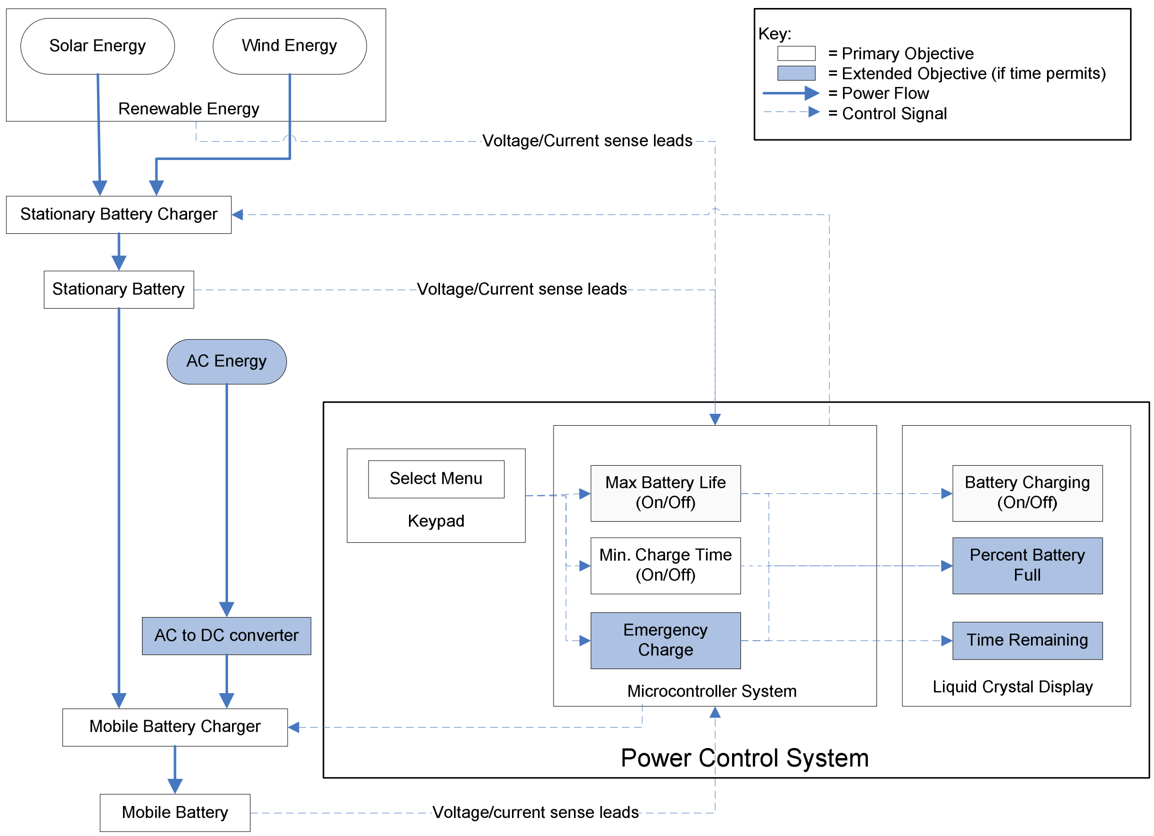


Figure 2.1: High Level System Block Diagram

2.1 Subsystems

Refer to Figure 2.1 as each subsystem is briefly explained.

2.1.1 Renewable Energy

The renewable energy subsystem includes wind and solar energy. Ideally, wind energy would be provided by a full scale wind turbine, and solar energy would be provided by a photovoltaic array. For proof of concept, a DC motor will drive a DC generator simulating a scaled down version of a wind turbine. Photovoltaic cells will be used to collect power from the sun.

2.1.2 Stationary Battery Charger

The stationary battery charger will process the two renewable energy sources to generate a single regulated output voltage capable of charging a stationary battery. The battery charger will always operate in a mode consistent with maximizing the stationary battery's life, and will always be charging as long as the renewable power does not drop below a certain threshold. The minimum power threshold has not yet been determined.

2.1.3 Stationary Battery

The stationary battery will store renewable energy until power is needed to charge a mobile battery. The stationary battery will be composed of Ni-MH to accommodate deep cycle discharging, trickle charging, a relatively high number of charge cycles, and constant battery capacity throughout its lifetime [1]. When the battery can only hold a 80% charge, it will be assumed the battery has reached the end of its life [2].

2.1.4 Mobile Battery Charger

The mobile battery charger subsystem is similar to the stationary battery charger subsystem. However, the mobile battery charger will have the ability to switch modes. The mobile battery charger will accept power from the stationary battery and the (paralleled) stationary battery charger. If the extended objectives are met, this charger will also have the ability to use AC power if no other power is available.

2.1.5 Mobile Battery

The mobile battery will be an electric car battery. For proof of concept, this project will use a Panasonic LC-RA1212P 12V lead-acid battery. The rated capacity for this battery is 12Ah [3]. The Panasonic datasheet for this battery is included in Appendix A. Maximum battery life and minimal charge time characteristics for this battery will need to be researched.

2.1.6 Voltage/Current Probes

Voltage and current sensors will be used to detect available power from the renewable sources. The sensor outputs will be used within the microcontroller system to determine what power sources are used to charge the mobile battery. In addition, the sensors will be used to control the charging algorithm for each battery. If the extended objectives are completed, AC power can be used to charge the mobile battery if the charge state of the stationary battery is inadequate.

2.1.7 Power Control System

The power control system will be an 8-bit microcontroller based module responsible for routing the power flow in a manner that maximizes renewable energy utilization. It will analyze data from the user and from the voltage and current sensors to achieve optimum battery charging efficiency.

2.1.8 Mobile Charger User Interface Input

A keypad will be used as the power control system user interface. From the keypad the user will be able to choose the desired mode of operation based on his or her current circumstances. The three modes of operation are:

- Maximum Battery Life
    - Only the stationary battery is used to charge the mobile battery. Renewable energy sources will continue to provide energy to the stationary battery and to the mobile battery during charging. This method will charge the mobile battery in such a way as to maximize battery life. As an extended objective, AC power may be used in combination with the stationary battery in this step to charge the mobile battery.
- Minimum Charge Time
    - Minimal charge time mode will contain the same sources as maximum battery life mode. However, a different charging algorithm will be used in minimal charge time mode to charge the mobile battery as fast as possible.
- Emergency Charge:
    - As an extended objective, an emergency charge mode may be implemented. This mode will use AC power to charge the battery in emergency circumstances. By using AC power, the user can charge the battery anywhere a standard 120V power outlet is available.

2.1.9 Mobile Charger User Interface Output

A LCD controlled by the power control system will be used for interface output. The power control system will have the ability to collect and analyze data to provide the user with the following information:

- battery charging status (charging on/off)
- extended objectives
  - the charge percentage of maximum capacity
  - the time remaining until the battery is charged to maximum capacity
  - a battery longevity indicator that will indicate approximately how many charge cycles the battery will tolerate before replacement is needed

3. Software Flowcharts

The software will include two separate microcontroller systems, one for the stationary battery charger and one for the mobile battery charger. The mobile battery charger software will handle user inputs and outputs. The High Level Mobile Battery Charger Software Flow Chart is shown in Figure 5.1, where extended objectives are shaded.

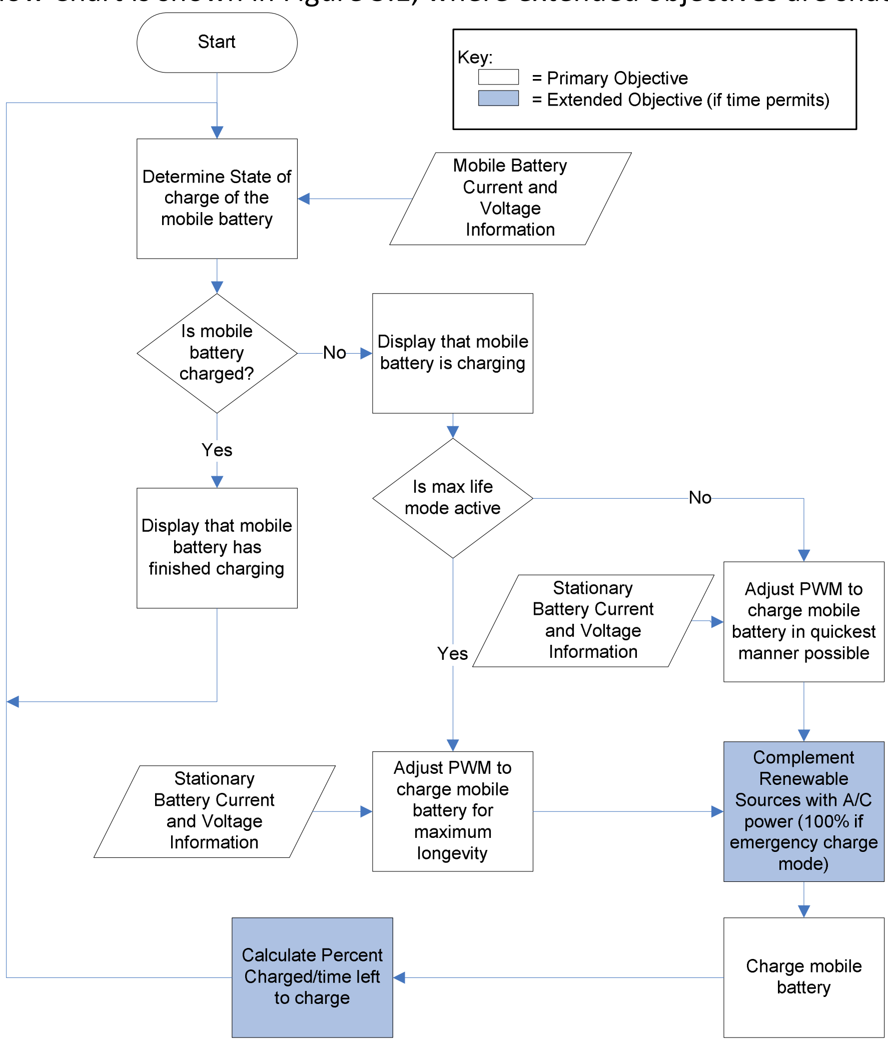


Figure 5.1: High Level Mobile Battery Charger Software Flow Chart

Depending on which mode is active, the microcontroller determines the correct pulse width modulated signal to either maximize battery life or minimize charge time. Also, in the extended functionality, an AC source will be used in either an emergency mode or to complement the renewable energy to charge the battery in either charge mode. Initially, the only output will be the status of the charge i.e. charging or not charging. As part of the extended objectives, the user output will additionally display time remaining to charge, percent of the battery charged, and a battery longevity indicator. The battery longevity indicator would approximate how many charge cycles the battery will tolerate before replacement is needed. The High Level Stationary Battery Charger Software Flow Chart is shown in Figure 5.2. The stationary battery charger will function in a manner similar to the mobile battery charger except it will always be in the maximum battery life mode.

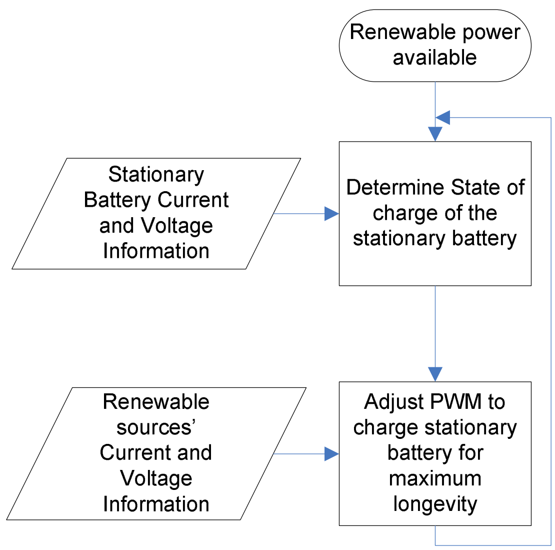


Figure 5.2: High Level Stationary Battery Charger Software Flow Chart

4. Appendix A

VALVE-REGULATED LEAD ACID BATTERIES: INDIVIDUAL DATA SHEET

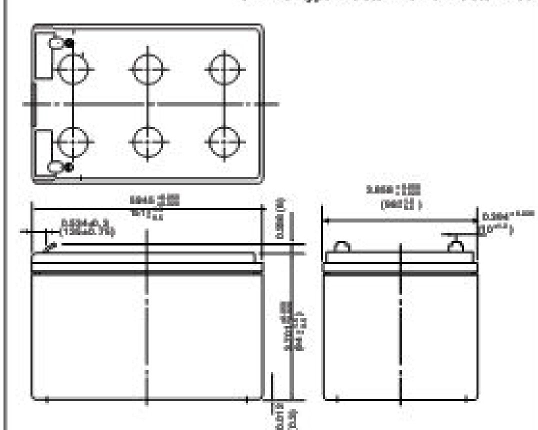
LC-RA1212P

For main and standby power supplies.
Expected trickle life: 3-5 years at 25°C, Approx. 5 years at 20°C.

Photo/Label for reference only.

Dimensions (mm)

Terminal type: Faston 187 or Faston 250



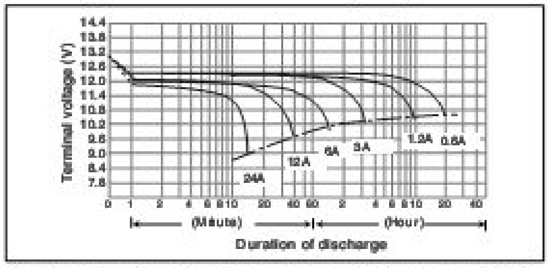
Battery case resin: Standard (UL94HB) Color is black.

Specifications

Nominal voltage		12V
Rated capacity (20 hour rate)		12Ah
Dimensions	Length	5.945 inches (151.0 mm)
	Width	3.860 inches (98.0 mm)
	Height	3.702 inches (94.0 mm)
	Total Height*	3.937 inches (100.0 mm)
Approx. mass		8.36 lbs (3.8 kg)
Standard Terminals and Resin	UL94HB Faston 187	LC-RA1212P
	UL94HB Faston 250	LC-RA1212P1

* The total height with #250 terminal is 101.5mm.

Discharge characteristics 77°F (25°C) (Note)

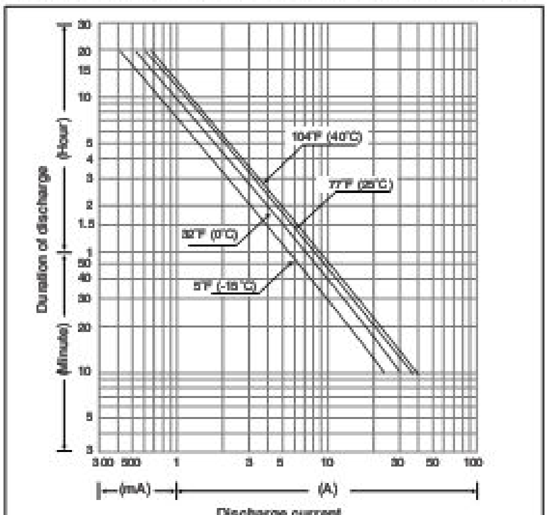


Characteristics

Capacity (Note) 77°F (25°C)		20 hour rate (600mA)	12Ah
		10 hour rate (1130mA)	11.3Ah
		5 hour rate (2080mA)	10.4Ah
		1 hour rate (8100mA)	8.1Ah
		1.5 hour rate discharge Cut-off voltage 10.5 V	5.8A
Internal resistance		Fully charged battery 77°F (25°C)	Approx. 30mΩ
Temperature dependency of capacity (20 hour rate)		104°F (40°C)	102%
		77°F (25°C)	100%
		32°F (0°C)	85%
		5°F (-15°C)	65%
Self discharge 77°F (25°C)		Residual capacity after standing 3 months	91%
		Residual capacity after standing 6 months	82%
		Residual capacity after standing 12 months	64%
Charge Method (Constant Voltage)	Cycle use (Repeating use)	Initial current	4.8 A or smaller
		Control voltage	14.5V to 14.9 V (per 12V cell 25°C)
	Trickle use	Initial current	1.8 A or smaller
		Control voltage	13.6V to 13.8V (per 12V cell 25°C)

(Note) The above characteristics data are average values obtained within three charge/discharge. Cycles not the minimum values.

Duration of discharge vs. Discharge current (Note)



5. References

[1] David, Linden, and Thomas Reddy. Handbook of Batteries. New York: McGraw-Hill Professional, 2002.

[2] Kiehne, H.A.. Battery Technology Handbook, Second Edition (Electrical and Computer Engineering). Boca Raton: CRC, 2003.

[3] "Valve-Regulated Lead Acid Batteries: Individual Data Sheet LC-RA1212P." VLRA Batteries. 29 Nov. 2007 <cegt201.bradley.edu/projects/proj2008/lcc/pdf/mobile_battery_datasheet.pdf>.

[4] "Solar power insolation for U.S. major cities." Solar power can be a practical power source when using advanced photovoltaic equipment.. 29 Nov. 2007 <http://solar4power.com/solar-power-insolation.html>.

[5] "Illinois Wind Maps." Energy Efficiency and Renwable Energy. 29 Nov. 2007 <www.eere.energy.gov/windandhydro/windpoweringamerica/images/windmaps/il_std800.jpg>.